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REPORT TO THE CONGRESS

Need For A National Earthquake Research Program B-176621

Department of Commerce

Department of the Interior and
Other Agencies

BY THE COMPTROLLER GENERAL
OF THE UNITED STATES

093479
~~713397~~

SEPT. 11, 1972



COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D C 20548

B-176621

To the President of the Senate and the
Speaker of the House of Representatives

This is our report on the need for a national earthquake research program. Earthquake research activities are administered by the Departments of Commerce and the Interior and by other agencies.

Our review was made pursuant to the Budget and Accounting Act, 1921 (31 U S C 53), and the Accounting and Auditing Act of 1950 (31 U S.C. 67)

Copies of this report are being sent to the Director, Office of Management and Budget, the Secretary of Commerce, the Secretary of the Interior; the Secretary of Defense, the Secretary of Housing and Urban Development, the Director, National Science Foundation, the Director, Office of Science and Technology, and the Chairman, Atomic Energy Commission.

A handwritten signature in black ink, appearing to read "A. G. Keller".

Acting Comptroller General
of the United States

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ABBREVIATIONS

AEC	Atomic Energy Commission
ARPA	Advanced Research Projects Agency
EML	Earthquake Mechanisms Laboratory
DOD	Department of Defense
GAO	General Accounting Office
HUD	Department of Housing and Urban Development
NBS	National Bureau of Standards
NCER	National Center for Earthquake Research
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
OERCS	Office of Earthquake Research and Crustal Studies
OMB	Office of Management and Budget
OST	Office of Science and Technology

GLOSSARY OF
EARTHQUAKE RESEARCH TERMINOLOGY

Earthquake engineering research--research to provide information on the nature and effect of destructive ground shaking, to develop practical methods of analysis and design, and to develop safe and economical earthquake countermeasures.

Fault--a fracture in the earth's crust along which two blocks of the crust have slipped with respect to each other.

Intensity--a measure of an earthquake's apparent severity at a specified location, as determined by experienced observers.

Magnitude--a measure of earthquake size observed on seismograph records and relates to the total seismic energy released by an earthquake.

Microearthquake--an earthquake which measures a magnitude below three on the Richter Scale.

Modified Mercalli Intensity Scale--a scale used to evaluate earthquake intensity. Observed effects are placed into 12 classes ranging from I, felt only under favorable circumstances, to XII, damage total.

Richter Scale--a scale developed by C. F. Richter for measuring the magnitude of earthquakes.

Seismology--a science that deals with earthquakes and with artificially produced vibrations of the earth.

Tectonic--refers to the forces or conditions within the earth that cause movements of the crust, such as earthquakes, folds, faults, and the like.

Tsunami--a series of traveling ocean waves of great length and long period, generated by disturbances associated with earthquakes in oceanic and coastal regions.

CHAPTER 1

INTRODUCTION

The Federal Government conducts programs in earthquake research and related seismological activities and supports earthquake research activities through grants and contracts.

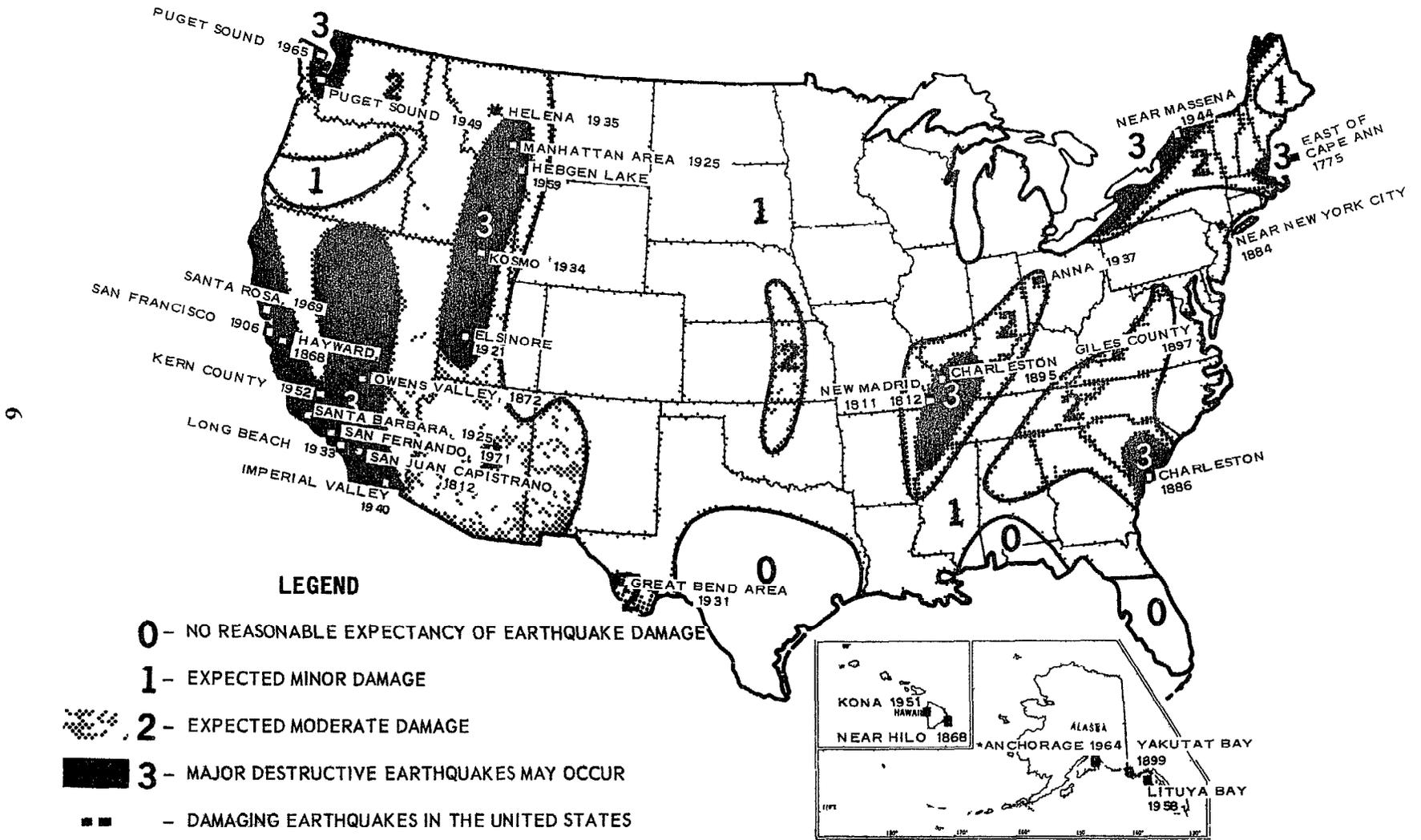
Earthquakes have occurred extensively across the United States, as illustrated by the map on page 6 which shows seismic risk zones and areas where damaging earthquakes have occurred. Damaging earthquakes have occurred most frequently in California, Nevada, and Alaska, but two large and disastrous earthquakes occurred in Missouri (1811-12) and South Carolina (1886).

During this century earthquakes and tsunamis (seismic sea waves) in the United States resulted in about 1,550 deaths and in property damage estimated at \$1.7 billion.

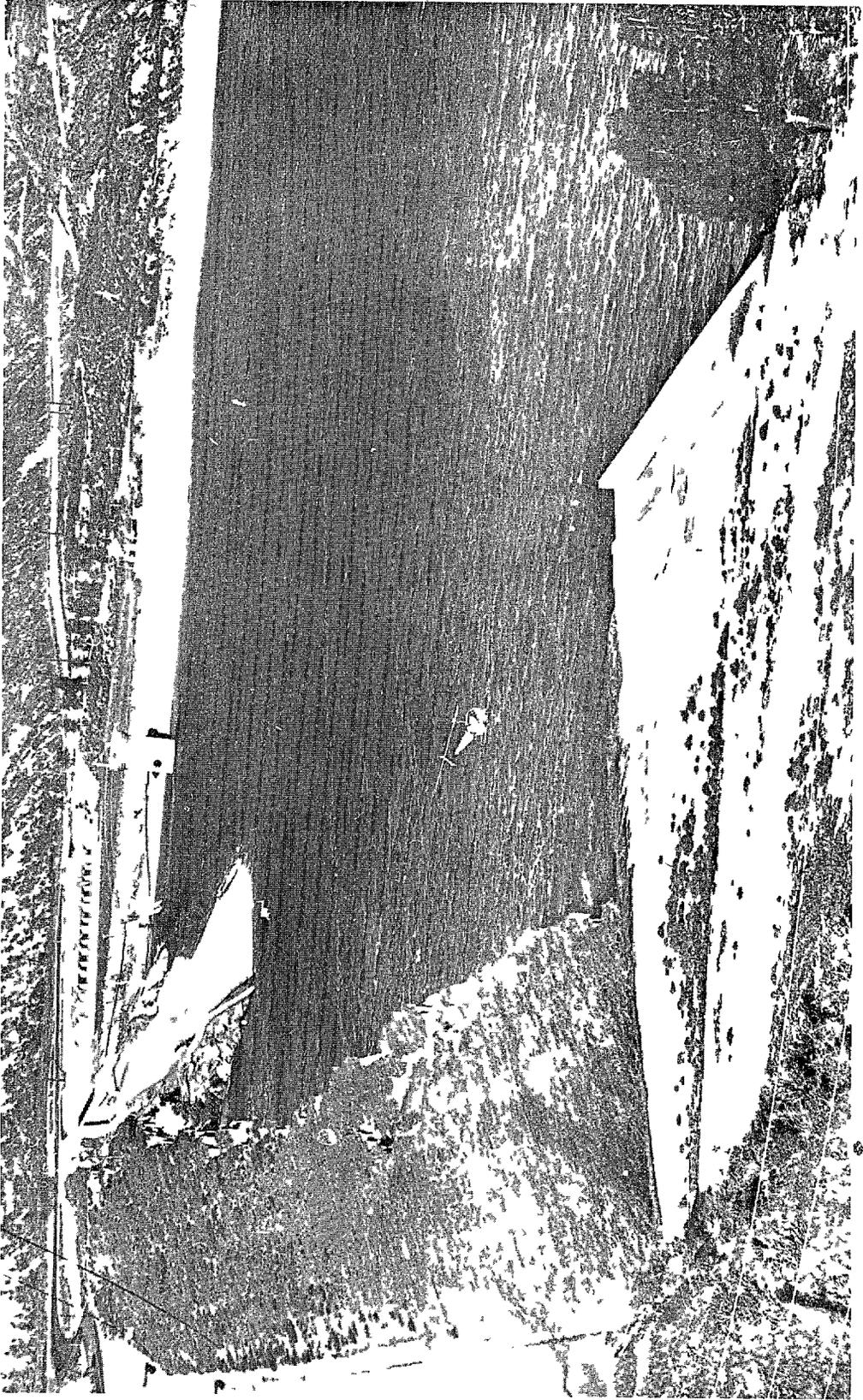
The San Francisco, Calif., earthquake and following fire of 1906 resulted in about 700 deaths and in property damage estimated at \$524 million. The most recent damaging earthquake occurring in the United States was the San Fernando, Calif., earthquake of February 1971 which, although a moderate-sized earthquake, resulted in 64 deaths and in property damage estimated at about \$550 million. The San Francisco earthquake of 1906 was estimated by scientists to have radiated a few hundred times more energy and inflicted severe damage over a much greater area than did the San Fernando earthquake. Scientists have concluded that it is reasonable to expect a major destructive earthquake similar to that of 1906 to strike in or near one of California's major metropolitan areas and to result in more casualties and property loss than that suffered at San Fernando.

Federal earthquake research can be traced to a modest beginning in 1930 when about \$10,000 was expended by Federal agencies for support of seismology. Over the years Federal support of seismology gradually increased to about \$500,000 in 1958. The term "seismology" is defined as a science that deals with earthquakes and with artificially produced vibrations of the earth. A glossary of other principal scientific terms used in this report follows the contents.

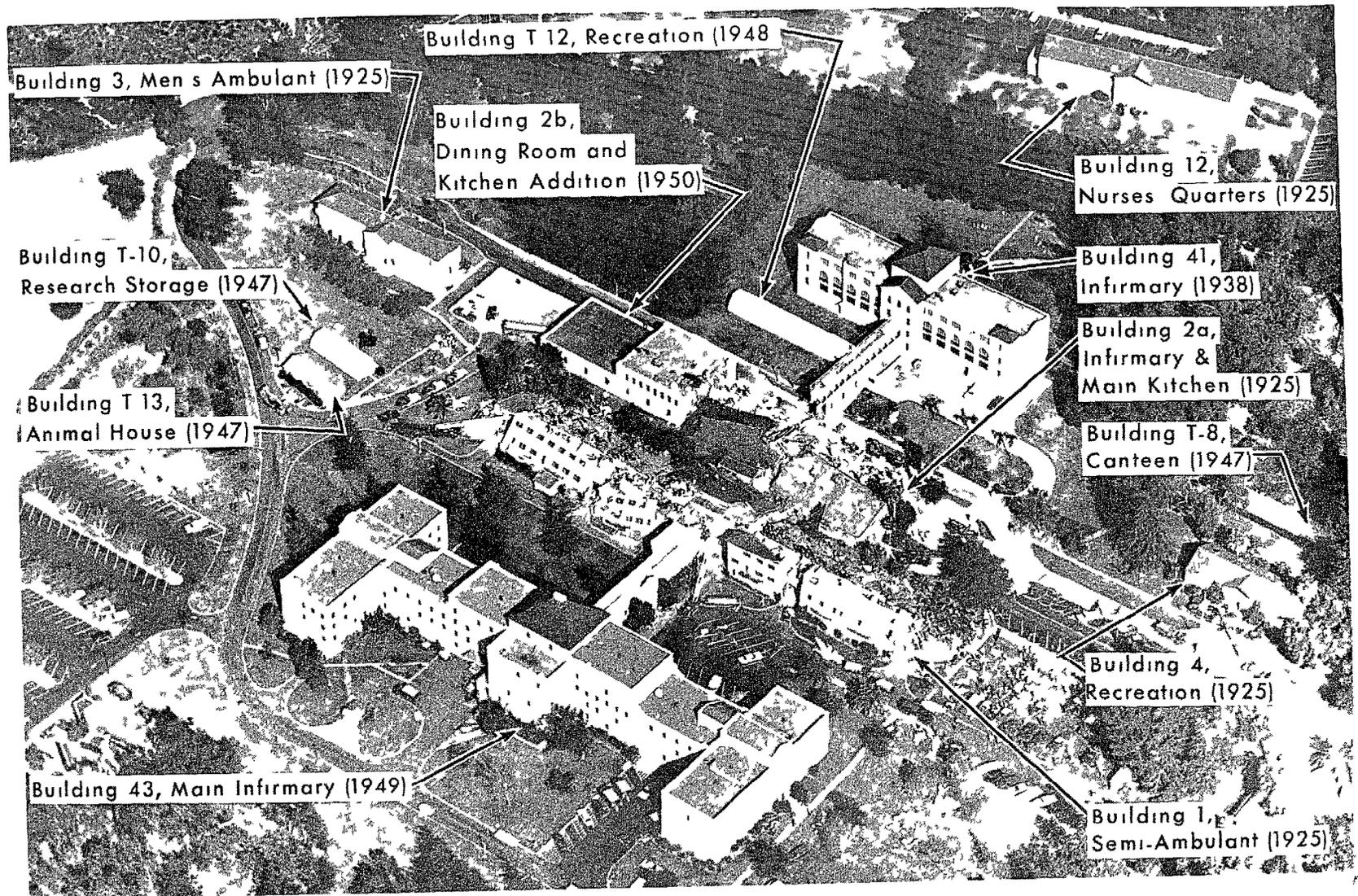
SEISMIC RISK ZONES AND DAMAGING EARTHQUAKES OCCURRING IN THE UNITED STATES



SOURCE MAPS PREPARED BY THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, DEPARTMENT OF COMMERCE
 NOTE SEISMIC RISK ZONES HAVE NOT BEEN ASSIGNED TO ALASKA AND HAWAII

