UNITED STATES

DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Office of Earthquake Studies

PROCEEDINGS OF

CONFERENCE IV

THE USE OF VOLUNTEERS IN THE

EARTHQUAKE HAZARDS REDUCTION PROGRAM

Convened under Auspices of

NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM

2-3 February, 1978

OPEN-FILE REPORT 78-336

This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards and nomenclature

Menlo Park, California

1978

Conferences to Date

Conference I	Abnormal Animal behavior Prior to Earthquakes, I
Conference II	Experimental Studies of Rock Friction with Application to Earthquake Prediction
Conference III	Fault Mechanics and its Relation to Earthquake Prediction
Conference IV	Use of Volunteers in the Earthquake Hazards Reduction Program

Conferences in Process

Conference V	Methodology for Identifying Seismic Gaps and Soon-To-Break Seismic Gaps
Conference VI	Measurements of Stress and Strain Pertinent to Earthquake Prediction

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Organizer and Editor

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United States Geological Survey

Office of Earthquake Studies

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VOLUNTEERS IN THE EARTHQUAKE HAZARD REDUCTION PROGRAM

by

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There are tens of thousands of people in the United States who could play an important voluntary role in reducing earthquake hazards and are probably willing to do so. Under the Earthquake Hazard Reduction Act of 1977 the Federal government is significantly increasing its effort "to reduce the risk of life and property from future earthquakes in the United States through the establishment and maintenance of an effective earthquake hazards reduction program." This program involves research, for example, by geologists, seismologists, engineers, sociologists, educators, and public policy experts sponsored primarily by the U.S. Geological Survey and the National Science Foundation. There is a heavy emphasis, however, on the implementation of these results in local communities. When all the research results are available, the benefits of these efforts will depend on whether individual citizens living in earthquake zones accurately perceive the relative importance of earthquake hazards. These individuals can then decide for themselves how to modify their own lifestyles to minimize these hazards. Thus, one of the seven objectives of this national program is "the education of the public, including state and local officials, as to earthquake phenomena, the identification of locations and structures which are especially susceptible to earthquake damage, ways to reduce the adverse consequences of an earthquake, and related matters."

Recognizing the importance of involving the public in earthquake research and education, the U.S. Geological Survey organized a small workshop for approximately 30 people on February 2 and 3, 1978, in Menlo Park, California. The purpose of this meeting was to discuss methods of involving volunteers in a meaningful way in earthquake research and in educating the public about earthquake hazards. The emphasis was on earthquake prediction research but many of the conclusions ranged over the whole earthquake hazard reduction program. Representatives attended from the earthquake research community, from those doing socioeconomic research on earthquake matters and from a wide variety of organizations who might sponsor volunteers such as 4-H Clubs, Girl Scouts, the American Association of Retired Persons, Community Colleges, State Colleges, High Schools, Amateur Radio Clubs, etc. In addition, representatives attended from groups who are mobilizing volunteers such as the American Red Cross and the National Weather Service. There was also a representative of the National Science Foundation, a newspaper reporter, a representative of an advertizing agency specializing in public awareness campaigns and a monitor of a non-profit curriculum development organization. This paper is a summary of the discussion during the workshop. Papers by most participants are included in subsequent sections of this report.

The Benefits of Involving Volunteers

An obvious benefit of involving volunteers in research or operational programs is that large numbers of observations can be made over wide areas at very low cost. Fred Whipple, for example, of the Smithsonian Astrophysical Observatory set up, in 1956, 70 teams of 1,500 volunteers in a matter of months to track satellites. By the mid-seventies when automatic equipment was able to take over this responsibility, over 5,000 volunteers around the world had made 400,000 observations that were valued at over 14 million dollars (Cornell, 1975). The National Weather Service receives help spotting and warning of tornadoes from over 500 networks of volunteers involving over 50,000 people. The Red Cross has more than two million active volunteers collecting blood, teaching courses on water safety or first aid, responding to disasters, etc.

A second major benefit is that a large corps of volunteers can disseminate information through personal contact to a very large audience. We often find it easiest to accept information from a friend or someone in our community with whom we can relate socially, economically, politically, or through similar beliefs. Fire prevention groups have found it very effective to reach parents through short awareness programs in the grade schools. Service clubs, scouting organizations, and politicians have proved very effective at raising public awareness through door to door drives.

A third benefit of involving volunteers is in attracting people to follow careers in a given field. Most of us are pursuing our present careers because at sometime in the past we related very favorably to some activity or more likely some person and became intrigued with a particular subject or approach. Volunteer programs provide a way of increasing significantly the number of people who have personal contact with a field such as earthquake research and could lead to recruiting many people, especially minorities, into research careers.

Considerations in Mobilizing Volunteers

A dictionary typically defines a volunteer as one who offers his (or her) services of his own free will. In a more legal sense a volunteer is one who offers services without any legal obligation, payment or other valuable consideration. There is a wide variety of factors that may motivate a person to volunteer. Certainly one of these factors is a desire to do something that is socially important. The number of people having this desire seems to be increasing over the last few years. There may also be desires for recognition, social participation, self-improvement, career-advancement, and the like. In discussing how to mobilize volunteers in the earthquake hazard reduction program, participants in the workshop came up with the following considerations:

1. Use existing organizations. Generally it is better to contact volunteers through existing organizations that already have established leadership structures, communication channels, and incentive systems, and that are most likely to provide long-term continuity. Dealing with individuals may be advantageous in many cases but this also carries a risk of damage of credibility, should an individual publicize interpretations of his results that are beyond his capability.

2. Combine many activities. Considering that much of the work that might be done by volunteers in the earthquake program involves collecting data over long periods of time without the promise of immediate results, it seems advisable to diversify the volunteer program to include other activities possibly related to other natural hazards so that a variety of results can be observed through time. This approach increases the interest and potential educational value to the volunteer and is another reason for utilizing existing organizatins with their own basic programs.

3. Provide incentives and opportunities for personal development. It is very human to want recognition and many groups mobilizing volunteers have found it important to offer awards, pins,

bumper-stickers, T-shirts, and other rewards to provide visible recognition and tangible goals. There is also some dissatisfaction with volunteerism as an end and growing interest in it as a stepping stone for personal development. It can be a way to try out an appropriate career before stepping into the job market. Many workers see it as a way of changing to a career that is closer to their interests. Many volunteers are simply looking for a challenge or for personal enrichment. For the retired, volunteerism offers a richly rewarding way for mature and experienced people to continue their social usefulness and to stay active in a meaningful social effort.

4. Give the volunteers a sense of importance. With a growing desire among students and others to do important, socially worthwhile work, a volunteer should clearly perceive that the work being performed does contribute in a meaningful way to an important goal such as saving lives or reducing hazards. Volunteer participation is likely to be more responsible and sustained if volunteers are involved in some aspects of interpretation and decision making based on their experience in making the observations.

5. Provide significant feedback. Much of the disillusionment or fatigue of volunteers seems to stem from inadequate benefit to the volunteer. It is important, for example, if a volunteer is sending in routine data, that he or she receive regular feedback on the results and importance of the data both in writing and through personal contact.

6. Give some independence but not too much. It is important to create dual lines of authority within the volunteer and professional communities so that the volunteer has room for advancement and can participate in decision making. For example, a volunteer organization might regularly screen all data that it collects and only report to the sponsoring scientist when abnormal results are seen. At the same time it would be unreasonable to let the volunteer groups issue warnings or predictions from their data unless direct cause and effect relationships had been established and proven. Scientists are trained to be doubting, critical, and logical. Many feel that they will not believe something unless they do it themselves or can recreate the results themselves. Many volunteers have these abilities too and if the volunteers are to take pride in their work they need to be trusted. In the end the results will have to stand up to intense scrutinity and if the volunteers know this and feel responsible for their data and for screening their data, they are more likely to keep up high standards. It is important to define the appropriate relationship between the volunteer organizations and the scientists at the outset.

7. Be ready to handle the data. The scientists mobilizing volunteers must be able to handle the data rapidly in order to provide significant feedback. If much of the data handling is entrusted to volunteer groups, the scientist's problems are reduced and the volunteers interest is kept up. There should be some method for crisis reporting of

what appear to be especially significant observations. This opportunity will make the entire activity more meaningful as a part of an earthquake-alerting program and not merely a data-gathering enterprise.

8. Set recognized standards for performance. Standards of performance provide a way to maintain high quality data and set goals for individual volunteers. The more widely recognized these standards are, the higher the peer pressure to maintain them.

A volunteer program involves recruitment, orientation, training, evaluation, feedback, recognition, and promotion. Each of these components is important and each should be well planned in advance. Experience shows that recruitment of large numbers of qualified volunteers takes hard work and a carefully organized program.

Needs for Volunteers in Earthquake Prediction Research

There have been many advances in earthquake prediction in the past decade. Most seismologists now believe that prediction will be possible but it may be one or many decades before an operational prediction system exists. While direct studies of earthquake locations and ground deformation will undoubtably be important in earthquake prediction research, there are many other studies such as of abnormal animal behavior, water-levels, earth-currents, and gas emission that may or may not turn out to be useful. Volunteers must recognize that in this research environment their work may or may not lead to important results. They must have some level of sophistication to make adequate judgements about their observations. Adequate self-discipline must be encouraged to be sure that tenuous data of questionable quality are not promoted out of perspective.