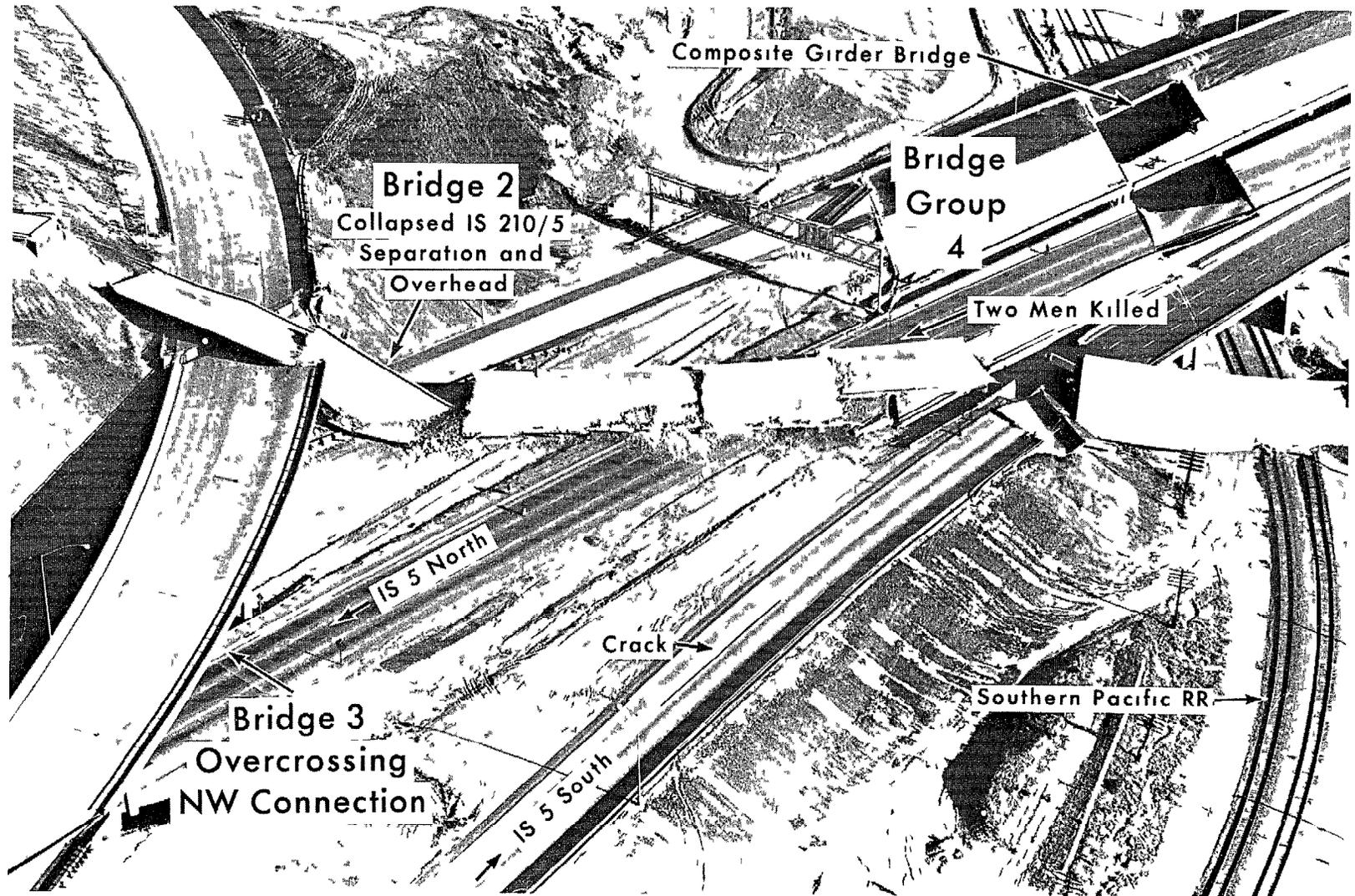


Lower Van Norman Dam The near failure of the hydraulic fill dam forced temporary evacuation of about 79,000 people from their homes This photograph was taken the day of the San Fernando, California, earthquake of February 9, 1971 (Los Angeles Times Photo)



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Aerial view of the San Fernando Veterans Administration Hospital where 46 patients and hospital workers were killed during the San Fernando, California, earthquake of February 9, 1971 (Los Angeles Times Photo)



Freeway damage caused by the San Fernando, California, earthquake of February 9, 1971 Two men in a truck lost their lives as a result of the collapse of the freeway separation and overhead (Los Angeles Times Photo)

With the establishment in 1959 by the Department of Defense (DOD) of Project VELA Uniform, the annual level of Federal funding for earthquake research increased to almost \$30 million by 1961. This program was initiated to obtain a better understanding of seismic phenomena which was needed to detect remote underground nuclear tests and to make possible meaningful negotiations with other nations to limit testing of nuclear weapons.

Support for seismology activities under Project VELA Uniform began to decline in 1964 as the program achieved many of its research goals. To maintain the momentum in seismological research created by the project, many universities, Government agencies, and industrial firms reoriented their research and development programs toward earthquake investigations. As the expenditures for seismology under the project decreased, support for seismology was sustained primarily through the earthquake research programs conducted by the Department of Commerce, the Department of the Interior, the Atomic Energy Commission (AEC), and universities and other nonprofit organizations under grants by the National Science Foundation (NSF). Other agencies supporting earthquake research are the Corps of Engineers, the Department of Housing and Urban Development (HUD), and the National Aeronautics and Space Administration (NASA). The total funds expended during fiscal year 1971 for earthquake research and supporting activities by the agencies included in our review were:

<u>Agency</u>	Earthquake research expenditures (000 omitted)	Percentage of total
Department of Commerce		
National Bureau of Standards	\$ 100	7
National Oceanic and Atmospheric Administration	5,404	37 1
Department of the Interior		
Geological Survey	2,966	20 4
Bureau of Reclamation	116	8
NSF	4,086	28 0
AEC	1,707	11 7
Corps of Engineers	<u>195</u>	<u>1 3</u>
Total	<u>\$14,574</u>	<u>100 0</u>

Note The amounts shown include expenditures reimbursed by other agencies, including HUD and NASA

Our review included obtaining information on Federal earthquake research and identifying opportunities for improvement in the administration of the research, particularly (1) the selection of research projects to accomplish national goals, (2) the coordination of research among the agencies, and (3) the duplication and overlap of research effort.

CHAPTER 2

DEVELOPMENT OF FEDERAL EARTHQUAKE RESEARCH

FEDERALLY SPONSORED STUDIES

The Alaska earthquake in 1964 focused national attention on the threat posed by earthquakes in the United States and precipitated a series of federally sponsored studies conducted by various advisory committees to evaluate the Federal earthquake research effort and to propose a national research program. A summary of each of the reports on these studies is presented below.

"Earthquake Prediction, A Proposal for a Ten-Year Program of Research"

In 1964 an Ad Hoc Panel on Earthquake Prediction was convened by the Director, Office of Science and Technology (OST), for the purpose of studying the opportunities for research in earthquake prediction. The Panel's report, issued in September 1965, recommended a 10-year program of research with required support estimated at \$137 million. The elements of the program recommended by the Panel included:

- Development of a new generation of instruments for monitoring earthquake faults and for installing and operating these instruments, in California and Alaska.
- Extensive geological and geophysical surveys of fault zones.
- Laboratory and theoretical studies of the mechanism of fracture and creep of rocks under realistic pressures and temperatures.
- Research in prediction theory as applied to geophysical phenomena.
- Research in earthquake engineering.

"Proposal for a Ten-Year
National Earthquake Hazards Program"

In April 1966, following the submission of the report by the Ad Hoc Panel on Earthquake Prediction, OST established an Ad Hoc Interagency Working Group for Earthquake Research in accordance with a decision of the Federal Council for Science and Technology. The functions of this working group were (1) to consider the recommendations of the Panel, (2) to make recommendations as to what a national program in earthquake research might consist of and how the Government might be organized for this function, and (3) to prepare a justification for the program.

The working group's report published in December 1968, recommended implementation of a 10-year National Earthquake Hazards Research Program, which incorporated the recommendations of the Panel. The working group's report, although primarily concerned with earthquake prediction, placed greater emphasis on earthquake engineering research than did the Panel's report and recommended expansion of the geological and geophysical field studies of earthquake fault zones. The report recommended also the establishment of a permanent coordinating and guidance group to be responsible for:

- "a. Formulating a National program in earthquake research and providing a focal point for information on the program.
- "b. Continually appraising the adequacy of the National Earthquake Hazards program; identifying missing elements, and recommending appropriate action.
- "c. Analyzing existing distribution and level of funds and assessing the progress toward defined objectives.
- "d. Undertake special studies at the request of the Office of Science and Technology "

"Toward Reduction of Losses from Earthquakes"

This report was prepared in 1969 for the National Academy of Sciences by the Committee on the Alaska Earthquake at the request of the President and represented a summary of the principal conclusions drawn from its study of the Alaska earthquake of 1964. The Committee's report suggested measures that could be taken to minimize loss of life and property in future earthquakes and was based on the review of events during and following the Alaska earthquake. The report outlined specific recommendations which the Committee believed could be applied to any region where strong earthquakes might be expected.

"Earthquake Engineering Research"

This report was prepared in 1969 by the Committee on Earthquake Engineering Research of the National Academy of Engineering through support provided by NSF. The Committee was formed after the Ad Hoc Panel on Earthquake Prediction had published its report (see p. 12) which recommended a relatively low level of funding for earthquake engineering research.

The Committee's report outlined a program of earthquake engineering research aimed at providing basic information on destructive earthquakes, developing knowledge of the behavior of structures and soils during an earthquake, obtaining data on the physical properties of materials, and developing practical and efficient methods of analyses and design. The Committee stated that its report was the only one that dealt entirely with the practical problems of public welfare and safety during earthquakes.

The recommended research effort to make a major impact was estimated by the Committee to total \$380 million over a 10-year period.

"Seismology - Responsibilities and Requirements of a Growing Science"

This report was published in 1969 by the Committee on Seismology of the National Research Council because of the decreasing support provided for seismology by programs, such

as the DOD Project VELA Uniform. To insure that the seismological manpower developed under this and other programs was not dissipated, the Committee on Seismology recommended a strong program supporting seismology.

The Committee recommended also that a 10-year national program in seismology be conducted with much of the effort directed toward new programs in hazard mitigation, prediction, and control. The Committee estimated that over a 10-year period the program would cost about \$503 million. The recommended program would greatly expand the seismological research recommended in the reports previously discussed; however, the Committee's estimate of the cost of the program does not include the cost of research to be conducted in earthquake engineering.

"Earthquake Hazard Reduction"

This report was issued in 1970 by the OST Task Force on Earthquake Hazard Reduction through support provided by the Geological Survey. The mission of the task force was the development of an appropriate national action program for reducing human suffering and property damage resulting from an earthquake. The task force proposed a national earthquake hazard-reduction program, and its recommendations of required research were grouped into three time-related categories reflecting when significant public benefits would begin to be derived from the implementation of each of the recommendations. These recommendations are listed in appendix I. (See p. 61.)

Agency officials informed us that the task force had submitted a confidential report to OST and that OST subsequently submitted that report to the Office of Management and Budget (OMB). Both of these offices acknowledged receipt of the confidential report but refused to release the report to us. An OMB official advised us that the confidential report was classified "pending proposal" and could not be released until OMB had taken formal action.

A report entitled "In the Interest of Earthquake Safety" was published by the University of California in 1971 to summarize background information, findings, and conclusions developed by the task force and was intended to complement

the task force's 1970 report by interpreting the group's findings. The list of contributors for the summary report was the same as the membership of the task force.

Action on advisory committee reports

Each of the previously mentioned advisory committees urged the Federal Government to undertake or sponsor a number of programs and studies in selected aspects of earthquake research. Many of the committees also recommended the establishment of a permanent coordinating group to be responsible for formulating an effective national program in earthquake research.

The Federal Government, however, has not established a national program in earthquake research and has not set up a coordinating group as had been recommended in the various advisory committee reports. We noted that some of the individual agencies supporting earthquake research activities had based their justification for the initiation or expansion of certain research activities on recommendations by the advisory committees. Commerce and the Interior advised us that they accept the 1970 report "Earthquake Hazards Reduction" as an outline of a de facto national program.

EARTHQUAKE RESEARCH SUPPORTED BY THE FEDERAL GOVERNMENT

A number of Federal agencies are active in the field of earthquake research and supporting services, including the Departments of Commerce and the Interior, DOD, HUD, NSF, AEC, the Corps of Engineers, and NASA. A summary of the earthquake research activities of the principal agencies is presented below, and the programs of other agencies are described in appendix II. (See p. 63.)

Department of Commerce

The Department of Commerce is actively engaged in a number of programs on earthquake research and related seismological activities. These programs are concentrated in the National Oceanic and Atmospheric Administration (NOAA). NOAA was established on October 3, 1970, by consolidating the Environmental Science Services Administration (ESSA), Department of Commerce, with elements and programs of other Federal organizations in accordance with Reorganization Plan No. 4 of 1970. NOAA has statutory authority to conduct seismological and related geophysical measurements and investigations (33 U.S.C. 883a). In addition, NOAA is authorized to conduct investigations and research in seismology (33 U.S.C. 883d). Pursuant to these authorizations, NOAA conducts a broad program of earthquake investigations and supporting services with emphasis on reducing the hazardous effects of earthquakes and on providing the data base for a broad national research effort.

NOAA's earthquake research studies are conducted by its Environmental Research Laboratories and supporting services are provided by its Environmental Data Service. The Earth Sciences Laboratory of the Environmental Research Laboratories conducts studies (1) directed toward understanding the natural forces generating earthquakes, (2) of the mechanics of earthquakes, and (3) of ways to quantify the earthquake hazard potential in given regions. These studies are designed to develop a prediction system of earthquakes and tsunamis and to help improve design and engineering of earthquake-resistant structures.

The Earth Sciences Laboratory also has a program in strong-motion seismology to obtain seismic data regarding earthquake-response characteristics for specific types of structures considering the geologic foundation, soil condition, and other factors. It collaborates in studies with university groups; structural engineers; and State, county, and municipal regulatory agencies interested in engineering seismology problems. A network of strong-motion stations is permanently installed in buildings, dams, bridges, and other structures throughout the western United States, Alaska, and Central and South America.

The Earth Sciences Laboratory also conducts earthquake research studies at its Earthquake Mechanism Laboratory (EML) in San Francisco. EML was created in 1965 to conduct studies along the major California faults. Its function includes the study of the earth's internal structure and the mechanism that cause earthquakes and the application of the knowledge gained from these studies to the problem of earthquake prediction.

NOAA operates and maintains a network of 17 seismological observatories in the United States and its territories and assists in the operation and maintenance of a network of 15 cooperative seismic stations under the guidance of universities, research institutes, or other Government agencies. In addition, NOAA is responsible for the implementation and maintenance of the Worldwide Standardized Seismograph Network. This cooperative standard equipment network, which consists of approximately 115 stations located in over 60 countries and territories, was established as part of Project VELA Uniform. NOAA collects, films, archives, and disseminates data to technical and public users. A more extensive history and description of NOAA's activities are included as appendix III. (See p. 67.)

The Environmental Research Laboratories in 1970 adopted a general policy to reduce dependence upon funds from other agencies by ceasing to solicit reimbursable projects from other agencies. The funding for NOAA's earthquake-related activities for fiscal years 1967 through 1971, as compiled from NOAA's records with the assistance of program officials, are shown in the following table.

<u>Fiscal year</u>	<u>NOAA expenditures</u>		
	<u>Direct funding</u>	<u>Reimbursable (note a)</u>	<u>Total</u>
	(000 omitted)		
1967	\$ 1,684	\$ 3,430	\$ 5,114
1968	2,301	2,070	4,371
1969	2,798	3,214	6,012
1970	2,943	1,985	4,928
1971	<u>3,640</u>	<u>1,764</u>	<u>5,404</u>
Total	<u>\$13,366</u>	<u>\$12,463</u>	<u>\$25,829</u>

^aAEC and DOD provided most of the reimbursable funding.

Department of the Interior

Most of the Interior's earthquake research program is conducted by the Geological Survey. However, the Bureau of Reclamation conducts research in earthquake engineering and the Bureau of Mines conducts research programs that are relevant to earthquake problems.

Survey is authorized to classify the public lands and to examine the geological structure, mineral reserves, and products of the national domain (43 U.S.C. 31a). Survey uses many disciplines to carry out this mission, including geology and geophysics.

Survey's program of earthquake research is conducted primarily by its Geologic Division through the National Center for Earthquake Research (NCER) located in Menlo Park, Calif. NCER coordinates all the earthquake-related activities of the Geologic Division, including those of its Office of Earthquake Research and Crustal Studies (OERCS). OERCS is responsible for most of the earthquake research conducted.

NCER was established in 1965 in response to the recommendation of the Ad Hoc Panel on Earthquake Prediction to conduct a program to acquire and analyze data on seismic belts of the western United States and Alaska, with emphasis on the San Andreas fault zone of California. A primary purpose of NCER is to blend research efforts aimed at understanding the fundamental nature of earthquakes and to

translate its understanding into prediction and modification of earthquakes to reduce loss of life and property. A more extensive history and description of Survey's activities is included as appendix IV. (See p. 71.)

Survey actively solicits funds from other agencies as a means of strengthening its earthquake research program. The growth of Survey's earthquake research program from fiscal year 1965 through fiscal year 1971 is indicated by the expenditures shown below.

<u>Fiscal year</u>	<u>Survey expenditures</u>		
	<u>Direct funding</u>	<u>Reimbursables</u>	<u>Total</u>
(000 omitted)			
1965	\$ 529	\$ 20	\$ 549
1966	1,199	129	1,328
1967	1,209	154	1,363
1968	1,065	293	1,358
1969	1,150	412	1,562
1970	1,377	1,074	2,451
1971	<u>1,465</u>	<u>1,501</u>	<u>2,966</u>
Total	<u>\$7,994</u>	<u>\$3,583</u>	<u>\$11,577</u>

National Science Foundation

NSF is authorized and directed by the National Science Foundation Act of 1950 (42 U.S.C. 1861) to develop and encourage the pursuit of a national policy for promoting basic research and education in the sciences and to initiate and support basic scientific research through contracts and grants. NSF sponsors earthquake research activities in nine basic areas (1) socioeconomic effects and costs, (2) ground-motion instrumentation and measurements, (3) effects on solids and foundations, (4) dynamic analysis of structures, (5) detailed fabrication of structures, (6) tsunami observation and protection, (7) design and distribution aspects of public services and utilities, (8) postearthquake inspection and engineering evaluation, and (9) technological transfer.

NSF began providing financial support for earthquake engineering on a program level in fiscal year 1966. Some of

the funds have been used to support the development of special reports, such as the National Academy of Engineering's 1969 report on "Earthquake Engineering Research" (see p. 14), and to support other special activities, such as the post-earthquake inspection arrangement, which was set up by NSF through the National Academy of Engineering to insure that inspection teams can be sent to inspect and document disastrous effects of earthquakes.

NSF attempts to support earthquake research in areas not falling within the mission of other agencies. In addition, NSF has provided funds to NOAA since fiscal year 1968 for support of the foreign standardized seismological stations and for processing data from these stations. These foreign stations, along with stations in the United States and its territories, make up the Worldwide Standardized Seismograph Network. (See p. 18.)

NSF has provided funds for support of earthquake research for fiscal years 1965 through 1971, as shown below.

<u>Fiscal year</u>	NSF support for earthquake research (note a)		<u>Total</u>
	<u>Earthquake engineering</u>	<u>Other geophysical</u>	
	(000 omitted)		
1965	nominal	\$ 1,241	\$ 1,241
1966	\$ 249	1,296	1,545
1967	1,122	2,898	4,020
1968	922	1,868	2,790
1969	1,323	2,516	3,839
1970	659	2,510	3,169
1971	<u>2,592</u>	<u>1,494</u>	<u>4,086</u>
Total	<u>\$6,867</u>	<u>\$13,823</u>	<u>\$20,690</u>

^a Amounts do not include funds provided NOAA.

CHAPTER 3

NEED FOR A NATIONAL EARTHQUAKE RESEARCH PROGRAM

AND IMPROVED COORDINATION

Our review of the earthquake research and supporting services administered by the various Federal agencies indicated that there was a need for an established national earthquake research program and for improved coordination among the Federal agencies supporting earthquake research. A national program has not been established to guide the efforts of the various Federal agencies nor has a permanent coordinating group been established to insure that maximum benefit is obtained from available resources.

NEED FOR A NATIONAL PROGRAM

The current fragmentation of responsibility for earthquake research among the Federal agencies and the complexities of the earthquake problem have made it extremely difficult for a coordinated attack on the Nation's earthquake problem. We believe that earthquake research would be most effective if conducted under a comprehensive program setting forth national objectives and employing basic management controls. For example, plans should be developed in terms of their contribution--both short and long range--to program objectives with resource requirements, anticipated benefits and outputs, alternatives, and priorities clearly identified for management review and decision.

A national program in earthquake research has not been developed, however, to guide the efforts of the various agencies conducting earthquake research. As a result, national objectives and target dates for evaluating progress in accomplishing the objectives have not been established, priorities have not been assigned, and the research roles of the various agencies in relation to the objectives have not been defined.

Need for objectives and
definition of agencies' roles

Disagreement existed among scientists and others as to the relative importance of the primary earthquake research objectives. These differences of opinion were evident in a comparison of the studies made by the advisory committees. The composition of the committees had been quite varied, but each committee strongly recommended that the Federal Government undertake or sponsor programs and studies in seismology, geology, engineering, and disaster relief and each committee recognized the need to carry out a well-balanced earthquake research program with adequate support given to all research aspects. The committees, however, differed in their opinions on the direction of a national program as shown below.

<u>Report</u>	<u>Year issued</u>	<u>Research area of primary emphasis</u>
Earthquake Prediction	1965	Earthquake prediction
Ten-Year National Earth- quake Hazards Program	1968	Earthquake prediction
Toward Reduction of Losses from Earth- quakes	1969	Earthquake engineering
Earthquake Engineering Research	1969	Earthquake engineering
Seismology- Responsibilities and Requirements of a Growing Science	1969	Earthquake prediction and control
Earthquake Hazard Reduction	1970	Earthquake engineering and prediction and control

One of the research areas, earthquake prediction, has been a subject of particular controversy among scientists and agency officials and concerns the possibility of, and the benefits to be derived from, developing a technique for

predicting earthquakes An official of Survey, in hearings held in June 1971 before the Senate Committee on Public Works, stated his belief that Survey might be able to predict some earthquakes in the next 10 years. A NOAA official, however, commented in the same hearings that:

"*** nobody has come anywhere near estimating the magnitude of the effort that would be required in a program aimed at coming up with earthquake prediction in 10 years "

A noted scientist in earthquake research stated at the International Meeting on Earthquakes held in San Francisco in May 1971 that:

"A hope of prediction is often held out as a means to enlist support for an earthquake research program. This is misleading, whether intentionally or not, and ultimately it tends to damage relations between science and the public. Fortunately, procedures undertaken with the nominal purpose of prediction often have increased our actual understanding of earthquakes Nevertheless, predictions are pernicious, even when they come from obviously incompetent sources; the possible evil effects of a false alarm coming from apparently scientific sources are even more serious.

"Public obsession with prediction diverts attention away from the actually possible measures to diminish the damaging effects of future earthquakes. Conversely, the impossibility of exact prediction is used as an argument against any and all precautionary measures, ignoring the obvious fact that where earthquakes have occurred in the past they may be expected in the future."

The scientist was expressing his view that a balanced research program was needed and that earthquake prediction should not be funded to the level that engineering-related activities are neglected.

At the International Meeting on Earthquakes, the Director of the Office of Emergency Preparedness stated that:

"*** predictions will be of limited usefulness if the people in the earthquake-prone areas have not prepared and as a result, for example, all the houses fall down from the effects of only a moderate earthquake. We must also acknowledge the costs and difficulties of stronger construction "

Most of the agencies have selected recommendations from the advisory committee reports as the basis for their earthquake research activities. The stated primary objective or objectives of each of the principal agencies conducting earthquake research is as follows:

<u>Agency</u>	<u>Objective</u>
NOAA	Understand physical basis of earthquakes.
Survey	Understand fundamental nature of earthquakes for developing means to predict and modify earthquakes.
AEC	Insure safety in major AEC programs in weapons testing, peaceful use of nuclear explosives, and siting of nuclear facilities.
NSF	Support basic research related to earthquakes

In addition to being affected by the determination of primary objectives on an individual-agency basis, the Federal earthquake research effort has been affected by the necessity for each agency, in the development of its research program, to conform with its basic missions. The research activities of the various agencies therefore have not resulted in a balanced earthquake research program with adequate support given to all research areas.

The OST Task Force in its report "Earthquake Hazard Reduction" discussed the difficulties in formulating a program for earthquake hazard reduction and commented, as follows:

"Many people outside the engineering and scientific communities do not appreciate the seriousness of the gaps that currently exist in our fundamental knowledge of earthquakes and their effects ***."

Need for increased
earthquake engineering research

The area in which research effort has been most noticeably deficient relative to its potential impact is in the development and application of improved earthquake engineering techniques. In a letter to the Director of OST, dated July 20, 1971, HUD's Assistant Secretary for Research and Technology in commenting on the status of earthquake research activities stated that:

"As many of HUD's concerns deal with the structural design [engineering], social, and political aspects of earthquake hazard reduction, I cannot but help notice that those areas apparently continue to be neglected."

The basic goal of all earthquake engineering research is the development of better and safer structures, designed to withstand foreseeable future earthquakes. The relative importance of earthquake engineering, in the opinion of the National Academy of Sciences, is indicated by the following comment in the Academy's 1969 report "Toward Reduction of Losses from Earthquakes." (See p. 14.)

"***man will continue to live and work in areas of seismic hazard, and [the] first consideration therefore should be given to safety factors in structural design and in patterns of use and occupance. Research and regulation are recommended only insofar as they appear to

offer a basis for (a) improved design, construction, and land-use decisions, or (b) better containment of disasters."

The advisory committee reports issued subsequent to the 1965 "Earthquake Prediction" report have recommended significant increases in the support for earthquake engineering. A listing of the recommended 10-year funding for earthquake engineering, as contained in selected reports, follows.

<u>Report</u>	<u>Date issued</u>	<u>Funding</u>
Earthquake Prediction (see p. 12)	1965	\$ 19,600,000
Ten-Year National Earth- quake Hazards Program (see p. 13)	1968	59,700,000
Earthquake Engineering Research (see p. 14)	1969	345,000,000 ^a

^aDoes not include \$35 million for studies in geology and seismology.

We found that some of the mission-oriented agencies, such as AEC, the Corps of Engineers, the National Bureau of Standards (NBS), and the Bureau of Reclamation had provided some support for earthquake engineering research as an integral part of their other research activities; however, the principal support had been provided by NSF. Authorities involved in earthquake research have advised us that no Federal agency currently has the personnel or other resources to conduct earthquake engineering research at the level recommended in the various advisory committee reports.

The Assistant Commissioner of Reclamation in a May 1967 letter to the Chairman of the Ad Hoc Interagency Working Group commenting on an early draft of the OST report "Proposal for a Ten-Year National Program for Earthquake Research" stated that:

"The text places very strong emphasis on earthquake engineering research which is not supported by the funding suggested. *** from a funding standpoint, earthquake engineering represents

only 20% of the entire interagency group program, while geological and geophysical aspects comprise 80% of the program. It is our opinion that engineering research is underemphasized. While research to predict and locate earthquake potential in seismically active areas is essential, we must learn to design and build structures which will withstand earthquake shocks safely and as economically as possible. We believe that research in earthquake potential and earthquake engineering should be equally funded." (Underscoring supplied.)