The People's Republic of China has a major national effort in earthquake prediction involving over 10,000 workers and 100,000 volunteers (Haicheng Earthquake Study Delegation, 1977). The volunteer effort, begun only in the early 1970's, was a way of greatly extending the base of data available to scientists through a type of organization that was highly compatible with the philosophy of the current Chinese political regime. Volunteers have collected a significant amount of data, much of which may be of questionable quality but they have also played a major role in the response of local communities to earthquake warnings and earthquake hazards.

Earthquake prediction research in the United States is presently being pursued in only a small geographical area. In most cases, the most significant data to be collected are within ten to twenty kilometers of an active fault. The area in California where volunteers could provide the most significant contribution to reseach is shown in the shaded zone in figure 1 and includes much of the most populated part of the state.

Other regions of research include the Puget Sound area of Washington, Western Nevada, near Salt Lake City, Utah, and near New Madrid, Missouri. These are some of the regions where large earthquakes are most likely to occur in the contiguous 48 states or where sufficient small earthquakes are being recorded to allow close study. Damaging earthquakes, however, have occurred in 39 states, so that the potential role of the volunteer in earthquake hazard education is much more widespread. Figure 2 shows the relative level of risk from earthquakes throughout the United States.

There is a wide range of tasks that volunteers might perform in the prediction research program ranging from very routine sampling to constructing and/or operating complex instruments. Here are eleven examples listed in order of increasing complexity for the volunteer:

1. <u>Collecting water samples</u> from wells near the fault and sending the samples to a laboratory for analysis to determine the level of such elements as radon or helium, which have been observed to change before earthquakes. The volunteer can perform this routine work in minutes, typically once a day but has no way of following the results except from information sent to him by the scientist. The number of volunteers required is severely limited by the number of samples the laboratory can process.

2. Measuring water level in wells to within 10 or 20 millimeters. Wells must be chosen that are not influenced by pumping of water nearby. The volunteer in this case, as in most of the following cases, can see the results daily and be aware immediately of any abnormal changes.

3. Measure motion on faults where they cross roads by taping the distance, to within a few millimeters, between masonry nails driven into pavement. A geologist should assist in setting up the nails so that energy is not wasted measuring cracks not due to faulting.

4. Measure the water level at several points around lakes to 10 or 20 millimeters in order to look for evidence of regional tilt of the ground.

5. Measure local tilt of the ground using an easily constructed tiltbar that costs about $75 and looks like a large and accurate carpenters level. This instrument is accurate to only about 5 parts in a million but may produce results before large earthquakes or near active faults of moderate earthquakes.

6. Measure temperature, rainfall, and barometric pressure near sites where precise instruments are operated that may be influenced by the weather.

Figure 1: Fault map of California. The shaded area is the region where volunteer observers would be most useful in the earthquake prediction program.

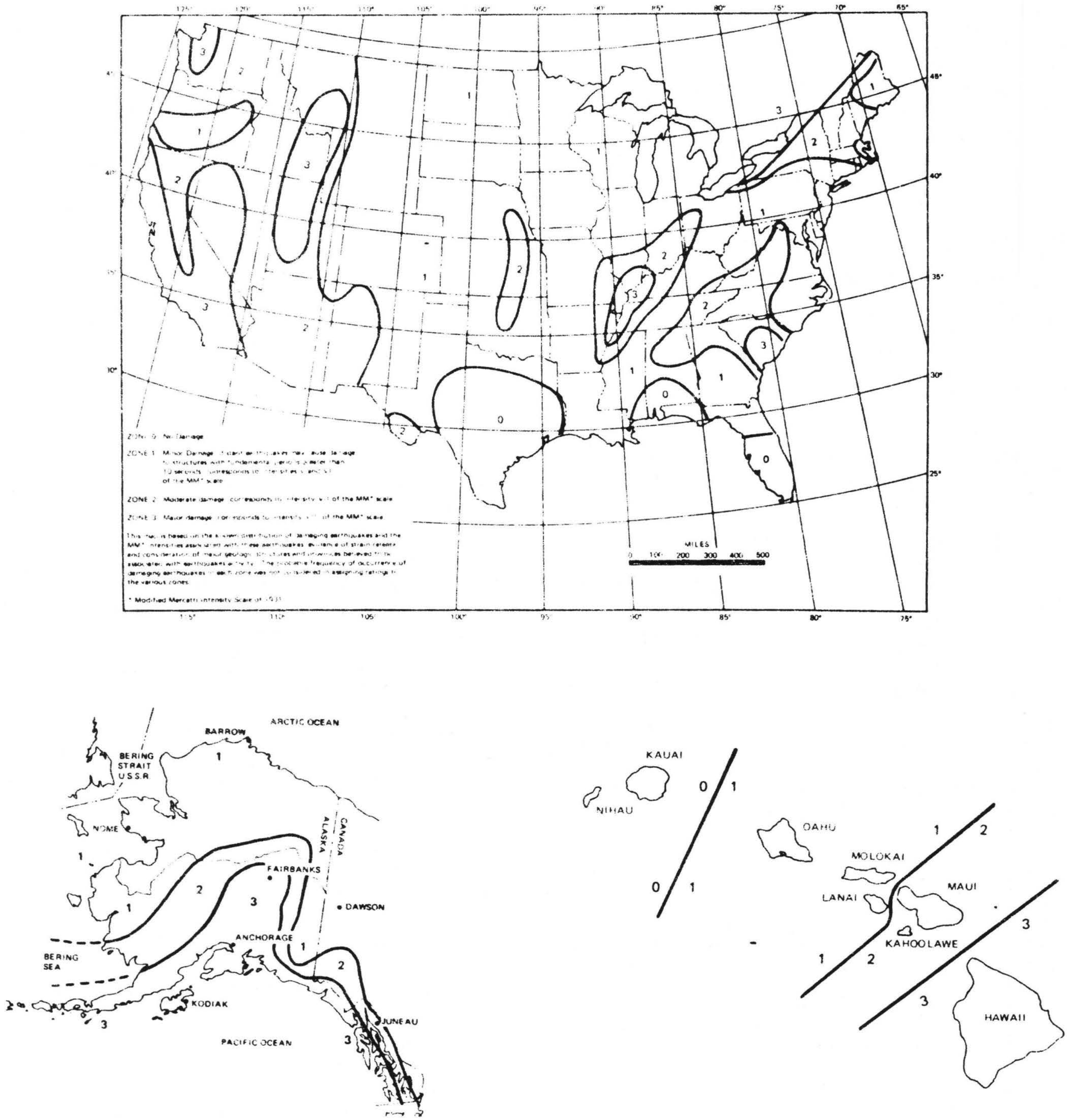

Figure 2: Maps of the mainland 48 states, Alaska and Hawaii showing relative damage to be expected from earthquakes. No damage is expected in zone 0, minor damage in zone 1 (Intensity V and VI), moderate damage in zone 2 (Intensity VII), and major damage in zone 3 (Intensity VIII or greater) (Taken from Algermissen, 1969, and Uniform Building Code, 1973).

7. Measure the electrical self-potential in the ground using two electrodes connected with about 100 meters of wire. This work requires some practical experience and a fair amount of judgement to get reliable results.

8. Observe abnormal animal behavior. This work might be performed by thousands of people. Good results, however, probably depend on quantifying what is "abnormal" and finding ways to handle the data. Reasonably careful judgement is required on the part of the volunteer. Routine observations need to be reported, not just perceived anomalies, to be sure that an increase in anomalies does not simply reflect an increased concern by the observers about an impending earthquake.

9. Measuring local tilt of the ground using a precise level. A high quality instrument used by many surveyors is required along with careful field procedures. Such work might be ideal for college classes, retired engineers, etc.

10. Measuring differences in the earth's magnetic field. Amateur radio operators, for example, might be able to build and operate magnetometers capable of recording differences in the magnetic field between stations 5 to 10 km apart. This work requires relatively sophisticated electronics and accurate relative timing.

11. Recording earthquake waves. Breakthroughs in electronics are bringing the cost of seismic equipment more and more into the range feasible for a volunteer program. A relatively sophisticated effort would be required, however, to obtain the accurate timing necessary for these data to be useful. A seismograph, nevertheless, might be one of the more interesting instruments for a volunteer to operate.

Needs for Volunteers in Other Types of Earthquake Research

1. Surveying public attitudes or knowledge of earthquake matters. Questionnaires of varying complexity would need to be designed by scientists depending on the expertise of the volunteer group.

2. Surveying damage intensities in great detail after local earthquakes. Johnsen and Duke (1973) report on such a survey done by university students after the 1971 San Fernando earthquake. This work requires some careful instruction and a fair amount of judgement.

3. Measure ground acceleration during earthquakes. Inexpensive recorders might be designed that can be built or purchased by volunteer groups. One instrument used now, called a seismoscope, only costs about $300.