We noted that the final report in December 1968 stated that earthquake engineering represented 27 percent, or \$59.7 million, of the recommended 10-year funding of \$220.3 million for an earthquake hazards reduction program.

Actions of the Office of
Science and Technology

OST has been the recipient of the reports of most of the federally sponsored study groups. An OST official informed us that OST had used these reports in attempts to generate a unified approach to earthquake research. He advised us in April 1971 that OST had planned to recommend to OMB that a national program be established on the basis of proposals in the various study reports and that the current setup of participation by the agencies be formalized.

The Director of OST by letter dated May 20, 1971, requested NOAA, Survey, and the Advanced Research Projects Agency (ARPA) to suggest a combined program, to begin in fiscal year 1972, of research on the broad geophysical and geological aspects of earthquake hazards reduction. This request resulted in NOAA's and Survey's submitting to OST a proposal for an increase in funds to expand their existing programs in accordance with the recommendations contained in the OST 1970 report entitled "Earthquake Hazard Reduction." (See p. 61.) The Director of ARPA suggested that a comprehensive plan be formulated before further funds were sought and therefore did not request any increase in funds. A summary of the activities to be funded, as proposed in the submission by the other two agencies, follows.

<u>OST recommenda- tion</u>	<u>Activities</u>	<u>Proposed funding</u>		
		<u>NOAA</u>	<u>Survey</u>	<u>Total</u>
——(000 omitted)——				
A-3	Seismicity maps	\$ 567	-	\$ 567
A-4	Geologic hazards maps	-	\$ 900	900
A-12	Strong motion studies	400	-	400
B-2	Postearthquake analysis	100	250	350
	Postearthquake analysis (San Fernando)	1,060	250	1,310
B-3	Fault mapping, dating, and specialized geologic mapping	-	1,200	1,200
B-4	Local seismic networks	819	-	819
C-2	Earthquake prediction research	-	1,500	1,500
C-3	Earthquake control research	-	-	-
C-4	Geodetic research	784	-	784
C-6	Tsunami hazard research	375	-	375
C-7	Basic research in seismology	375	-	375
C-8	Rock mechanics	-	400	400
	Total	<u>\$4,480</u>	<u>\$4,500</u>	<u>\$8,980</u>

We noted that the proposal which was not funded, provided primarily for expanding existing earthquake research activities but did not provide for research in neglected areas such as earthquake engineering. Certain elements in earthquake engineering (notably research in the earthquake resistant design of structures and other works) were not included in the NOAA and Survey programs because the expertise of these agencies did not extend to that part of the earthquake engineering field.

NOAA prepared draft legislation to establish a comprehensive national program of earthquake monitoring, research, and engineering and to provide for studies leading to earthquake prediction and control. Senate bill 3584, which was introduced in the Congress on May 9, 1972, provides for a clarification on the authority and roles of the three major Federal agencies involved in earthquake activities; namely, NOAA, Survey, and NSF. The Administrator of NOAA, in commenting on the bill, stated that the bill would insure that a comprehensive effort toward earthquakes would be undertaken and that the bill recognized the need for coordination of activities.

NEED FOR IMPROVED COORDINATION

Most Federal agencies' earthquake research activities are an integral part of their total research programs and supplement larger research functions; each agency has its own procedures for setting priorities, allocating responsibilities, and insuring coordination within the agency. Also each agency generally coordinates earthquake research with its other research activities. The variety of NOAA's and Survey's research programs has resulted in multiple investigations on similar problem areas with no formal coordination. Although multiple approaches to problem solving may be effective in accomplishing certain objectives, we believe that the approaches need to be carefully coordinated and that priorities need to be established to obtain the maximum benefits from the resources available.

Our review indicated that the coordination of Federal earthquake research activities had been limited to meetings of informal groups, such as the Interagency Geophysics Discussion Group, the Ad Hoc Panel on Earthquake Prediction, and the Interagency Working Group for Earthquake Research. We were informed by NOAA and Survey officials that NOAA and Survey had made no formal attempts to coordinate their earthquake research programs. (See p. 50 for action taken subsequent to our fieldwork.)

We observed a number of situations involving NOAA and Survey which indicated that the present informal means of coordinating Federal earthquake research had not been effective because the two agencies had similar plans and objectives and had been carrying out similar research activities along the same portions of major California faults. The limited coordination between NOAA and Survey has prevented the two agencies from obtaining maximum benefits from the resources available. These situations are discussed in more detail in subsequent sections.

Similarity of NOAA's and Survey's plans and long-range objectives

NOAA and Survey have prepared statements outlining their earthquake research plans and long-range objectives.

A comparison of those elements of their plans which are similar in nature follows.

NOAA

Survey

(Planned accomplishment by the end of fiscal year 1975)

A. Basic research

A. Basic research

1. "Determine the relationship between the accumulation of strain in the rock adjacent to active faults and the release of that strain by means of earthquakes and fault creep."

1. "*** determine by 1980 the relationship between stress accumulation, geologic structures, and earthquake frequency and magnitude as a basis for estimating earthquake probability and predicting earthquake."

2. "Delineate regions of active fault movement both of sudden breakage and 'Fault Creep' on the San Andreas and related fault systems."

2. "*** identify and delineate active fault breaks, by 1975 for the San Andreas fault system and its branches and by 1980 for other major active fault systems."

3. "Identify recognizable premonitory variations in measurable physical parameters of the earth which may precede large earthquakes."

3. "*** investigate potential premonitory phenomena such as variations in the earth's magnetic field as a basis for earthquake prediction."

B. Related activities

B. Related activities

1. "Establish practical criteria, based on sound geophysical principles, to permit a useful and realistic method of

1. "*** develop improved criteria for estimating the intensity and duration of earthquake ground motion in

evaluating the seismic hazards associated with large engineered structures (large dams, nuclear reactors, etc.) and with large underground explosions."

various geologic environments and for predicting the location and nature of disastrous ground failure; to apply these criteria to delineate hazardous areas. Program results will be developed for immediate application from the beginning of the program. A comprehensive set of criteria will be achieved in 1980."

2. "Develop comprehensive regional seismic risk maps for the western and central United States to provide guidance for design criteria, planning economic development, and to aid in determining improved insurance rates."

2. "*** develop sets of maps to assist planners in making provision in long range land-use planning to protect against earthquake hazards."

3. "Develop an ESSA [now NOAA] Earthquake Emergency Plan and provide for its implementation."

3. "*** develop the specific information required for the planning of emergency, postdisaster actions."

NOAA and Survey officials informed us that there was no formal coordination between NOAA and Survey in the planning of their earthquake research activities. We believe that the implementation or further expansion of the above-listed similar plans and long-range objectives by NOAA and Survey could result in significant duplication and overlapping of research effort.

Duplication and overlapping in monitoring earthquake faults

NOAA and Survey conduct duplicate and overlapping studies of microearthquakes, strain accumulation in the earth's crust, and fault movement along the same portions of the major California earthquake faults. The studies are designed to develop understanding of earthquake mechanisms for translation into prediction of earthquakes. NOAA and Survey utilize similar research equipment in conducting these studies, however, there is no regular exchange in data. Additionally, NOAA and Survey have not coordinated the planning of the studies nor the placement of their research equipment.

NOAA's earthquake research is conducted primarily by EML, which is part of its Earth Sciences Laboratory in San Francisco. The Survey's earthquake research is conducted primarily by OERCS, which is located about 35 miles from San Francisco in Menlo Park.

In a 1969 National Academy of Sciences and National Academy of Engineering advisory committee report to NOAA, the advisory committee stated that.

"There exists an obvious overlap between ESSA [now NOAA] and the U.S. Geological Survey in some aspects of research activities on earthquake problems. The overlap is especially strong in the San Francisco area."

Microearthquake studies

The major portion of the NOAA and Survey seismograph networks in California are designed to record microearthquakes--earthquakes which measure a magnitude below three on the Richter Scale. Officials in charge of EML and of OERCS informed us that microearthquake studies were an essential element of their research program as these studies were correlated with strain- and fault-movement studies to develop an understanding of earthquake mechanisms.

NOAA's California network, at the time of our review, was composed of 13 seismograph stations. Of the 13 stations,

eight were maintained by EML, three by the California Department of Water Resources, one by the California Institute of Technology, and one by the University of Nevada. EML estimated the cost of each station at about \$1,300 to \$3,700, depending on the type of equipment installed. EML also receives data from six stations in Nevada maintained by the Special Projects Party of the Earth Sciences Laboratory

Survey's seismograph network in California was composed of 83 stations. OERCS officials estimated that it cost about \$2,000 to establish each station. OERCS also receives data from 90 stations located outside California, most of which are devoted to special projects funded by other agencies-- primarily by ARPA of DOD and by AEC

The Chief of OERCS advised us that Survey's microearthquake network utilized more stations than did NOAA's network because, in addition to providing data for correlating microearthquake activity with other tectonic¹ processes, the network was designed to provide seismic data on known and suspected faults. He advised us also that, to accurately locate the area where an earthquake was generated, called the hypocenter, it was necessary to have seismograph stations relatively near the hypocenter. He estimated that about 150 to 200 seismographs would be necessary to accurately locate microearthquakes along the San Andreas fault.

The Director of EML informed us that NOAA had not established as many seismograph stations as had Survey because EML was not interested in precise mapping of earthquake activity along the fault. He informed us also that the network had not been extended along the entire San Andreas fault because funds for such expansion and for the personnel needed to maintain an expanded network had not been available. The Director stated that NOAA and Survey did not coordinate the planning of their research projects or the placement of their stations.

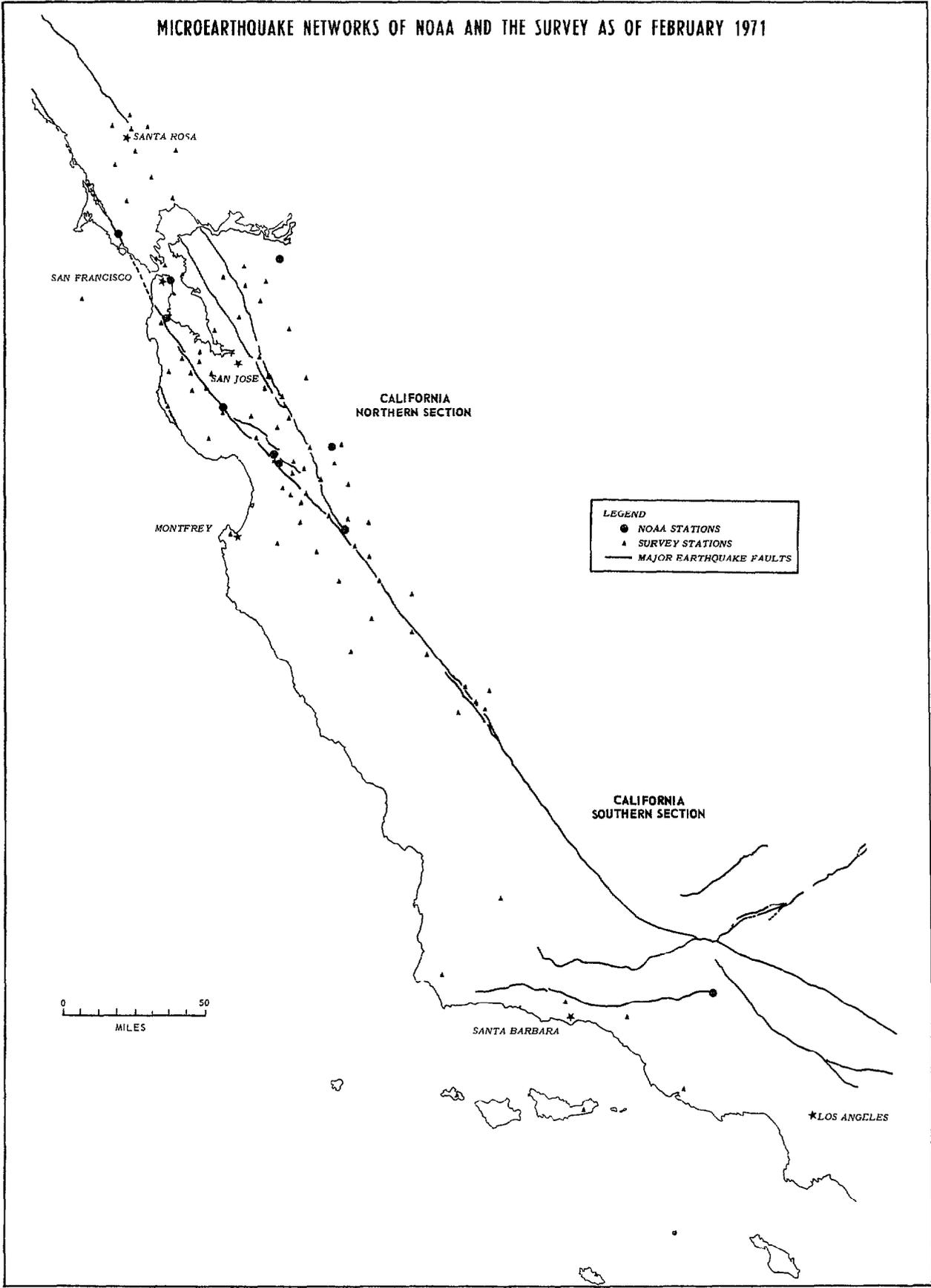
We believe that the effective use of the limited resources available for earthquake research requires that all

¹See glossary.

aspects of earthquake research efforts be properly coordinated

The following map illustrates the relative position of NOAA's and Survey's microearthquake network in California.

MICROEARTHQUAKE NETWORKS OF NOAA AND THE SURVEY AS OF FEBRUARY 1971



Strain accumulation studies

EML, in conducting NOAA's strain accumulation study program, uses data developed under its geodetic surveying program and by its strainmeter installations on the San Andreas fault and at sites located in Nevada and the Aleutian Islands--the installations at these sites are sponsored by AEC.

Geodetic surveys to detect crustal movements are conducted about every 10 to 15 years at selected locations. The Director of EML informed us that the geodetic surveys provide basic research information for NOAA's overall seismological research program and provides information to the scientific community in general.

In addition to using the geodetic data, EML uses quartz-rod strainmeters which record deformation of the earth's surface. EML had installed such instruments at a cost of approximately \$30,000 at one site on the San Andreas fault. Strainmeters of the same type have been installed in Nevada and the Aleutian Islands to assess the magnitude of the changes of the strain in the earth's crust induced by large underground nuclear explosions and by any subsequent earthquakes.

Survey, under its geodetic survey program, has nine geodimeter networks located along the San Andreas fault to develop crustal-strain data. A geodimeter network contains two or more survey monuments spaced approximately 1 to 10 kilometers apart and costs approximately \$3,000 to install. Each network is surveyed once a year, at a cost of about \$2,000, to measure crustal strain. The OERCS official in charge of Survey's crustal-strain program explained to us that, although Survey's geodetic surveying consisting of the geodimeter network overlapped NOAA's geodetic surveying, Survey needed more precise data than that obtained by NOAA. He advised us that NOAA's surveys had not been conducted regularly enough to be of benefit in detecting crustal-strain accumulation over a short period of time.

The Chief of OERCS stated that Survey was interested in NOAA's crustal-strain work but had not developed its own studies using quartz-rod strainmeters because NOAA was

working with these instruments and, in his opinion, the information produced to date had not been significant. He explained that, should NOAA's studies produce significant data, he expected that Survey would establish its own quartz-rod installations.

Fault creep installations

NOAA has a network of 31 creepmeters located at 27 sites. These creepmeters, which straddle the major California faults with a rod, are designed to monitor the same phenomenon as are Survey's creepmeters. We were informed that at one site a NOAA creepmeter was located about 500 yards from a Survey creepmeter. NOAA developed its creepmeters in-house and installed them at a cost of about \$800 each. The data recorded by these creepmeters is read manually.

Survey has a network of 15 creepmeters located on segments of the main San Andreas fault and two creepmeters located on the adjacent Hayward fault. These creepmeters straddle the fault with a wire anchored at two points and connected to a gage which records movement along the fault. Survey developed its creepmeters in-house and installed them at a cost of about \$800 each. Of Survey's 17 creepmeters, five have their recorded data telemetered to NCER and 12 have it read manually.

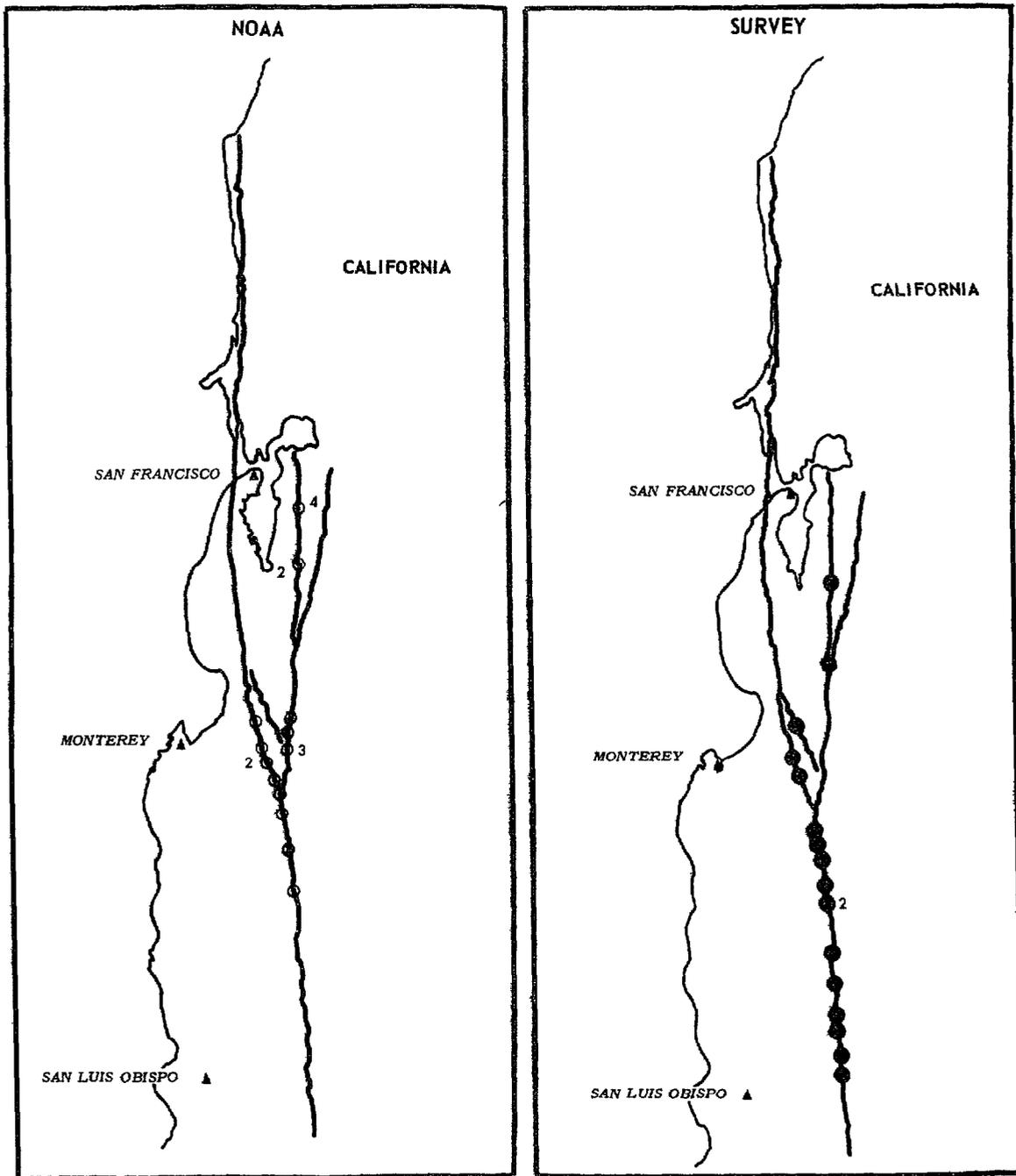
In discussions with NOAA and Survey officials we were informed that, although the creepmeters were designed for the same purpose, they had been developed independently. The primary difference between the creepmeters was the instrumentation that had been developed to record the fault movement as indicated by the changes in the length of the wire or rod. The heads of EML and OERCS informed us that the two creepmeter programs duplicated each other and that there had been no regular exchange by NOAA and Survey of data pertaining to creepmeter studies even though an exchange of the data would have been useful to both agencies.

The Director of NOAA's National Ocean Survey in a June 1969 letter to the Administrator of NOAA (then ESSA) stated that:

"In a few instances, there has been duplication of effort or two groups have been making creep measurements in the same locality at approximately the same time."

The following map illustrates the approximate locations of the majority of the NOAA and Survey creepmeter installations in northern and central California.

CREEPMETER SITES FOR NOAA AND THE SURVEY
APRIL 1971



LEGEND
○ NOAA CREEPMETER SITES
● SURVEY CREEPMETER SITES
— MAJOR EARTHQUAKE FAULTS

0 50
MILES

Alignment arrays

NOAA and Survey have installed a number of alignment arrays across major California earthquake faults. An alignment array consists of a line of survey monuments perpendicular to the fault that are used for measuring slip along the fault.

NOAA has installed 21 alignment arrays across the San Andreas fault and 20 across the adjacent Calaveras and Hayward faults. Of the arrays across the Hayward fault, 11 are maintained in cooperation with local municipalities. NOAA also has one alignment array across each of two minor faults in southern California. NOAA informed us that the initial cost for the alignment arrays ranged from \$50 to \$350, depending on the type installed, and that the alignments were surveyed once a year at a cost of about \$60 for each array.

Survey has installed 26 alignment arrays across the San Andreas fault, five across the adjacent Calaveras and Hayward faults, and four across other faults in southern California. Survey informed us that the arrays cost about \$400 each and were surveyed once a year at a cost of about \$60 each.

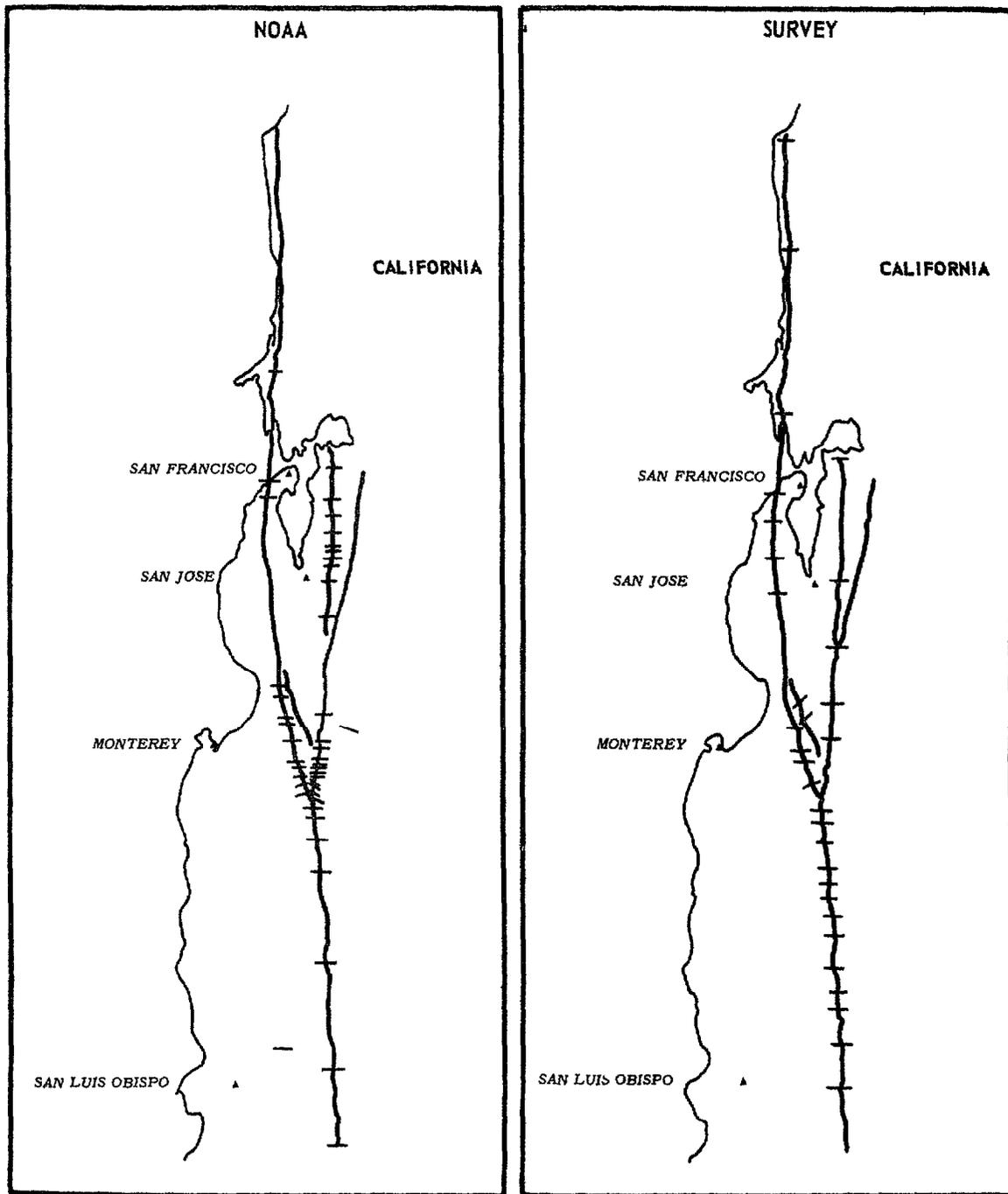
The alignment arrays of both organizations are located primarily in northern and central California, as illustrated by the map on the following page.

Tiltmeters

Both NOAA and Survey have tiltmeter stations to record earth deformations by measuring tilting of the earth's surface. NOAA and Survey did not exchange data from these stations and did not coordinate the development of the instrumentation.

NOAA has one tiltmeter station containing three tiltmeters located at Stone Canyon, near Hollister, Calif. The tiltmeters were developed and installed in 1966 by a contractor at a total cost of \$9,600. NOAA has also established three tiltmeter stations in the Aleutian Islands for conducting strain studies sponsored by AEC.

LOCATION OF ALIGNMENT ARRAYS OF NOAA AND THE SURVEY
APRIL 1971



LEGEND
— ALIGNMENT ARRAY
— MAJOR EARTHQUAKE FAULT

0 50
MILES

Survey has installed 12 tiltmeters at four stations in the San Francisco Bay area. These instruments were developed in-house and installed by Survey at a cost of approximately \$2,000 each, a total cost of \$24,000 for all stations.

Congressional interest
in eliminating duplication

The intent of the Congress to minimize or prevent duplication and overlapping in earthquake studies conducted by NOAA and Survey was indicated by the comments of the Chairman, Subcommittee on the Interior and Related Agencies, House Committee on Appropriations.

In hearings before the Subcommittee on the Departments of State, Justice, and Commerce, the Judiciary, and Related Agencies, House Committee on Appropriations, for fiscal year 1966, NOAA proposed a program of investigation to establish and conduct a comprehensive seismological and related geophysical study of earthquakes. This study was to include periodic measurements and continuous monitoring of a variety of measurable properties (gravity, magnetic, radioactive, thermal, acoustic, and seismic) to determine their diagnostic influences on predicting future occurrences of earthquakes. The San Andreas fault in California was proposed as an ideal natural laboratory for such a geophysical study.

Subsequently, Survey, during its fiscal year 1966 hearings before the Subcommittee on the Department of the Interior and Related Agencies, House Committee on Appropriations, proposed to use the San Andreas fault zone as a model for carrying on exhaustive integrated geological and geophysical field and laboratory investigations.

The proposed study was to get an understanding of the processes involved in earthquakes and ultimately to be able to predict earthquake occurrences. The Subcommittee Chairman commented that NOAA had requested to conduct research on the same problem in the same area and questioned whether there was a duplication of effort. The then-Director of Survey replied that particular effort had been made to insure coordination and that the programs Survey had underway

or proposed on earthquake studies in no way duplicated the programs proposed by NOAA.

Survey's appropriation hearings for fiscal year 1970 were held before the same Subcommittee. Survey's budget for that year included \$150,000 for an earthquake action program. The first part of this action program was to set up an advisory committee to outline a Government-wide program to reduce earthquake hazards and to recommend the necessary supporting research. The Subcommittee Chairman asked whether the advisory group was to insure that there would be no overlapping or duplication of effort. The then-Director of Survey informed the Subcommittee that the primary intent of the advisory committee would be to insure that there would be no unwarranted duplication. The advisory committee's report entitled "Earthquake Hazard Reduction" was published in 1970; however, it does not include a discussion of overlapping or duplication of effort.