Needs for Volunteers in Earthquake Hazard Education

There are many important roles that volunteers might play in making the public aware of earthquake hazards and how to minimize them. Informed volunteers could give lectures to schools, service groups, clubs, etc. Displays could be set up and staffed in such phases as in libraries and shopping centers. Appropriate information could be put in the myriads of newsletters that different groups distribute. Youth organizations, for example, after an appropriate training program could visit houses and offer to point out earthquake hazards. Guided tours could be given of fault zones or potential landslide zones in a community. Many students who participate in such activities may grow up to occupy positions of leadership in their community.

Examples of Volunteers Available

A volunteer, or even more so an amateur, is often misunderstood to be inexperienced, unprofessional, untrained, or unskilled. Most volunteers will not have as much training in, for example, seismology as a scientist in the earthquake research program. But most will, however, have special talents, experience, or abilities that are valuable in a given situation and in fact the volunteers may even be better suited for a particular task than the research scientist. For example, many amateur radio operators are professional electronic engineers or technicians who may be better able to repair and operate instruments better than a given research scientist who may not be particularly interested in electronics. A college teacher, by virtue of his experience in teaching, may be able to communicate with the public about earthquake hazards more effectively than a research scientist. A volunteer program provides a way to diversify the expertise available. The challenge in organizing such a program is to match up needs and skills in a way that everyone benefits. Here are a few examples of how such resources might be mobilized.

<u>Amateur radio operators</u>. There are over 900,000 HAMS in the United States and 100,000? in California. To be a HAM, in contrast with a citizen-band radio operator, one must pass an examination on basic electronic principles, radio theory, electric-magnetic wave propogation, and use of Internatinal Morse Code. HAMS are well organized and well disciplined. They have developed much new equipment including their own satellites for communication. They have proved to be the primary resource for communications in and out of severely damaged areas after earthquakes, floods, tornados, etc. and for rapid assessment of the damages. They organized ASTRONET in 1959 to observe transient lunar phenomena using rapid radio communications and home-made telescopes. Very few of these phenomena had been observed previously and none correlated by several observers. ASTRONET was able to simultaneous photograph 3 transients the first year and numerous more sightings have been made since then. HAMS clearly provide a significant resource not only in rapid communication but in operating modestly complex equipment. Many HAMS are interested in ways of putting their hobby to meaningful use.

Retired people. There are currently 23 million people 65 years of age and over in the U.S. Half of these belong to the National Retired Teachers Association (NRTA) and the American Association of Retired Persons (AARP). About 35,000 of these members perform volunteer work of some type in accordance with the associations' motto "To serve and not be served." In California alone there are more than 250 local chapters and units, many of whose members spent their careers in the field of science and education which admirably fit them to play important roles in an earthquake hazard reduction program.

Community colleges. In California, for example, there are 104 community colleges serving 1.3 million students with an average age of about 30 years. One out of every eight Californian adults is served in regular instruction programs by community colleges. Each college raises funds locally through a permissive override tax for programs of general community enrichment. Such funds can be used for displays, lectures, museums, etc. Most of these colleges have departments in Geology, Physics, and Electronics. Thus, community colleges provide a significant source of expertise for making observations and for educating the public. For example, N. Timothy Hall, and his students at Foothill College, have built two self-guided "earthquake trails" along the San Andreas Fault near Point Reyes and near Palo Alto that are being visited by thousands of people per year. The Foothill Science Center, which is part of the Community Services Program, has produced, with the cooperation of the Foothill Geology Department, an exhibit on local geology and earthquake hazards.

Universities and colleges. Universities and colleges constitute a large source of potential volunteers. In California, for example, there are over 85 campuses with geoscience departments. Many colleges have special project courses where students make routine observations, map study areas, or carry out reseach projects. Many have courses teaching surveying. Many students are studying to be teachers and would welcome the opportunity to give lectures on a subject like earthquake hazards. These lectures could be part of a requirement in an earthquake hazards course. At some campuses faculty and students in geology, engineering, sociology, economics, and political science are getting together to discuss the many aspects of earthquake hazard reduction. There is an increasing desire among students, faculty, and administrators to make college and university programs more relevant to the needs of the communities in a way that will enhance the colleges' educational mission and improve the educational process. College teachers and their classes might agree to take certain routine measurements and perhaps even compile data collected by many other volunteers. They might receive regular reports and recent data from other research scientists that could be used in laboratory exercises in their studies. Students would have the excitement of participating in a small way in a current research project and might well make personal contact with possible future employers. College groups could also play a major role in developing and distributing educational materials for grade schools, high schools, and the general public.

High schools. There are over 800 high schools in California, most of which give physics courses and many of which give earth-science courses. There is a large amount of energy available for volunteer work. One problem in mobilizing this group relates to liability insurance. High schools are facing a rapid rise in their premiums for liability insurance and are being forced to curtail extra-curricula activities, particularly those involving transportation.

Youth groups. There are over 144,000 girl scouts, 330,000 boy scouts and 110,000 4-H club members in California, alone, along with over 150,000 parents who volunteer their time to make these organizations run. Some groups may wish to take on routine observations of animals or water-well levels, for example. Programs and badges might be introduced for studies and action in the area of earthquake hazard reduction. "Hazard hunts" might be organized where members, after some training, visit most households in their community to point out earthquake hazards.

Other groups. The League of Women Voters might, for example, become interested in the legislative and legal issues. State agencies, such as Parks and Recreation, might allow its employees to volunteer some official time to take observations or provide information. Many Red Cross chapters are presently giving lectures on earthquake hazards. Many public service clubs might be interested. The list could go on and on. It is clear that there is a wide variety of volunteer resources and interests. Each could play an important role. Some would provide primary data-gathering functions; others would serve primarily to educate the public. Most would probably want to contribute in both capacities.

Where Do We Go From Here?

There are important needs for volunteers in earthquake research and public education; there are many talented volunteers available. How do we link up the supply to the demand? It would be easy to call for volunteers before appropriate methods were set up for organizing, processing data, providing feedback, providing educational materials, etc. The chances are the program would fall into disrepute within a few years. Instead we have decided to encourage a few groups to take the initiative and develop pilot projects that fit the needs of both the program and their group. As different pilot projects become successful, their approach could be expanded. Any scientists who have a need for volunteers and any representatives of any organization who wish to provide volunteers are encouraged to contact the author to discuss ways to proceed.

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A Volunteer Collection Network for Earthquake Prediction

by

Irving Friedman and Joan Blackwell

For the past year, the U. S. Geological Survey, Isotope Geology Branch, has been operating a volunteer water collection network for earthquake prediction. The volunteers sample well water daily and send the samples to the laboratory for helium analysis. Most wells are used domestically, although a few are used for irrigation or for municipal water supply.

Before setting up this volunteer network, we considered the fact that untrained volunteers could not be asked to carry out time consuming and complex tasks. The collection equipment had to be inexpensive, simple to operate, and relatively fool proof. Returning the samples to the laboratry had to be equally uncomplicated.

In the sampling procedure we now use, the volunteer fills an inexpensive ($.15) hypodermic syringe with 9 cc's of water, attaches a needle, and injects the sample into a previously evacuated, commercially available glass sample tube (Vacutainers). To prevent leakage, the rubber stopper is immediately sealed with RTV rubber sealant. The tubes are placed in a foam plastic mailing device used by the medical profession for shipping blood samples. Five tubes fit this particular commercially available mailer, and when the volunteer has collected five tubes, s/he sends the mailer, which has a franked label on it, to the analytical lab in Denver. When they arrive, we immediately send back a mailer containing empty tubes to the station.

In setting up the sample collection network, our approach has been to personally visit the individual and explain the project. The volunteer is told that it may be a year or more before an earthquake event of sufficient magnitude will occur so that we can access their particular collection site for its usefulness. In practically every instance, the person approached has been very cooperative and has carried out the assigned task for the year the network has been in operation. In return for the volunteers' cooperation, we send them the "Earthquake Bulletin" and occasionally a short newsletter on the progress of the project.

At present, the network consists of approximately thirty-three stations along the San Andreas fault in California from San Francisco to fifty miles south of Hollister and three geothermal stations in the Imperial Valley. In addition to these thirty-three collection stations in California, we also have ten collection stations in the vicinity of West Yellowstone, Montana (Hebgean Lake). Both areas are seismically active and we hope to determine whether changes in the helium abundance in waters can be used for earthquake prediction. From data available to us which had been collected by the Russians, we feel that we may find a change in helium concentration four to ten days before a major earthquake.

Preliminary results indicate that the most promising sample sites are those high in helium. In order to locate more wells in these areas, we have recently extended our volunteer effort to include California HAM (amateur radio) operators and students in the State University and Community College Systems. The HAM operators contact local well owners and obtain locations and some technical data. The students then visit and sample the prospective wells. The samples are sent to Denver and analyzed. If the analysis indicates a high helium abundance, the well owner is then visited personally by Survey personnel. By using the HAM operators and students, much preliminary screening can be done. This procedure also gives the students, who are mostly geology majors, the opportunity to participate in a research project. Our future plans include using the students as back-up samplers when the well owners are away so that there will be continuous samples from each station.