Limited exchange of data
between NOAA and Survey

NOAA and Survey officials have informed us that exchange of research raw data accumulated by NOAA and Survey would be beneficial to their research work. Our review, however, indicated that EML and OERCS did not regularly exchange basic research raw data nor coordinate their research activities.

The Director of EML stated that Survey was allowed free access to its research records but that it had been a "one-way street" because Survey had not been responsive in providing data to EML. He explained that Survey's data pertaining to creep, strain, and tilt were not readily available to EML because of Survey's reluctance to release the data before its findings were published.

The Chief of OERCS has informed us that the exchange of Survey's research data with NOAA would be beneficial to both agencies but that the data was not exchanged because of the distance (35 miles) and poor lines of communications between the two agencies. The Chief stated also that traditionally there was free exchange of information and raw data in the field of seismology but that when data had been used for current studies it had been "inconvenient" to provide the data while the scientist was conducting his research. We believe that this reluctance to release research raw data was due to the professional importance that was attributed to published findings and the fact that Survey was trying to establish a position of leadership in the field of earthquake research.

At the beginning of our review, in a discussion with the Chiefs of EML and OERCS regarding the exchange of data between the two agencies, we were informed that no microearthquake data had been exchanged. Shortly thereafter, however, OERCS began obtaining EML's microearthquake data.

We noted several incidents when the failure of NOAA and Survey to coordinate their research activities resulted in competition for funding for similar programs. For example, in August 1970, NOAA approved a plan entitled "Subprogram Plan for Seismological and Geomagnetic Observatories" which provided for a large increase in its seismograph network.

The Chief of OERCS in a letter to a member of the Committee on Seismology of the National Academy of Sciences recommended that the committee not endorse NOAA's plan without additional review. He informed us that, even though NOAA's plan did not conflict with Survey's studies, he took this position because of the limited funds available for earthquake research. He explained that the committee's support of NOAA's plan could lead to a decrease in the amount of funding available to Survey and adversely affect its ability to develop its programs.

The Chief of OERCS stated that NOAA and Survey were in direct competition for the funding provided by other Federal agencies and that this competition had adversely affected Survey's earthquake research program. He explained that the development of Survey's program was heavily dependent on the support from other Federal agencies and that the program would be stifled if such funding were provided to NOAA rather than to Survey.

The existence of competition between NOAA and Survey is further borne out by the following comment in a NOAA draft program summary prepared in 1969.

"There is no clear policy from the Congress or this Administration on the matter of which Government organization is to play the lead role in studying the 'solid' earth portions of man's environment. *** ESSA [NOAA] has strong capability in these areas and should be considered a prime candidate to lead the studies of earthquakes as an environmental hazard. It should be recognized, however, that the U. S. Geological Survey of the Department of Interior is a strong competitor for this role."

Advisory groups recognized
the need for coordination

Most of the advisory study groups recognized the need for improved coordination among the Federal agencies involved in earthquake research and recommended that a coordinating group be established to direct the earthquake activities of the Federal Government. Some of the advisory

groups recommended also that the coordinating group be independent of the Federal agencies involved. Pertinent comments by some of the advisory groups are presented below.

The Interagency Working Group for Earthquake Research in its report of 1968 (see p. 13) stated that:

"Much greater coordination of even the existing program must be effected. Five departments and two independent agencies support earthquake research. Scientists communicate on the personal level, through symposia and other meetings, and through publications. However, this is inadequate to effect policy making or program planning and implementation.

"*** there is need for expansion and stronger coordination of Federally supported earthquake-research programs."

The Interagency Working Group recommended:

"Establishment of a permanent coordinating and guidance group.

"The coordinating and guidance group will be responsible for:

- "a. Formulating a National program in earthquake research and providing a focal point for information on the program.
- "b. Continually appraising the adequacy of the National Earthquake Hazards program, identifying missing elements, and recommending appropriate action.
- "c. Analyzing existing distribution and level of funds and assessing the progress toward defined objectives."

The Committee on Seismology of the National Research Council in its report of 1969 (see p. 14) recommended that

"*** a group be formed at an appropriate level in the executive branch of the federal government specifically to provide an authoritative base for augmentation of worthwhile programs, to formulate and implement new programs, and to determine the level of support required for programs involving seismology that are essential to the achievement of prescribed national goals."

The Task Force on Earthquake Hazard Reduction in its report "In the Interest of Earthquake Safety" in 1971 (see p. 15) stated that:

"*** existing knowledge is not being utilized effectively. We lack appropriate and responsive public policies, based on the best information available, and we lack dependable machinery to implement such policies."

"*** pending implementation of an appropriate reorganization, establishment of a knowledgeable interdisciplinary advisory group would appear essential. The advisory group could review the Federal agencies, in order to help avoid unjustifiable duplication." (Underscoring supplied.)

Comments on and proposal for reorganization

Many Federal agency officials and scientists involved in earthquake research expressed the belief that, under the diversified program of earthquake research, duplication and overlap of activities and competition for funding existed between agencies which could have been eliminated and the programs made more effective by a unified program of earthquake research under a single organization.

The Committee on Seismology in its 1969 report proposed the establishment of a national program in seismology and stated that:

"Maximum effectiveness in achieving these [National] goals may require the combined efforts of several agencies, and even the reorientation or redistribution of effort by the agencies."

The Task Force on Earthquake Hazard Reduction in its 1971 report "In the Interest of Earthquake Safety" stated that:

"The present multiplicity of agencies poses administrative problems that could be substantially reduced if several of the competing entities were merged."

On March 25, 1971, the President transmitted to the Congress his plan for the reorganization of seven executive departments and several independent agencies. The President proposed the establishment of a department of natural resources and the transfer to it of certain responsibilities of NOAA and Survey. The transmittal contained the statement that in some earthquake activities NOAA and Survey conducted similar and sometimes overlapping operations and that this duplication should be eliminated by bringing certain responsibilities of the two organizations together. Several bills have been introduced in the Congress to create the proposed department; however, no action had been taken on the bills as of July 1, 1972.

Agency actions to improve coordination

In May 1970 NOAA and Survey established an Interagency Committee for Program Coordination to examine related activities within the full range of interface between the two agencies in programs as diverse as earthquake, marine geophysics, hydrology, mapping and charting, and geodetic surveys. This committee was specifically charged with arranging for cooperation and mutual support of related programs and with providing for the exchange of data and findings of mutual concern.

In February 1972 NOAA and Survey established the Joint NOAA-Survey Committee on Earthquake Hazards Reduction (1) to identify programs within the missions and competence of the two agencies which should be jointly undertaken to meet recognized need for information and research, (2) to inventory present and proposed programs of the two agencies designed to meet these needs and to develop mechanisms to insure optimum integration and coordination between the two agencies with free exchange of program plans and resulting data, (3) to develop mechanisms to integrate NOAA and Survey programs with those of other Federal agencies, State and local governments, academic institutions, and private industry, and (4) to formalize mechanisms to coordinate investigations following future major earthquakes.

NSF informed us in April 1972 that during the past several months there had been informal coordination of activities in the earthquake engineering area. Representatives from NSF, HUD, NBS, and Office of Emergency Preparedness have been meeting to formulate a jointly funded and jointly managed program in that area.

CHAPTER 4

CONCLUSIONS, RECOMMENDATIONS,

AND AGENCY COMMENTS

CONCLUSIONS

A national program in earthquake research operated under basic management controls is needed to achieve the maximum benefit from the use of Federal funds for earthquake research. The national program should establish goals and priorities, define agency responsibilities, and provide for a high degree of coordination among the agencies conducting earthquake research. We believe that the fragmentation of Federal responsibility and the lack of national goals have made it extremely difficult for the various Federal agencies supporting earthquake research to launch a coordinated attack on the Nation's earthquake problem and to obtain maximum benefit from available resources.

A permanent interdisciplinary coordinating and guidance group, independent of the involved agencies, is needed to provide guidance and assistance in conducting earthquake research activities. We believe that the complexities comprising earthquake research require continuous comprehensive planning and assessment of research activities on an overall Federal level. The Federal agencies' lack of effective coordination of their research activities has resulted in competition for funding for similar activities, limited exchanges of data, and duplication and overlapping of research effort.

OMB is responsible for insuring that Federal agency programs are coordinated and that the funds appropriated by the Congress for the programs are spent in the most economical manner with the least possible duplication and overlapping of research effort. NOAA and Survey officials informed us that OMB had not provided direction of their earthquake research activities.

The President's plan for reorganization of the executive departments, if approved by the Congress, would provide

opportunities for reducing the existing duplication and overlapping of earthquake research. We believe, however, that, in the interim, steps should be taken to define Federal earthquake research program goals and the responsibilities of the Federal agencies for achieving those goals.

RECOMMENDATIONS TO THE
DIRECTOR, OMB

We recommend that OMB:

- Establish goals and priorities for a national earthquake research program.
- Establish criteria by which to judge the effectiveness of the program to achieve the goals.
- Define and reassign, if appropriate, the responsibilities of all Federal agencies involved in earthquake research.
- Establish a permanent coordinating group, independent of agencies involved, to provide guidance and assistance in conducting the Nation's program.
- Monitor agency earthquake research activities to insure the coordination of these activities and the most effective use of available resources.

AGENCY COMMENTS

Comments on our draft report were received from the following agencies:

Office of Management and Budget
Office of Science and Technology
Department of Commerce
Department of the Interior
Advanced Research Projects Agency, DOD
Atomic Energy Commission
Department of Housing and Urban Development
National Science Foundation

These agencies were in general agreement that a national earthquake research program should be established and that a high degree of coordination of research activities was essential. On the basis of these comments, we have made certain revisions to the report. The comments of OMB and OST on our recommendations are included as appendixes V and VI. From the joint comments by the Departments of Commerce and the Interior, we have extracted, and have included as appendixes III and IV, their detailed comments on the history of their studies of earthquakes.

OFFICE OF MANAGEMENT AND BUDGET

OMB commented that the President's budget for fiscal year 1973 provides for a substantially expanded earthquake research program by requesting \$25 million compared with \$12 million in 1972. OMB stated that the principal goals of the program in order of priority are as follows:

"Improve knowledge of the risk of destructive earthquakes in particular locations, and of the nature and extent of the destruction which may result, based on various geologic conditions. Develop detailed seismic risk maps and geologic hazards maps for use in decisions on land use, design of structures, and emergency preparedness.

"Develop economically acceptable designs for structures and construction methods to minimize damage from earthquake hazards. It is expected

that this research effort will lead to development of improved design criteria, and construction codes and standards for use in areas of seismic risk.

"Determine the feasibility of predicting earthquakes. This effort will involve extensive study of microearthquakes, ground tilt, earth strain and other geophysical phenomena to determine whether there is a regular pattern of detectable events leading up to an earthquake.

"Determine the feasibility of limiting the maximum size of earthquakes by initiating small movements along fault zones to avoid the accumulation of strain which may result in a large earthquake. The research will include an analysis of the costs and benefits of any feasible control methods, as well as analysis of the social and legal implications of such control."

OMB commented also that attention would be given to developing criteria for evaluating the effectiveness of earthquake research programs and that the criteria would be established by the agencies involved in earthquake research in consultation with the Executive Office of the President. In addition, agency responsibilities for carrying out earthquake research programs would be defined as part of the broader effort of developing the detailed program plans for the expanded research effort and would be assigned by the Executive Office of the President.

OMB stated that it might be desirable to establish a group, independent of the agencies involved in earthquake research, to evaluate the effectiveness of the agencies' efforts and to provide advice to the Executive Office of the President and to the agencies regarding such matters as changes in national goals, improvements in coordination efforts, or improvements in agency program management. OMB stated also that the types of mechanisms or arrangements needed for planning, directing, coordinating, and evaluating the Federal earthquake research program would be studied in depth.

OMB stated that it would, with the assistance of OST, monitor agency earthquake activities to insure the most effective use of available resources.

OMB stated its belief that the expanded earthquake research program proposed in the President's 1973 budget, and the related actions which had been or soon would be taken to implement that program, would correct the problems noted in this report and largely fulfill our recommendations.

The 1973 budget request provides for a greater commitment of resources to earthquake research. We believe, however, that carrying out OMB's plans for establishing program objectives and related priorities and evaluation criteria, defining agency roles and responsibilities, and establishing an independent coordinating group are essential for achieving a coordinated national earthquake program.

NOAA AND SURVEY

NOAA and Survey collaborated in responding to our draft report and provided joint comments. The two agencies agreed on the importance of a national earthquake research program and on the value of an interdisciplinary coordinating group.

NOAA and Survey commented that they had accepted the 1970 report of the OST Task Force on Earthquake Hazards Reduction as an outline of a de facto national program and that we should have given greater recognition to that report as a comprehensive statement of goals and priorities of the national program.

We observed, however, that, although the various agencies had based their justification for the initiation or expansion of certain earthquake research activities on selected advisory committee recommendations, they had not adopted recommendations regarding other activities because their expertise did not extend to those areas. We believe that an established national program, in lieu of a de facto program, would provide for a more comprehensive and balanced approach to meeting earthquake research needs. In May 1972 NOAA introduced legislation to establish such a national program.

NOAA and Survey concurred that a high degree of coordination in earthquake hazards reduction programs was essential and agreed that there had been some problems in coordination of their field efforts in earthquake research in California. Although the agencies considered the magnitude of the problem to be smaller than implied in this report, they expressed concern about similar potential problems that might arise and stated that several steps had been taken. (See p. 50.)

In commenting on duplication and overlapping, NOAA and Survey observed that parallel attack did not necessarily constitute wasteful duplication of effort. They stated that:

"Problems of earthquakes, their effects on man, and steps that can be taken to reduce loss of life and property, are complex, difficult to solve, and of sufficient national urgency that all reasonable approaches must be investigated concurrently."

We have recognized that parallel research is sometimes necessary and appropriate to the achievement of important goals but are of the view that such research must be planned and coordinated to derive maximum benefit from the applied resources. As pointed out in this report, the limited coordination by NOAA and Survey of their earthquake research has prevented them from obtaining the maximum benefits from the applied resources. Limited coordination has resulted in duplication and overlapping and in competition for funding for NOAA's and Survey's individual programs.

ADVANCED RESEARCH PROJECTS AGENCY

The Director of ARPA stated that he was in complete agreement with the major conclusions that a national program in earthquake research is needed, that a permanent interdisciplinary coordinating and guidance group should be established, and that OMB should insure that the programs of the agencies involved are coordinated. The Director commented that the lack of a technical and administrative plan was the most serious obstacle to a successful program, more serious than the presently apparent duplication of efforts.