Our initial success with the enthusiasm and reliability of using volunteers has led us to expand our volunteer network. By incorporating existing groups into our project we have taken advantage of the organiziation and common interests of each. These volunteers will also receive the "Earthquake Bulletin" and newsletter as our project progesses.

CALIFORNIA EARTH SCIENCE CORPORATION

TECHNICAL REPORT 77-3

DESCRIPTION OF WATER LEVEL MONITORING PROGRAM ALONG SAN ANDREAS AND SAN JACINTO FAULTS, SOUTHERN CALIFORNIA

December 1977

by

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PREFACE

California Earth Science Corporation (CalESCO) has a contract from the U.S. Geological Survey, Office of Earthquake Studies, to monitor water levels and temperatures along the San Andreas and San Jacinto faults in southern California. The purpose is to determine whether fluctuations in water level and temperature occur before earthquakes and to establish methods for the possible use of such measurements for earthquake prediction. This report summarizes the basis for the hypothesis that such changes may occur premonitory to earthquakes, describes the monitoring program and presents instructions on the use of equipment and on the tabulation of water measurements.

BACKGROUND

A recently discovered crustal uplift centered near Palmdale (Castle, et al, 1976) (Fig. 1) may be a precursor of a major earthquake in southern California. However, data and present theory are inadequate to verify this hypothesis or to identify the possible causative fault and the time and magnitude of the next earthquake.

Between the 1857 great earthquake (magnitude $\geq$ 8.0) and November 1976, there was a curious lack of seismic activity along the Gorman-Palmdale-San Bernardino segment of the San Andreas fault in southern California. The absence of earthquakes in an otherwise geologically active region has been likened by some seismologists to an unusual calm before a storm (U.S.C. Geophysical Laboratory, 1976); it has been suggested that the San Andreas fault in this area is locked and may be characterized by infrequent large earthquakes (Allen, 1968). However, during the period November 3, 1976, to September 28, 1977, a number of small earthquakes ($M \leq 3$) occurred along the San Andreas fault east of Palmdale between Little Rock Reservoir and Valyermo (Gary Fuis, U.S. Geological Survey, personal communication, October, 1977). Based on the historic record, it is considered possible that the southern California uplift (Anonymous, 1976) and the recent seismicity are precursors to a major earthquake on the San Andreas fault. Observations of other possible earthquake precursors are required to determine the significance of these phenomena and the possibility of an impending major earthquake.

Variations in water level have been observed prior to earthquakes. Johnson (1973) recorded a drop of 78 centimeters (31 inches) and a subsequent rise of 11 centimeters (4 inches) beginning 22 days before a 2.4 magnitude earthquake near Harris Ranch on the San Andreas fault. Kuo, et al (1974) list 11 earthquakes in China for which water level changes of centimeters to meters were observed 14 hours to more than 10 days before earthquakes of 5.5 to 8.5 magnitude. More recently, abnormal behavior of water levels was used in conjunction with other precursors to predict the February 4, 1975, 7.3-magnitude Haicheng earthquake in northeast China. Changes were noted beginning in mid-December, followed by additional anomalies beginning in February. Changes were observed in 70 percent of the 81 wells being monitored (Anonymous, 1976; Hammond, 1976). The success of the Chinese earthquake prediction research depended on the monitoring of a great many wells by civilian volunteers.

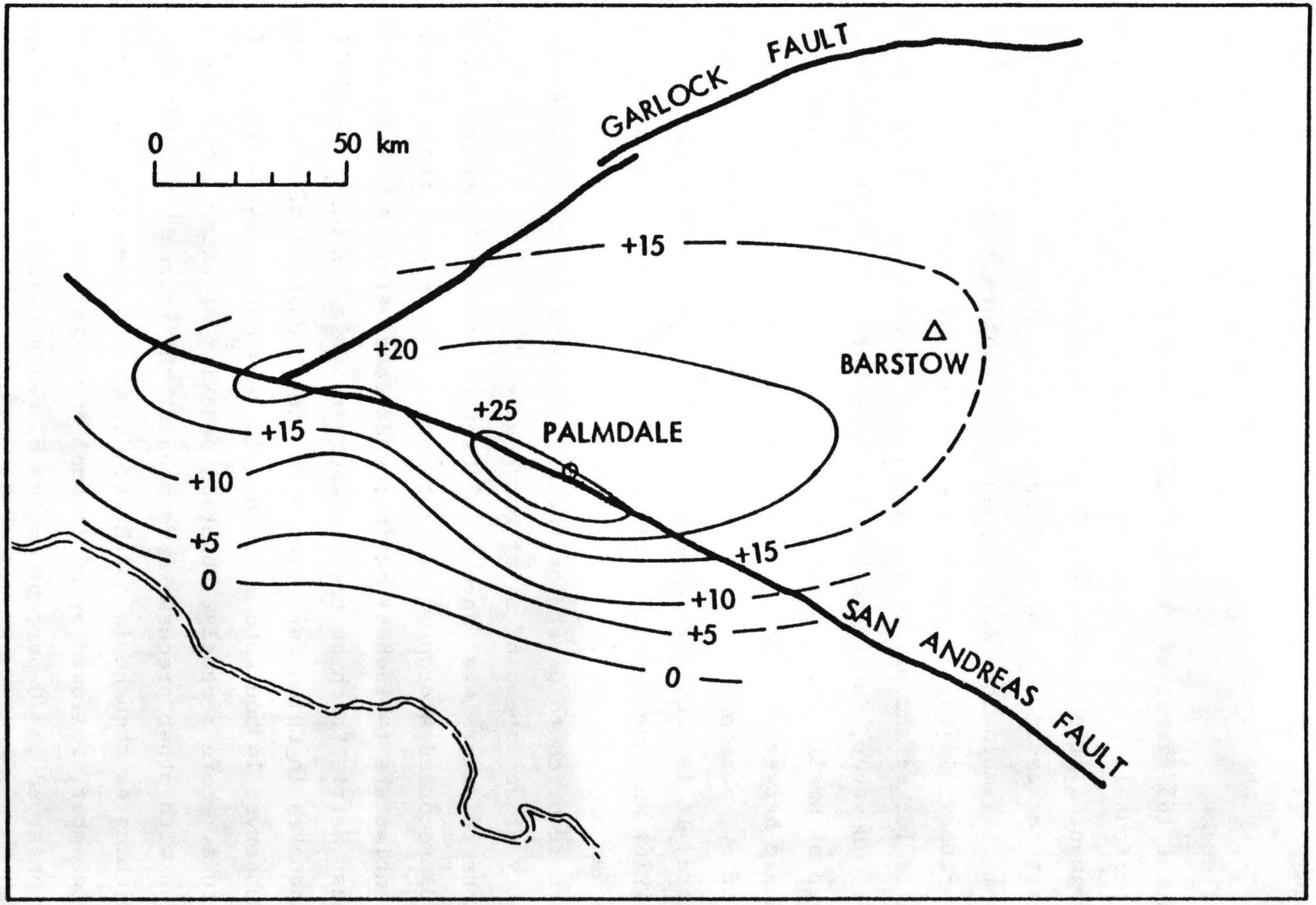

Fig. 1 - Map showing location of southern California uplift (contours in cm. adapted from Castle, et al, 1976).

Deformation of porous, saturated earth materials below the water table results in changes in volume and pore water pressure and increased flow rate of fluid; these effects are believed to cause the observed fluctuations in water level prior to earthquakes. These effects are consistent with either the dilatancy or dislocation earthquake models (Kovach, et al, 1975) which predict changes in crustal stress prior to earthquakes. Theory and recent observations indicate that changes in water level precede earthquakes.

Table 1 summarizes the causes, amplitudes and durations of water level changes in wells. In this study, we are looking for changes in the state of stress or strain premonitory to earthquakes; the other effects must be identified and separated to the maximum extent possible. Each well record has its peculiarities owing to differing aquifer characteristics, local environment (e.g., nearby wells, road, wind exposure) and instrument idiosyncrasies. A period of time is required to establish the changes that constitute a normal record, as well as man-made influences (see Table 1). Typical periods for the fluctuations vary from instantaneous to annual, and the nature of changes premonitory to earthquakes is poorly understood. The duration of such changes may be proportional to the magnitude of the earthquake (Scholz, et al, 1973). Thus, it is essential to our research to have records of both short-term and long-term variations.

DESCRIPTION OF MONITORING PROGRAM

A network of observation wells has been established along the San Andreas fault between Palmdale and Valyermo and along the San Jacinto fault between Ocotillo Wells and San Jacinto Valley. A search for additional observation wells along these faults is proceeding, and we are attempting to enlist the aid of volunteers to increase the number and frequency of well observations. The goal is to have continuous, high resolution records from several wells located in a variety of rock types within and adjacent to the fault zones so that any anomalous change in water level which may be a precursor to an earthquake can be detected. The results of the first year of the monitoring program have been described (Lamar and Merifield, 1977).

Stevens Type F continuous water level recorders have been installed over six wells. The recorder charts are changed once a week, and water depths are measured when the charts are changed. Temperatures in all of the wells and water depths in several wells without recorders are also measured once a week.

Table 1 - Summary of causes, amplitudes and durations of water level changes in wells.

Cause	Amplitude (Order of Magnitude)	Duration
Vehicles, wind, sonic booms, objects falling in well or hitting enclosure	centimeters	Instantaneous (spikes)
Earthquakes	centimeters	spikes, sharp rises or drops followed by recovery in hours
Barometric pressure, temperature, earth tides	millimeters to centimeters	diurnal, semidiurnal
Evapotranspiration (shallow water table only)	centimeters	diurnal
Rainfall (direct influence), ephemeral influent streams	centimeters	rise and gradual decay, hours or days
Pumping wells in same aquifer	decimeters	drop followed by recovery in days
Deformation of aquifer (may or may not be earthquake precursor)	decimeters to meters	days, weeks
Seasonal and secular changes of water in storage	meters	annual and longer

All of the weekly probed depths and temperatures are stored in a data set on disk which is updated each week. An example printout of the weekly data for well 5N/12W-1N1 is shown in Fig. 2. A computer program has been written which will generate hydrographs of weekly water levels for each well. Fig. 3 is a weekly hydrograph for well 5N/12W-1N1. Data on precipitation are also shown on the hydrograph to facilitate direct comparison.

PROCEDURES FOR OBSERVATIONS

The major product of the research is accurate observations of water levels and temperatures in wells. For these records to be useful with a minimum of effort, these procedures should be followed exactly. Be sure you have equipment and supplies listed on Table 2.

When you start day, enter date and Julian day/year and sign name on observations log sheet (first page of notebook of computer printouts). Some of the wells have old pumps and pipes in the casings so access is limited; others are clear of such material and have locking caps welded to the top of the casing to prevent vandalism. When making observations, be extremely careful that you don't drop anything down the well; be sure you have nothing loose in front shirt pocket. A master #3212 key will open all of the padlocks.

Make entries on computer printout sheets with sharp #2 pencil; be neat because we plan to use these pages as originals in our progress reports. Fig. 2 is a sample computer printout sheet with field entries for the last week.

Follow these steps at each well:

1. Use printout of previous week's depth to determine approximate water level and lower temperature probe about 2 feet below water surface. Leave in water to allow time to equalize.

2. Measure the water level with the self-potential water level recorder. The current which actuates the meter in this device is generated from the electro-potential difference between the steel casing and a piece of magnesium at the end of the steel tape (Fig. 4). To insure proper operation, scrape clean the lower end of magnesium block on water level indicator at beginning of each day. The clip should be attached to the well casing; the circuit will be completed when the magnesium probe touches the water surface. Enter the "probe depth below reference surface", usually top casing (T.C.) on the computer printout. Subtract the "height reference point above land surface" from the "probe depth below reference surface" to obtain "depth water below land surface."

WELL NUMBER: 5N/12W-1N1 PALMDALE QUAD
HEIGHT REFERENCE POINT ABOVE LAND SURFACE:.7 FT
LAND SURFACE ELEVATION: 2815.0 FT
TOTAL DEPTH OF WELL:149.25 FT
YMAX= -36.0 YMIN= -31.5

DATE MO/DA/YR	JULIAN DA/YR	TIME (PST)	TEMP (F)	OBSERVER	PROBE DEPTH BELOW REF. SURFACE (FT)	WATER DEPTH BELOW LAND SURFACE (FT)	NOTES
04/22/77	112/77	12:33		DC	32.960	32.260	
04/29/77	119/77	18:59		DC	33.023	32.323	
05/06/77	126/77	12:20		DC	33.043	32.343	
05/13/77	133/77	12:55		DC	33.022	32.322	
05/20/77	140/77	11:31		DC	32.895	32.195	
05/27/77	147/77	11:06	64.5	DC	32.835	32.135	
06/03/77	154/77	11:20	64.5	DC	32.788	32.088	
06/10/77	161/77	11:22	64.5	DC	32.873	32.173	
06/17/77	168/77	11:00	64.5	DC	33.010	32.310	
06/24/77	175/77	11:50	64.0	DC	33.250	32.550	
07/01/77	182/77	9:36	64.0	DC	33.600	32.900	
07/08/77	189/77	8:12	64.0	DC	33.957	33.257	
07/15/77	196/77	9:51	64.5	DC	34.301	33.601	
07/22/77	203/77	9:37	64.0	DC	34.609	33.909	
07/29/77	210/77	15:03	64.0	DC	34.888	34.188	
08/05/77	217/77	10:09	64.0	DC	35.084	34.384	
08/12/77	224/77	8:11	64.5	DC	35.258	34.558	
08/19/77	231/77	12:43	64.0	DC	35.346	34.646	
08/26/77	238/77	11:03	64.0	DC	35.243	34.543	
09/02/77	245/77	9:47	64.0	DC	35.241	34.541	
09/09/77	252/77	10:00	64.0	SM	35.368	34.668	
09/16/77	259/77	9:34	64.0	DC	35.519	34.819	
09/23/77	266/77	9:01	66.0	SM	35.538	34.838	
09/30/77	273/77	10:30	64.0	DC	35.581	34.881	
10/07/77	280/77	9:15	64.0	SM	35.663	34.963	
10/14/77	287/77	9:47	64.0	DC	35.728	35.028	
10/21/77	294/77	9:25	64.0	SM	35.795	35.095	
10/28/77	301/77	9:01	64.0	SM	35.787	35.087	

Fig. 2 - Sample computer printout of well data with entries for well 5N/12W-1N1, week ending October 28, 1977.

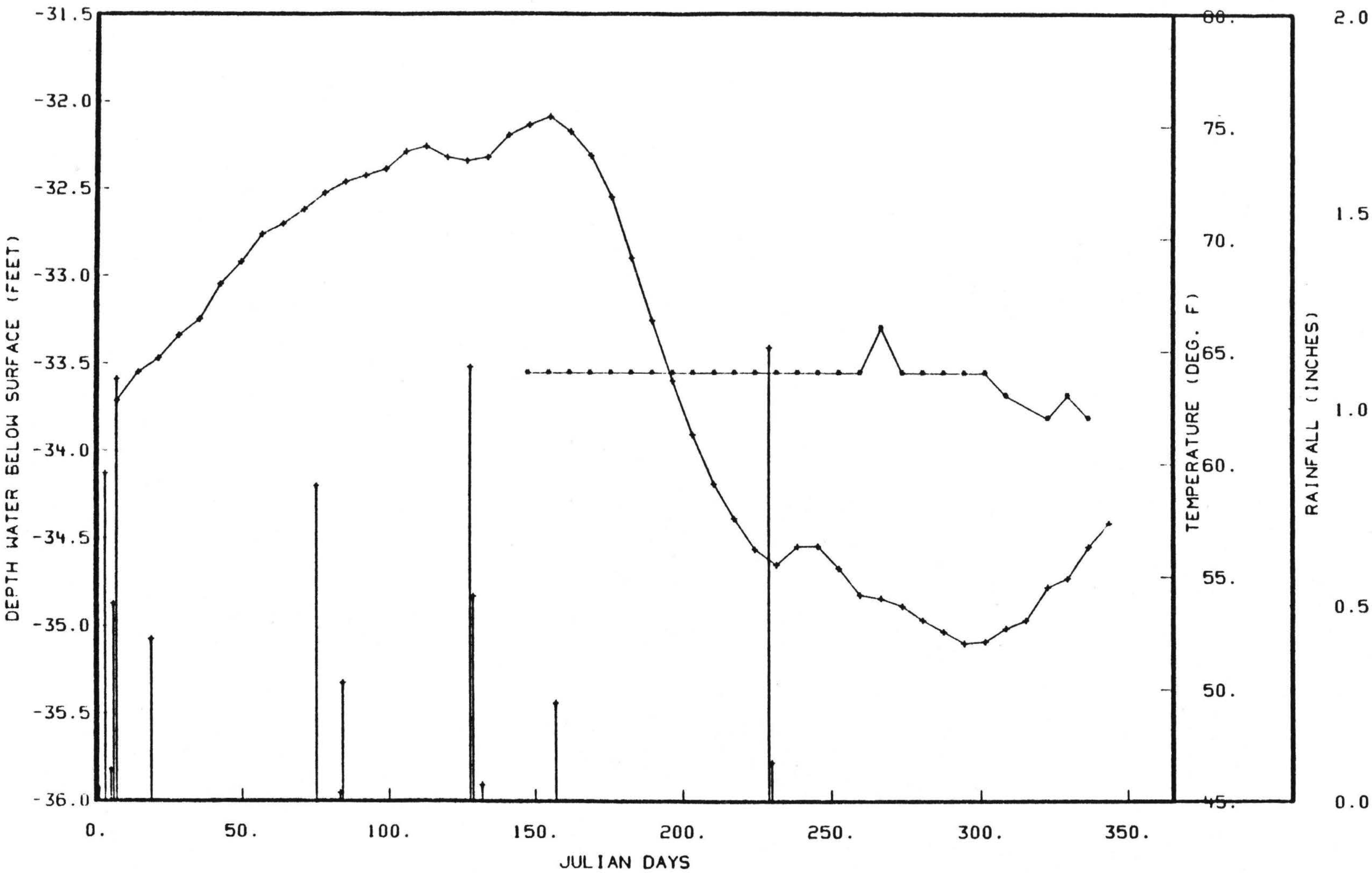

FIGURE 3 -- WEEKLY OBSERVATIONS OF WATER LEVEL AND TEMPERATURE IN WELL NUMBER 5N/12W-1N1 AND RAINFALL AT PALMDALE DURING 1977

Table 2 - Water level observation equipment and supply list. Be sure all supplies are returned to tool box. If you need something, buy it. Project cannot be accomplished without these items.