CHAPTER 5

SCOPE OF REVIEW

The principal objectives of our review were to obtain information on Federal earthquake research, to identify opportunities for improvement in the administration of the research, and to make observations relating to the management of federally funded earthquake research. We reviewed the earthquake research activities of various Federal agencies with particular emphasis on three objectives.

1. Evaluation of the selection of research projects.
2. Evaluation of the coordination among agencies in planning earthquake research.
3. Identification of research areas that contain duplication and overlap.

Our review was limited to those research projects and supporting services individually identified by each agency as earthquake research. Our review included an examination of legislative history and pertinent regulations and records; interviews with responsible management officials at the various Federal agencies, including OST and OMB; and interviews with recognized authorities outside the Federal Government.

Our review was performed at the offices of various Federal agencies in the Washington, D.C., area and at several locations in the States of Alaska, Washington, and California. Our examination at some of the agencies was limited in scope and did not include work to meet all the review objectives.

The following agencies were included in our review.

Atomic Energy Commission
Department of Commerce:
 National Bureau of Standards
 National Oceanic and Atmospheric Administration
Department of Defense:

Corps of Engineers
Advanced Research Projects Agency
Department of Housing and Urban Development
Department of the Interior.
Bureau of Mines
Bureau of Reclamation
Geological Survey
National Aeronautics and Space Administration
National Science Foundation
Office of Management and Budget
Office of Science and Technology

HIGH PRIORITY RECOMMENDATIONS OF THE OST
TASK FORCE ON EARTHQUAKE HAZARD REDUCTION

- A. Significant benefits probably beginning to accrue in the short term (less than 5 years after beginning of recommended action):
- A- 1 Engineered earthquake resistance for new governmental facilities.
 - A- 2 Engineered earthquake resistance for new nongovernmental facilities.
 - A- 3 Seismicity (or risk, or probability) maps.
 - A- 4 Earthquake geologic hazards maps.
 - A- 5 Urban planning to minimize seismic hazard.
 - A- 6 Earthquake hazards abatement in older facilities.
 - A- 7 Cost-benefit studies.
 - A- 8 State and local government role in geologic hazards reduction.
 - A- 9 Federal total plan for immediate response.
 - A-10 Federal responsibility in reconstruction.
 - A-11 Federal responsibility in earthquake insurance.
 - A-12 Strong-motion equipment and analyses.
 - A-13 Full-scale testing.
- B. Significant benefits probably beginning to accrue in the intermediate term (5 to 10 years after beginning of recommended action):
- B- 1 Applied research on seismic design criteria.
 - B- 2 Post-earthquake analyses.
 - B- 3 Fault mapping, dating, and specialized geologic mapping.
 - B- 4 Local seismic networks.
 - B- 5 State responsibility in earthquake hazards reduction.
 - B- 6 Newly discovered hazards and older construction.
 - B- 7 Taxes and tax reform.
- C. Significant benefits probably beginning to accrue mainly in the longer term (10 years or more after beginning of recommended action):
- C- 1 Basic research in earthquake engineering.
 - C- 2 Earthquake prediction research.

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- C- 3 Earthquake control research.
- C- 4 Geodetic research.
- C- 5 Worldwide seismic network continuation.
- C- 6 Tsunami hazard research.
- C- 7 Basic research in seismology.
- C- 8 Basic research on causes and mechanisms of
crustal failure.

DESCRIPTION OF EARTHQUAKE RESEARCH PROGRAMS OF
SELECTED FEDERAL AGENCIES

ATOMIC ENERGY COMMISSION

AEC supports earthquake research as an integral part of major programs in weapons testing, the peaceful uses of nuclear explosives, and the safe siting of nuclear facilities. Many of the research programs are carried out by university researchers, private companies, and consultants; others are contracted to such Federal agencies as NOAA and Survey. AEC's fiscal year 1971 funding for earthquake research totaled \$3.4 million, of which \$1.2 million was provided to NOAA and \$0.5 million to Survey.

DEPARTMENT OF COMMERCE

National Bureau of Standards

NBS conducts research programs to improve design and performance evaluation criteria for building structures, particularly those of factory-produced housing systems. NBS, at the request of the Office of Emergency Preparedness provided a team of investigators to study and report on the structural damage caused by the February 1971 San Fernando earthquake. NBS funding for maintaining its basic capabilities in earthquake research activities totals approximately \$100,000 a year.

DEPARTMENT OF DEFENSE

Advanced Research Projects Agency

ARPA supports earthquake research related to the detection and identification of underground nuclear explosions. ARPA supports also substantial research directed toward evaluating the hazards posed by earthquakes to military installations and developing techniques to control or mitigate these hazards.

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Corps of Engineers

The Corps of Engineers (military and civil) has supported a small program in earthquake engineering as part of its construction program. In fiscal year 1971 the Corps' expenditure for four earthquake engineering projects totaled \$195,000. These projects included studies on the influence of local geology on earthquake damage, earthquake resistance of earth and rockfill dams, structural model test of earthquake effects, and earthquake effects on concrete structures.

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

In fiscal year 1971 HUD sponsored two earthquake research projects. HUD provided \$155,000 to NOAA for support of a research project to reduce earthquake hazards through improvements in land use, building, and insuring practices and provided \$41,700 to Survey for part of a comprehensive 4-year environmental and resource study of the San Francisco Bay area being jointly undertaken by HUD and Survey.

DEPARTMENT OF THE INTERIOR

Bonneville Power Administration

Bonneville Power Administration is concerned primarily with the effects of earthquake on electric-power transmission systems. In fiscal year 1971 it sponsored a study of the seismic capabilities of the design of the high-voltage, direct-current converter station at the Dalles in Oregon--the terminal matching the heavily damaged Sylmar converter station in California. In fiscal year 1972 a new, broader study had been authorized to examine the seismic resistance of other key electric-power transmission facilities with an eye to modifying existing structures where necessary and to specifying basically earthquake-resistant facilities in the future where this would be feasible. The cost of the 1971 study was \$60,000. The cost of the fiscal year 1972 study was \$185,000. Subsequent funding will be based on specific modification recommendations. The goal is to reduce the earthquake hazard to an acceptable level by 1980.

Bureau of Mines

The Bureau is concerned primarily with the hazards caused by seismic vibrations generated by mining operations. Its program includes studies concerned with the interrelationships between seismology and rock mechanics and with applications of seismology to the design and maintenance of excavations. The Bureau had no identifiable earthquake research projects in fiscal year 1971.

Bureau of Reclamation

The Bureau of Reclamation conducts a program of earthquake engineering studies concerned primarily with the effects of earthquake on dams. Its program includes studies of foundation soil stability and rock properties, analyses and actual testings of the response of engineering structures to dynamic loadings, measurements in and around dams and surveillance of dam stability, and placements of instruments in areas where Bureau works are expected to be constructed in the future. In fiscal year 1971 the Bureau supported six research projects which totaled \$129,800.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA has developed techniques for making precise distance and angle measurements over large distances as a result of aerospace research required for satellite orbit determinations and radio astronomy research. NASA has initiated a program in Earth Physics and Physical Oceanography to study methods of using these techniques for making precise measurements for solid earth physics problems, such as earthquake prediction and control. This program is also sponsoring instrument development and field tests to improve the measurement precisions.

OFFICE OF EMERGENCY PREPAREDNESS

This Office assists and advises the President in the coordination and determination of policy for all emergency preparedness activities. It coordinates Federal assistance to States in coping with major disasters, such as earthquakes. The Office arranged for the International Meeting

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on Earthquakes which was held in May 1971 in San Francisco. NOAA is conducting a project for the Office to define what would happen and what the problems would be in case a massive earthquake occurred in San Francisco.

DESCRIPTION AND HISTORY OF EARTHQUAKE ACTIVITIES
OF THE DEPARTMENT OF COMMERCE

U.S. Coast & Geodetic Survey (USC&GS, predecessor to NOAA) involvement in seismology dates from 1905 when, as an unofficial program, the Bureau began operating seismographs at its magnetic observatories.

Seismological investigations were formally recognized by statute in 1914 when the Weather Bureau was given authority to collect and disseminate seismological data. By act of the Congress (H.R.8308), this function was transferred to USC&GS in 1925. Since 1925 NOAA has had a major Federal responsibility for making earthquake and seismological investigations in the United States.

The USC&GS' statutory authority for earthquake investigations was broadened by Public Law 373 enacted by the Eightieth Congress in 1947 to include the whole range of related geophysical studies. NOAA conducts a broad program of earthquake investigations and supporting services with emphasis on reducing the hazardous effects of earthquakes and on providing the data base for a broad national research effort. To alert the public of approaching tsunamis frequently generated by earthquakes around the rim of the Pacific Ocean, NOAA operates the Pacific Tsunami Warning System. This system is operated cooperatively through joint agreements with all nations that border the Pacific Ocean. A regional warning system is operated in Alaska to give rapid warning to that State of tsunamis generated by earthquakes in the Aleutian Islands. Efforts are constantly being made to upgrade both the Pacific and the Alaska warning services through further research and development on the mechanism of tsunami generation, theoretical studies of runup, etc.

To provide a data base for seismological research, NOAA determines the hypocenters of most significant earthquakes in the world (an average of about 6,000 a year) and all significant earthquakes in the United States (an average of about 1,600 a year). This raw data is distributed to all researchers and is used for a wide range of studies, including earthquake zoning and earthquake prediction studies.

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Since 1925 NOAA has routinely gathered damage and intensity data for all damaging earthquakes in the United States. This raw data is distributed to all researchers four times each year through the "Quarterly Seismological Reports" and is summarized annually in the series "United States Earthquakes." This data was the basis for the first seismic-risk map of the United States developed by NOAA in 1948, as well as the revised map published in 1969. The first map was adopted as the basis for earthquake resistant design by the Uniform Building Code in 1952; it was replaced by the revised map in 1970.

The Earth Sciences Laboratories operate a network of strong-motion seismographs that currently consists of almost 1,000 instruments. Approximately 700 of these are in California. Instruments are installed in buildings, dams, bridges, and other engineered structures and in a wide range of geological environments throughout the United States and in Central and South America. These instruments write a time record of the response (acceleration or displacement) of structures or geologic environments to earthquake-generated motions. Copies of the recordings are routinely distributed to all researchers. They are the basis of research in earthquake-resistant design of structures and thus are critical to the improvement of the earthquake provisions of local and national building codes.

NOAA conducts a multidisciplinary program in seismic-risk mapping of the United States which depends heavily on data from the strong-motion seismograph network, earthquake-damage surveys, soil amplification studies and other related research projects.

NOAA's geodetic survey program along the San Andreas Fault System dates from 1855. Following earthquakes in this area in 1868, it was recognized that significant information about deformation in earthquake zones could be obtained from repeat measurements of the movement of the geodetic monuments. The geodetic network spanning the length of the San Andreas Fault System was completed before 1900. Repeat measurements in selected areas were made following the San Francisco earthquake of 1906, and the network covering the overall system was reobserved in 1922 and 1923. Since then the network has been expanded into subregions of the fault

system, and systematic repeat surveys have been made at intervals ranging from 1 to 15 years. These measurements coupled with periodic measurement of vertical changes, continuous polar-motion measurements, and research studies of plate tectonic and global geophysics provide a suite of measurements ranging from annual fault slippage at specific locations through regional changes in fault subsystems.

This data is used for research within NOAA and is made available to other agencies having direct interest, as well as to universities and private research groups. Such data, in the form of special services and published reports, provides the parameters required for programs, such as the California Aqueduct System, the San Francisco Bay Rapid Transit System, and urban development in regions of extreme subsidence. NOAA has the responsibility for coordinating all geodetic surveys made by other Federal agencies, including the crustal-movement studies made by or funded by Federal agencies.

The Earth Sciences Laboratories conduct special earthquake research studies related to the San Andreas fault at its EML. EML, previously known as Advanced Seismic Experiments Group, was formed in February 1964, and has occupied its present quarters in San Francisco since December 1964. Its function includes the study of the earth's internal structure and the mechanisms that cause earthquakes. EML conducts extensive research on creep along the San Andreas fault and conducts a broad program in measuring strain fields in Nevada, California, and particularly in the Aleutian Islands. The strain program is in cooperation with AEC and some universities.

NOAA provides seismological information needed by other Federal agencies, State agencies, and regional and local regulatory authorities in conducting the programs and conducts research in supporting the programs. As an example, NOAA recently developed a method of computing economic losses in earthquakes that served as the technical basis for the HUD report to the Congress of the feasibility of a national program of earthquake insurance. NOAA has cooperated with the Office of Emergency Preparedness in the development of its Emergency Preparedness Plan by estimating the likely effects of large earthquakes in various parts of the United

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States. NOAA provides expert advice to AEC in its Nuclear Reaction Siting Program. NOAA operates the strong ground-motion measurement program for AEC both at its Nevada test site and more recently at the testing area in the Aleutian Islands.

NOAA, in addition to its working agreements with public agencies, collaborates with universities and nonprofit groups, such as the Earthquake Engineering Research Institute, to focus its research on both the immediate and long-range public needs.

DESCRIPTION AND HISTORY OF EARTHQUAKE ACTIVITIES
OF THE DEPARTMENT OF THE INTERIOR

The Geological Survey was created in 1879 by an act of Congress and was charged, among other things, with examining the geologic structure of the national domain. Since then the Survey program has spanned the whole realm of earth sciences, and it interfaces with the area of earthquake engineering. The seismic and geodetic aspects are components of an integrated program encompassing geophysics and geology. The study of geologic hazards, including those of earthquakes, has been a longstanding concern of Survey, and the talents of research scientists in many different fields of earth science are directed toward solution of a broad spectrum of problems that range from earthquake prediction to the defining of the effects of earthquake shock in specific areas.

Early efforts in seismology by Survey's scientists included investigations on the great 1886 earthquake of Charleston, S.C.; the 1906 earthquake in California; and the 1811-12 earthquake at New Madrid, Mo. (investigated and reported on in 1912), and, since then, many significant earthquakes in the United States have been reported on by Survey's scientists.

Since the turn of the century, Survey's scientists have played a major role in the geologic and geophysical analysis of active tectonic belts of Western North America, including such active earthquake faults as the San Andreas Fault. Many of the early fundamental studies of the San Andreas Fault were started by Survey's scientists shortly after the First World War. The work continued and expanded, leading to present concepts of large earth shifts, estimates of earthquake probability and recurrence, and preparation of maps of active fault strands for land-use planning.