Notebook with:

- Weekly observations log
- Computer printouts of previous well levels
- Instructions for water level observations
- Map of well locations

Tool box with:

- Copy of this list taped inside of lid
- Self-potential water level indicator
- Water temperature probe
- Keys, master #3212
- Mirror
- Several sharp #2 pencils
- Pocket knife
- Clips to mark position of water level reading on cable
- Flashlight

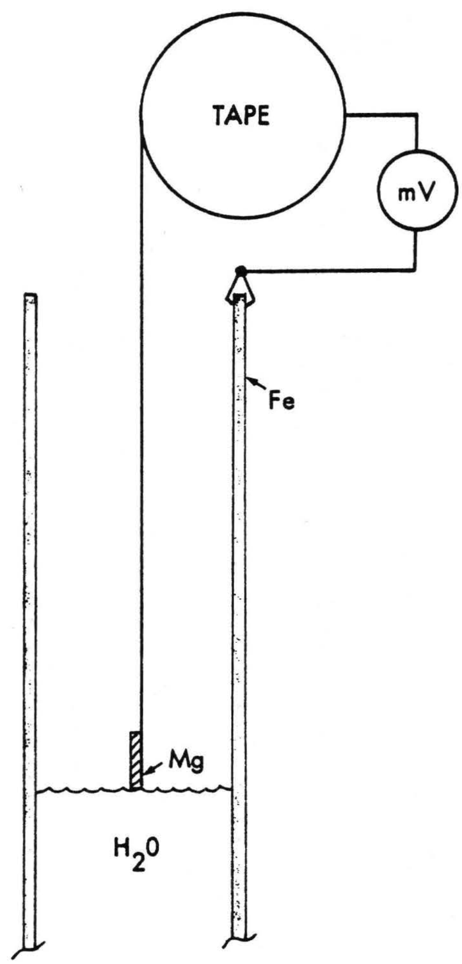

Fig. 4 - Schematic diagram of water depth indicator fabricated from a steel tape with small piece of magnesium (Mg) attached to lower end and upper end connected to steel well casing (Fe) through millivolt meter (mV).

3. Check this entry against computer printout of previous observations to be sure no major error was made.

4. Read temperature and enter on computer printout sheet.

5. Under notes, enter any problem encountered or recommendations which will help us next time.

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INSTRUMENTATION FOR A VOLUNTEER PROGRAM IN EARTHQUAKE PREDICTION

by

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INTRODUCTION

Crustal tilt anomalies were apparently one of the key geophysical parameters measured by Chinese volunteer groups which led to the successful prediction of the Haicheng, China earthquake of 1975, and tilt anomalies have been recognized as significant precursory elements for several major earthquakes elsewhere in the world.

The recent recognition of the southern California uplift and, more particularly, the documentation of the relatively rapid elevation changes that characterize it, show that regional crustal deformation takes place in seismically critical areas of the United States. Even though the relation of the southern California uplift to potentially impending earthquakes is not presently understood, sufficient observations elsewhere in the world establish the fact that many, but not all major earthquakes are preceded by regional crustal deformation and tilting.

Clearly, measurements of tilt variations from hundreds or thousands of points in southern California would aid in understanding the meaning and significance of the southern California uplift. If the uplift is ultimately related to an impending earthquake, the tilt measurements may help to predict the earthquake itself. Hundreds or thousands of data points, reported on a daily basis almost certainly require a highly coordinated network of volunteers. This paper presents some general considerations for the type of tiltmeter that a volunteer program might utilize to measure crustal tilting, and it describes the specific design, utility, and operational experience of a tiltmeter that fits the general requirements and that has already been used by volunteers on a limited basis.

INSTRUMENTATION REQUIREMENTS

Several considerations are immediately apparent in formulating the first phase of a volunteer program:

What should be measured?

What methods should be used to measure it?

How should the data be synthesized, interpreted and utilized?

It was argued above that crustal tilt would be an important parameter to measure. What determines the type of tiltmeter to use? From the standpoint of the geophysicist interested in useful and reliable data, the following guidelines seem to be obvious:

1) The data should be collected with standard instruments of similar design, manufacture, and operation;

2) The measurements should be objective, requiring no adjustment, interpolation, or interpretation by the individual volunteer; and

3) The method of data collection and reporting should be uniform, both temporally and procedurally.

But the interest and enthusiasm of the individual volunteer must be maintained over a period of time that may last many years. He must receive feedback to realize that he is playing a meaningful role in a serious scientific endeavor. Thus, the following guidelines should be considered:

1) The instrument must be easy to operate and to understand conceptually so that the volunteer knows what he is doing and can explain it and his role to others; and

2) The instrument should yield data that are easy to transmit to the data collection central and are also immediately available for the volunteer to plot himself to see progress and changes.

Parenthetically, but no less important are two non-instrumental considerations in maintaining the interest of, and thus diligence in data collection by the volunteer:

1) The individual's data should be available to him to use in school or organization projects, such as a science fair;

2) The individual volunteer must receive feedback in an easily understandable form from the data collection central in order to be always aware how his data relate to and help the total effort.

There are also important considerations from the standpoint of the central organizing and coordinating agency regarding provision of large numbers of instruments to a volunteer program, such as:

1) The instrument should be capable of documenting a sensitive precursory parameter reliably. That is, there must be some assurance that the synthesized data from a network of such instruments will yield information that will play a significant role in the earthquake prediction effort;

2) The individual instruments should be low cost and be virtually maintenance free; and

3) The instruments should be easily deployed, installed by the volunteer if possible, and easily recalled.

THE UCSB TILTBAR

The UCSB tiltbar has been used by volunteers on a limited basis for five years and may be regarded as an example of the kind of instrument a volunteer program can utilize easily and effectively. The tiltbar is a simple short-base tiltmeter that works on the principle of a carpenter's level. It was originally designed for on-site studies of relatively large crustal movements that are local in space and time, such as the tilting of a volcano edifice as it inflates during injection of magma, and strain accumulation closely adjacent to a fault prior to release in an earthquake. The tiltbar combines the advantages of moderately high sensitivity and portability with low cost and ease of installation and operation against its disadvantages of being subject to non-tectonic surface effects, such as thermal expansion and contraction of the ground, and it does not record automatically and continuously; it can be easily modified to do so, but at additional cost. The present cost of materials for a single tiltbar is about $75.00.

The essential features of the tiltbar are illustrated in Figure 1. It is a 120 cm long, hollow-box steel bar in the center of which is mounted a 40.6 cm long machinist's level bubble in a graduated glass vial. The hollow box configuration combines rigidity with low weight. A 0.01 mm micrometer with a carbide-tipped, non-rotating spindle is mounted in one end of the bar. The micrometer yields the numbers that are the eventual data. On the bottom of the opposite end of the bar is fastened a piece of stainless steel having two V-grooves cut perpendicular to one another, so that they always fit in the same position upon two 7 mm diameter tungsten-carbide or stainless steel balls that are brazed to a separate steel plate. When the tiltbar is in position, it is supported by the ball-and-groove arrangement at one end, and by the micrometer in point contact with a ball on another steel plate at the other end. The plates themselves are permanently fastened to nearly flat surfaces of concrete or rock by means of expansion bolts. A tilt array is comprised of four separate plates in a right-triangle configuration. A three-legged equilateral triangle can also be utilized by using six base plates. The tilt is calculated from the differences between reversed readings from each leg.

In practice, the tiltbar is placed carefully on two of the plates defining one leg of the triangle. The bubble in the level vial is centered by raising or lowering the micrometer. The micrometer is read when the bar is lifted before being placed in position on the other leg of the triangle. Temperatures of the air and of the bar are taken with appropriate kinds of thermometers. A set of four readings normally requires from 10 to 15 minutes.

An ideal tiltbar site is a sheltered, crack-free, nearly level rock or concrete surface having an area of at least 1.5 m^2 upon a deep foundation of sand or volcanic ash.

Reproducibility of a single measurement is $\pm$0.005 mm, equivalent to 5 μrad., which is from one to two orders of magnitude less sensitive than a standard borehole tiltmeter, but which is sufficient to document direction and magnitude of locally large crustal tilts related to tectonic processes. For example, Sylvester and Pollard (1972) observed tectonic tilt of approximately 35 μrad. about 30 m from the trace of a fault six hours before a M = 3.8 aftershock and 38 mm of vertical displacement took place along that fault. Thus, the tiltbar provides the sensitivity for which it was designed: frequent, if somewhat coarse documentation of near-field crustal tilting immediately preceding or following relatively rapid crustal strain. With refinements in design and procedure, it could be utilized to monitor regional crustal tilt variations that may presage damaging earthquakes.

The long-term sensitivity and reliability of the tiltbar has been tested by running it for one and one-half years in tandem with the short-base water-tube tiltmeter in the Uwekahuna vault on Kilauea Volcano, Hawaii. The water-tube tiltmeter has been in operation continuously for more than 20 years and is known to have a sensitivity of $\pm$1 μrad. Superposed records of the tiltbar and water-tube tiltmeter for the one and one-half year period show that the tiltbar tracked the water-tube tiltmeter to within ± 5 μrad. No systematic correlations have been found for effects of temperature, rainrall, or felt earthquakes, largely because of the environmental stability of the vault. In practice elsewhere, these factors will surely influence the raw data yielded by a tiltbar. The temperature effects can be minimized by reading the bar just before dawn or in the evening when the ground temperature has stabilized.

In the past five years, networks of tiltbar stations have been established to monitor tilt related to possible volcanic eruptions on Mount Baker Volcano in Washington, and Jan Mayen Island in the Norwegian-Greenland Sea. Faults in the San Fernando and Imperial Valley regions of California are being monitored by tiltbar networks. The Santa Barbara County Road Department is measuring the tilting of bridge abutments, and a Norwegian geophysical expedition is measuring tilting of ice floes in Antarctica.

The volunteer in San Fernando is a teen-ager who has been collecting tiltbar data daily for seven years and has used them in a project which has won awards in 4-H Science Fairs. But more importantly, the data show a persistent qualitative relationship of tilt prior to local earthquakes in the San Fernando area. The pattern is sufficiently well established empirically that, to the satisfaction of the teen-ager and his family, the approximate time, place, and magnitude of impending earthquakes in the San Fernando area can be predicted.

Experience with the UCSB tiltbar has encouraged us to believe that a network of inexpensive, relatively simple tiltmeters may provide supplemental data on regional tilt, if any, before earthquakes. To be sure, the UCSB tiltbar is only one kind of tiltmeter that might be the central instrument in a volunteer earthquake prediction program. Improvement and other designs are being considered to overcome the present shortcomings of the tiltbar.

STATE-OF-THE-ART OF EARTHQUAKE INSTRUMENTS

It is important for potential volunteers to realize that seismologists themselves have no single instrument, or combination of instruments, simple or sophisticated, with which to predict earthquakes with any degree of confidence. To be sure, some earthquakes have been reliably predicted recently, but the kind of premonitory signals that predicted one earthquake have not always been observed before other earthquakes. In general false alarms have followed, or earthquakes were missed, using techniques that were successful in the few correct predictions. Thus, until seismologists understand earthquakes well enough to predict them routinely by whatever means, there is no proven instrument to place in the hands of a network of volunteers at this time to predict earthquakes.

Baring a major breakthrough in the theory of earthquake mechanics and instrumental design, it will probably be several years before some sort of proven "household" instrument can be deployed among a multitude of volunteers. But there is no guarantee that the earthquake will wait those several years to be predicted. In the meantime, concurrent design and testing of simple instruments, such as the UCSB tiltbar, should be undertaken to complement more sophisticated instruments. For the most part, however, these design and test efforts are being, and probably will be done, on an individual basis and not as a massive, coordinated effort involving many volunteers.

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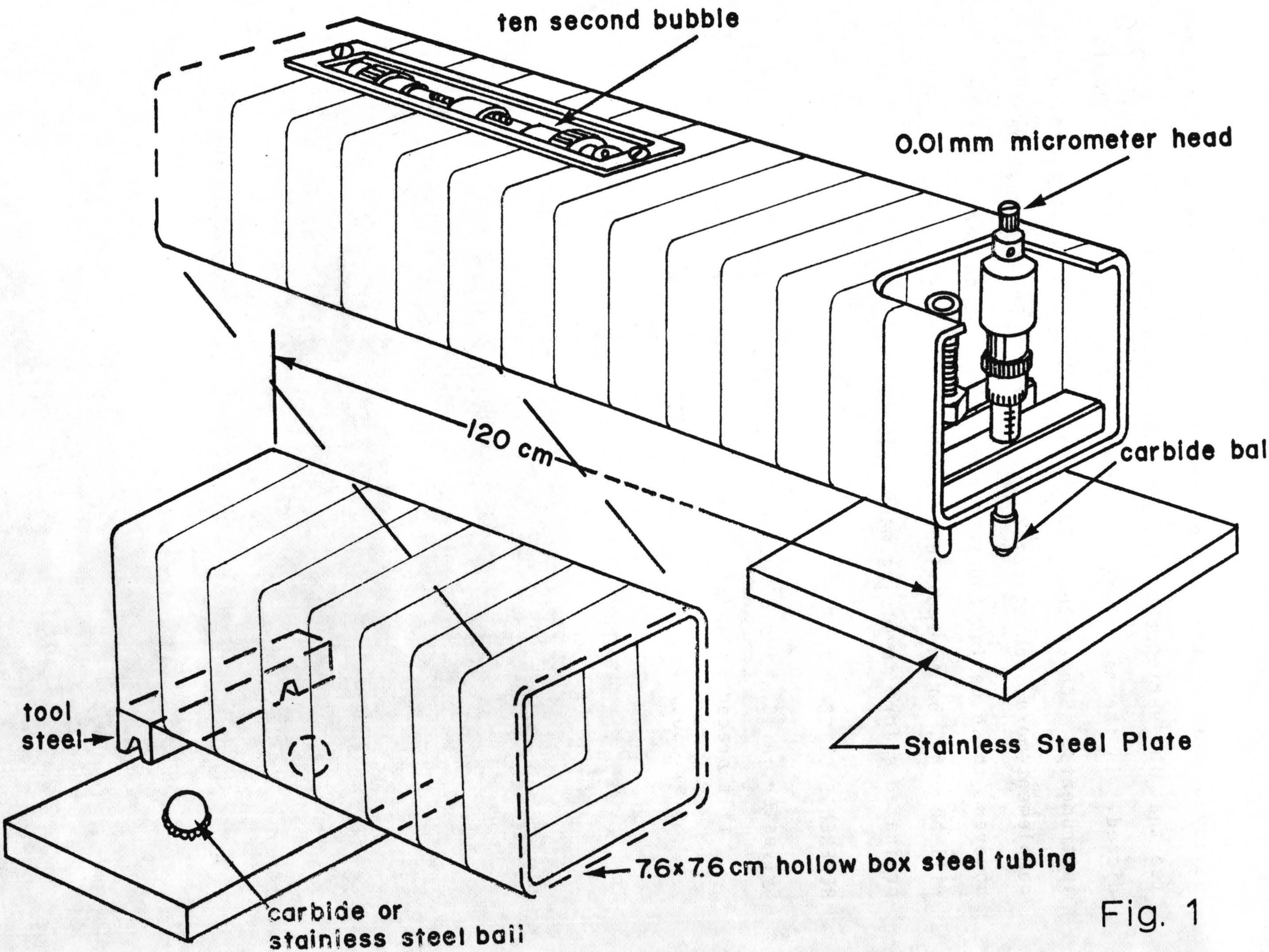
ten second bubble
0.01mm micrometer head
120 cm
carbide ball
tool steel
Stainless Steel Plate
7.6×7.6 cm hollow box steel tubing
carbide or stainless steel ball