Earth's crust and upper mantle studies by refraction seismology, heat-flow studies concerned with earthquake-driving mechanisms, landmark studies of the reversals of the earth's magnetic poles as revealed by paleomagnetism, laboratory studies of rock mechanics, and aeromagnetic mapping,

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all contributed fundamentally to the great breakthrough in the earth sciences in the 1960s known as the New Global Tectonics

Survey was responsible for synthesizing and publishing the tectonic map of North America which was made possible only by employing the vast accumulation of geological and geophysical information gathered over the decades

Subbottom acoustical profiling within the marine geology program of Survey has been employed to map active faults on the continental shelf to provide data for evaluating seismic hazards of coastal sites for nuclear reactors.

In 1924 Survey took over the research program of the Hawaiian Volcano Observatory (HVO) and employed seismic instruments with tiltmeters to analyze volcanic activity and related seismicity. Since then, the study of microearthquakes has been a technique commonly employed by Survey's scientists to analyze geologic structures and processes ranging from active faults, sources of geothermal energy, mine-tunnel failures, to volcanism. In the mid-1950s techniques of employing local seismic nets and tiltmeters at HVO were improved by Survey and led to successful prediction of eruptions of Kilauea volcano.

The seismic and related geophysical studies of Survey were expanded in the 1960s to serve the Project VELA Uniform program of ARPA, and after the successful completion of that program, the expanded capabilities were refocused on studies of the earth's upper mantle and natural earthquakes. Geophysical staff was moved from Denver, Colo., to Menlo Park to be brought together with geologic staff, and the combined effort became NCER by proclamation of the Secretary of the Interior in 1965.

The geologic hazards of earth failure--including landslides, mudflows, liquefaction, land spreading, and differential subsidence--are greatly amplified during earthquakes and have been subjects of continuing research in the engineering geology program aimed at developing techniques and criteria for the recognition of hazards and at delineating on maps the areas underlain by such hazardous deposits. The first major physical environmental study of an urban

area to be concerned with delineating geologic hazards for urban and regional land-use planning was launched in 1969 by Survey with partial support by HUD

The seismological and geological capabilities of Survey have been increasingly utilized during the past 10 years by many other agencies, including AEC, HUD, ARPA, Veterans Administration, Office of Emergency Preparedness, NASA, and State and local governments. Survey's scientists have examined the results of many earthquakes in other parts of the world in collaboration with international organizations, such as the Central Treaty Organization and the United Nations Educational, Scientific, and Cultural Organization. Close involvement with universities, including part-time employment of professors, has been traditional, and programs of postdoctoral fellowships and visiting scientists have perpetuated strong liaison with scientific research throughout the world. The strength of the Survey program in earthquake research and the reason Survey is called upon by other agencies rest basically on the wide diversity of research talent in the earth sciences available to attack all aspects of the problem.

APPENDIX V

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON D C 20503

APR 20 1972

Mr. A.T. Samuelson
Director, Civil Division
General Accounting Office
Washington, D.C. 20548

Dear Mr. Samuelson:

We have reviewed your draft report on The Need for a National Earthquake Research Program, and we appreciate the opportunity to comment.

As you may know, the President's 1973 Budget provides for a substantially expanded earthquake research program, and your draft report provides information which will be helpful to the Executive Office and the agencies in implementing these program plans.

We have the following comments on the specific "recommendation or suggestions" included in the report:

1. Recommendation

The Office of Management and Budget should establish national goals and priorities for a Federal earthquake research program

OMB Comment

The President's Budget for FY 1973 provides for the development of a comprehensive earthquake research program. In summary, the principal goals of the program are as follows, in order of priority:

- Improve knowledge of the risk of destructive earthquakes in particular locations, and of the nature and extent of the destruction which may result, based on various geologic conditions. Develop detailed seismic risk maps and geologic hazards maps for use in decisions on land use, design of structures, and emergency preparedness.
- Develop economically acceptable designs for structures and construction methods to minimize damage from earthquake hazards. It is expected that this research effort will lead to development of improved design criteria, and construction codes and standards for use in areas of seismic risk.

- Determine the feasibility of predicting earthquakes. This effort will involve extensive study of micro-earthquakes, ground tilt, earth strain and other geophysical phenomena to determine whether there is a regular pattern of detectable events leading up to an earthquake.
- Determine the feasibility of limiting the maximum size of earthquakes by initiating small movements along fault zones to avoid the accumulation of strain which may result in a large earthquake. The research will include an analysis of the costs and benefits of any feasible control methods, as well as analysis of the social and legal implications of such control.

The 1973 Budget requests a total of approximately \$25 million for these programs, compared to about \$12 million in 1972 for research efforts in these areas.

2. Recommendation

The Office of Management and Budget should establish criteria by which to judge the effectiveness of the Government's program to achieve national goals.

OMB Comment

In developing the detailed program plans for the expanded earthquake research program provided for in the President's 1973 Budget, attention will be given to developing criteria for evaluating the effectiveness of the programs in achieving the objectives. The evaluation criteria will be established by the agencies in consultation with the Executive Office of the President, including the Office of Science and Technology, the Office of Emergency Preparedness and the Office of Management and Budget.

3. Recommendation

The Office of Management and Budget should define and reassign, if appropriate, the responsibilities for all Federal agencies that provide financial support or conduct earthquake research.

OMB Comment

Agency responsibilities for carrying out earthquake research programs are being defined as part of the broader effort of developing the detailed program plans for the expanded earthquake research effort. The National Science Foundation has

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been assigned the principal responsibility for accomplishing the goal of developing economically acceptable designs for structures to minimize damage from earthquakes. The U S. Geological Survey has the principal responsibility for determining the feasibility of limiting the maximum size of earthquakes.

It is anticipated that as part of developing the detailed plans for the expanded program, principal agency responsibility will be assigned for each of the major goals. Also, several agencies will have supporting roles in the program, and appropriate cooperative and coordinating mechanisms will be established.

These assignments and coordinating arrangements will be established by the Executive Office of the President, in consultation with the agencies.

4 Recommendation

The Office of Management and Budget should establish a permanent coordinating group independent of agencies involved to direct the Federal program.

OMB Comment

We believe it is not feasible or desirable to have a group independent of agencies involved to "direct" the Federal program. As program goals are established, and agencies' responsibilities determined, each responsible agency must direct its own research efforts. Also, the coordination of efforts among agencies toward established goals must include the participation of the responsible agencies.

It may be desirable to establish a group independent of the agencies involved to evaluate the effectiveness of agencies' efforts and to provide advice to the Executive Office of the President and the agencies regarding matters such as changes in national goals, improvements in coordination efforts, or improvements in agency program management. The types of mechanisms or arrangements needed for planning, directing, coordinating and evaluating the Federal earthquake research programs will be studied in depth as part of the effort to implement the program requested in the President's 1973 Budget. In any event, the Office of Science and Technology and the Office of Management and Budget will be working closely together to monitor the programs of the agencies to help ensure that the national goals are achieved effectively and efficiently

5. Recommendation

The Office of Management and Budget should monitor agency activities to ensure the coordination of earthquake research programs, and the most effective use of available resources

OMB Comment

As stated in response to the previous recommendation, the Office of Management and Budget, with the assistance of the Office of Science and Technology, will be monitoring agency earthquake research activities to help ensure the most effective use of resources.

In summary, we believe that the expanded earthquake research program proposed in the President's 1973 Budget, and the related actions which have been or soon will be taken to implement that program, will correct the problems noted in the report and largely fulfill the proposed recommendations of the report. We believe the draft report should be revised to note these recent actions by the Administration.

As we proceed with the implementation of these new or expanded earthquake research programs, we expect that the findings and recommendations of the GAO report will be of significant value.

Sincerely,



Director

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY
WASHINGTON D C 20506

March 23, 1972

Dear Mr. Samuelson

Thank you for the opportunity to comment on the GAO's Draft Report to the Congress of the United States, "Need for a National Earthquake Research Program " This does indeed represent an extensive study of the problem, one that required considerable effort and time to compile.

As a matter of fact, some of the problems uncovered have been recognized and to some extent acted upon by the agencies concerned, in the interim between the compiling of the information and the issuance of the draft report Thus the report is not completely up to date, although much of its basic thrust remains valid

As an example, the U. S. Geological Survey and the National Oceanic and Atmospheric Administration have recently formed a Joint Earthquake Hazards Reduction Committee at the program manager level If effective, and we should assume that it will be until we have evidence to the contrary, this Committee should at least improve coordination of the implementation of the USGS and NOAA earthquake research programs, a need recognized by both agencies

The formation of this Committee is a step in the right direction, but we entertain some doubt that it will prove to be adequate especially in view of the anticipated expansion of the overall program. While it may promote coordination of program implementation, better coordination of the programs themselves will likely be required at a higher policy level. Furthermore, the Committee does not yet, we understand, include representation from the National Science Foundation, which sponsors a major portion of the overall program, nor from other interested agencies, such as the Office of Emergency Preparedness, the civil engineering functions of the Department of Defense, or the Advanced Research Projects Agency.

This Office has the following comments on the Recommendations or Suggestions presented on page 5 of the draft report.

"OMB should establish national goals and priorities for a federal earthquake research program "

This has just been done by the Executive Office of the President and the agencies concerned, in the course of developing the FY'73 budget Goals for programs of research in earthquake engineering, prediction, and control have been formulated, and are included in the President's Budget for FY'73. The principal agencies involved are USGS, NOAA, and NSF. The program will, of course, be subject to continuing review

"OMB should establish criteria by which to judge the effectiveness of the government's program to achieve national goals "

This is a normal function of OST in the area of significant R and D programs. The mechanisms by which this responsibility is carried out depend upon the size and nature of the program, and upon the complexity of interagency relationships involved. If the growth or complexity of the earthquake research program should warrant it, consideration will be given to the formation of a special review and coordinating structure, possibly under FCST sponsorship

"OMB should define and reassign, if appropriate, the responsibilities for all Federal Agencies that provide financial support or conduct earthquake research "

This is a recognized problem. It is under study and is expected to be resolved prior to the commencement of the FY'73 proposed program. An ad hoc subcommittee of the President's Science Advisory Committee has been appointed to advise us in the resolution of the problem.

"OMB should establish a permanent coordinating group independent of agencies involved to direct the Federal program. "

We do not believe that this would be a feasible management technique. A coordinating group does not direct, and a management group cannot be independent of that which is being managed.

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"OMB should monitor agency activities to ensure the coordination of earthquake research programs, and the most effective use of available resources."

This recommendation is closely related to the first three, as a means for their continuing implementation. The monitoring and review function with respect to R and D programs is a normal responsibility of OST, in collaboration with OMB and other offices as appropriate, such as OEP in this instance. As noted earlier, consideration will be given by this Office to the formation of an appropriate review structure, in view of the anticipated growth in size and complexity of the earthquake program. Lead responsibilities for the major phases of the program will be assigned as appropriate. Our analysis and comments have been coordinated with those of OMB

Sincerely,



John D Baldeschwieler
Acting Director

Mr A. T Samuelson
Director
Civil Division
United States General Accounting Office
Washington, D. C. 20548

PRINCIPAL OFFICIALS OF GOVERNMENT AGENCIES
RESPONSIBLE FOR ADMINISTRATION OF ACTIVITIES
DISCUSSED IN THIS REPORT

	Tenure of office	
	From	To
<u>DEPARTMENT OF COMMERCE</u>		
SECRETARY OF COMMERCE:		
Peter G. Peterson	Feb. 1972	Present
Maurice H. Stans	Jan. 1969	Feb. 1972
UNDER SECRETARY OF COMMERCE:		
James T. Lynn	Apr 1971	Present
Rocco C. Siciliano	Feb. 1969	Apr. 1971
ADMINISTRATOR, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (note a):		
Robert M. White	Feb. 1971	Present
Robert M. White (acting)	Oct 1970	Feb 1971
Robert M. White	July 1965	Oct. 1970
DEPUTY ADMINISTRATOR:		
Howard W. Pollack	Feb. 1971	Present
Robert M. White (acting)	Oct. 1970	Feb. 1971
John W. Townsend, Jr.	July 1968	Oct. 1970
<u>DEPARTMENT OF THE INTERIOR</u>		
SECRETARY OF THE INTERIOR:		
Rogers C. B. Morton	Jan. 1971	Present
Fred J. Russell (acting)	Nov. 1970	Jan. 1971
Walter J. Hickel	Jan. 1969	Nov. 1970
ASSISTANT SECRETARY (MINERAL RESOURCES):		
Hollis M. Dole	Mar. 1969	Present

APPENDIX VII

		<u>Tenure of office</u>	
		<u>From</u>	<u>To</u>

DEPARTMENT OF THE INTERIOR (continued)

DIRECTOR, GEOLOGICAL SURVEY:

Vincent E. McKelvey	Dec. 1971	Present
William A. Radlinski (acting)	May 1971	Dec. 1971
William T. Pecora	Sept. 1965	May 1971

OFFICE OF MANAGEMENT AND BUDGET (note b)

DIRECTOR

Caspar W. Weinberger	June 1972	Present
George P. Shultz	July 1970	June 1972
Robert P. Mayo	Jan. 1969	July 1970
Charles J. Zwick	Jan. 1968	Jan. 1969

DEPARTMENT OF DEFENSE

SECRETARY OF DEFENSE

Melvin R. Laird	Jan. 1969	Present
Clark M. Clifford	Mar. 1968	Jan. 1969

DIRECTOR, ADVANCED RESEARCH

PROJECTS AGENCY:

Dr. Stephen J. Lukasik	Apr. 1971	Present
Dr. Eberhardt Rechtin	Nov. 1967	Dec. 1970

ATOMIC ENERGY COMMISSION

CHAIRMAN:

Dr. James R. Schlesinger	Aug. 1971	Present
Dr. Glenn T. Seaborg	Mar. 1961	Aug. 1971

DEPARTMENT OF HOUSING AND URBAN
DEVELOPMENTSECRETARY OF HOUSING AND URBAN DE-
VELOPMENT (Formerly Administra-
tor, Housing and Home Finance
Agency)

George W. Romney	Jan. 1969	Present
Robert C. Wood	Jan. 1969	Jan. 1969
Robert C. Weaver	Feb. 1961	Dec. 1968

<u>Tenure of office</u>	
<u>From</u>	<u>To</u>

NATIONAL SCIENCE FOUNDATION

DIRECTOR:

H. Guyford Stever	Feb. 1972	Present
Raymond L. Bisplinghoff (acting)	Jan. 1972	Feb. 1972
William D. McElroy	July 1969	Jan. 1972

^aThe agency was established effective October 1970 pursuant to Reorganization Plan No. 4. The reorganization consolidated the Environmental Science Services Administration with elements and programs of other Federal organizations that have marine science responsibilities.

^bOn July 1, 1970, the Bureau of the Budget became the Office of Management and Budget.

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