Fig. 1

VOLUNTEER INVOLVEMENT IN ELECTRIC AND MAGNETIC STUDIES RELATED TO EARTHQUAKE PHENOMENA AND EARTHQUAKE PREDICTION

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Introduction

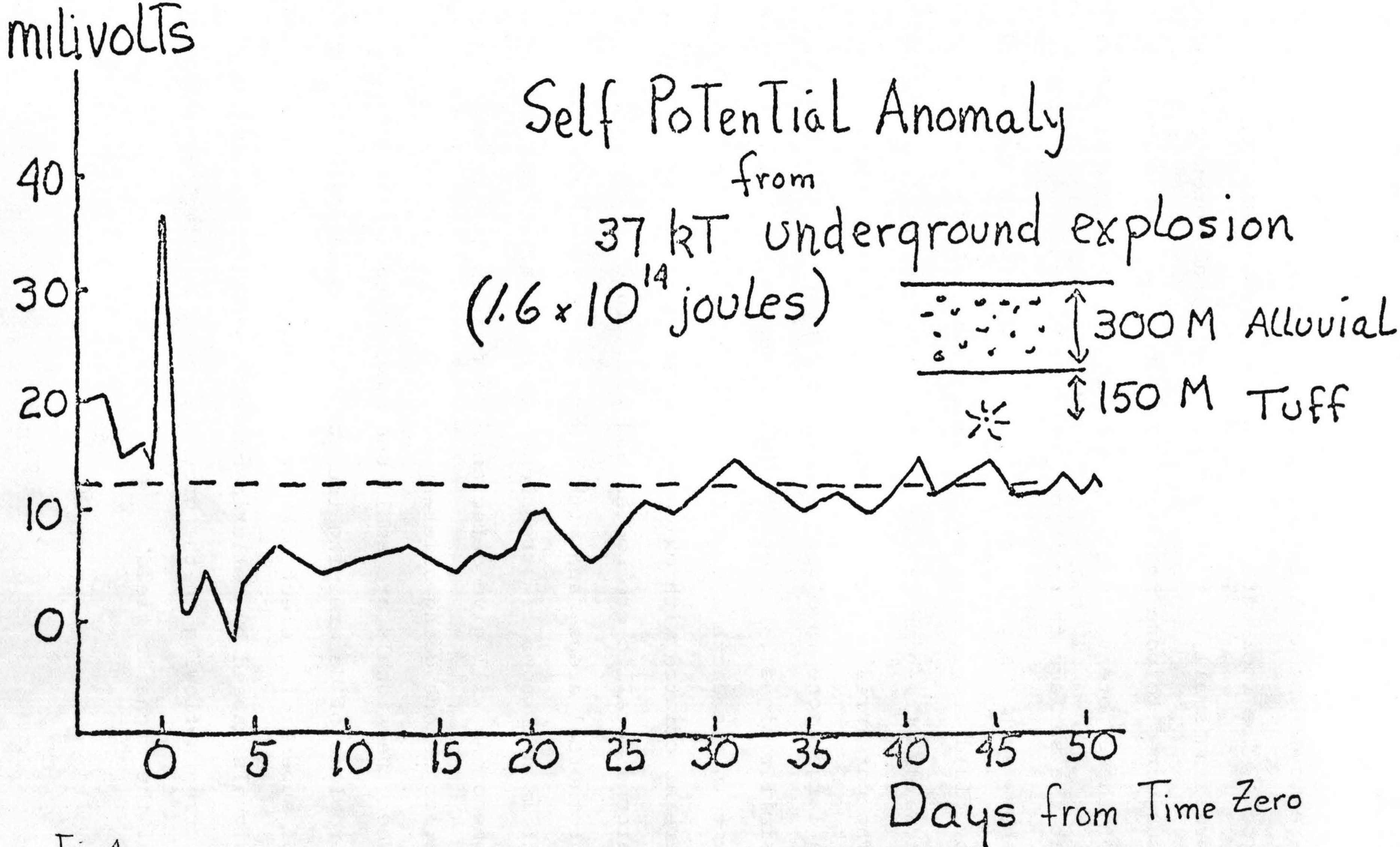
Volunteer contributions to earthquake studies and earthquake prediction can be considered at three levels. One level would be involvement in an operational system. Since our science has not advanced yet to the point where we think we understand all the important phenomena or know how to predict, participation at this level remains in the future. Another level is participation in the research on earthquake prediction. The third level is more an educational involvement, where participants would carry out studies involving fault zones and earthquakes without the direct commitment to further the research, although if possible some research component should be included. Electrical and magnetic studies lend themselves to both these last two categories. Before discussing involvement in electrical and magnetic studies, let us briefly review current ideas about how electric and magnetic phenomena might be used to study earthquake phenomena.

Electrical Conductivity

Electrical conduction in rocks and soil is due to the water in the rocks which holds dissolved salts that make it conductive and which can form continuous paths for the electric current to flow along. These conduction paths which are the cracks and pores of the rock are greatly affected by any strains the rocks undergo so that the electrical conductivity changes are sensitive measures of strain changes. The usual strain changes are extremely small, however (1-100 parts per million), so that even though the electrical properties are sensitive (electrical conductivity changes are 5-500 times as large as strain changes) very accurate measurements are required. If the rocks are stressed to the point of going dilatant prior to failure, a suggestion made by Amos Nur of Stanford University to explain many reported precursor phenomena, the resulting fluid pressure decrease could have an exaggerated effect on the electrical conductivity. (Dilatancy is the phenomena of expanding when a shear stress is applied. It is easily observed in sand when walking on the beach near the water's edge and also occurs in rocks when they are stressed to near the breaking point.)

Streaming Potentials

Because the cracks and pores of a rock are its weakest parts, any stresses are transmitted to the fluid in the rock. These fluid stresses are called the pore pressure and they are important in influencing the effective strength of the rock. The rock-water system has the remarkable ability of creating small, but measurable, electrical potentials when subjected to pore pressure gradients, and some expression of these potentials can be seen at the surface even though at the surface there is no pressure variation. Figure 1 shows such a signal, called a streaming potential, caused by fluid flow first away from and then afterwards back towards the bomb cavity of an underground nuclear explosion. The pore pressure changes were large in this example, but a larger zone involving a smaller pressure would give a similar signal. Electric signals such as this one generated within the earth are called self-potentials. Self-potentials are associated with oxidation-reduction (corrosion) reactions around metallic ore bodies and with fluid convection in geothermal areas, and with ground water flow down steep slopes. It is not known if stress changes associated with earthquake phenomena will give detectable self-potential signals, but a large zone going dilatant would probably be hard to miss. When the signals are small one must contend with special problems of determining the absolute ground potential devoid of superficial electrochemical potentials and also with the signals caused by telluric currents which are electric currents flowing in the ground induced by time variations of the magnetic field.



milivolts
Self Potential Anomaly
from
37 kT underground explosion
(1.6 x 10^14 joules)
300 M Alluvial
150 M Tuff
40
30
20
10
0
0 5 10 15 20 25 30 35 40 45 50
Days from Time Zero

Fig 1

Magnetic Variations

Magnetic minerals in the rocks in the presence of the earth's magnetic field set up a secondary magnetic field. Stress on such magnetic rocks can make small changes in their magnetic properties which will then make small changes in the magnetic field seen at the surface. Quite large magnetic field changes are always occurring, however, due to electric currents in the ionosphere and in the magnetosphere which could easily mask the small field changes due to stresses. These external field changes are quite consistent over large distances and one can detect smaller local changes by simultaneous comparisons of the magnetic field at several locations.

Atmospheric Electricity

Many people who have examined the reports on anomalous animal behavior prior to earthquakes feel that the animals may be responding to anomalous atmospheric electric fields. Also, reports of earthquake lights seem to fit the description of atmospheric electric discharge phenomena. The atmosphere is a very good insulator and it is possible to set up large electric potential gradients without much of an electric current. In fact, the normal clear air field is about 100 volts/meter and under thunderclouds it can reach 10,000 volts/meter. Anyone in such a large field knows it as his hair will literally stand on end. Most of these fields are due to the transport of ions or of charged aerosol particles by convective air motions or possibly also by the gravity fall of charged water and ice particles. It is not known how earthquake phenomena influences these atmospheric fields, if they indeed do, but a few possibilities have been suggested. One untested suggestion, which I favor, is that the top soil may contain a large charged aerosol population which if pushed out from the soil by a sort of earth exhalation could be further picked up by the boundary layer eddy diffusion processes and thus build up a large near-surface atmospheric electric field. At present this aspect of earthquake phenomena is quite speculative and its study may be rendered more difficult by the anomalous levels of aerosols in the air in many parts of California, but we are not at present drowning in any avalanche of recorded data.

Possible Volunteer Programs in Electrical and Magnetic Studies

A. Educational Programs

Most studies in this area require sophisticated equipment which makes them impractical for educational purposes. The exceptions to this are the self-potential measurements and possibly the atmospheric electric field measurements.

The self-potential measurements can be made with equipment costing $200, as only a length of well-insulated wire (100-200 meters long), porous ceramic crucibles, silver gauze electrodes, and an electronic millivoltmeter are required. The ceramic crucibles, called porous pots, and the silver gauze are used to make an AgCl:KCl reference electrode which is used to determine the ground potential and the wire is used to connect up two such electrodes so that the milivoltmeter can measure any potential difference between them. With a series of such measurements made along some sort of grid, one can map the natural self-potential field. For earthquake studies one would be interested in looking for anomalous fields associated with fault zones and especially with any time changes of these fields which could reflect unusual pore fluid flows underneath. These studies could be expanded, however, to investigate a number of other electrical phenomena. This could include the detection of corrosion currents, underground fluid flows and earth dam leakage, and the investigation of biological electric currents. The measurement technique itself needs further investigation as troublesome localized potential differences are often found which are related to not too well understood electrochemical phenomena in the top soil.

Field mills, the name given to instruments that measure the atmospheric electric field, can be constructed with easily obtainable components so that instrumenting for atmospheric electric field measurements is not expensive. Earthquake studies will probably require continuous monitoring which becomes more difficult, but related studies of animal behavior with respect to these fields would be of interest. Again, these studies could be expanded to investigate other phenomena of general interest, such as the effect of topography, trees, and smog on the fields and the meteorological factors.

B. Research Programs

In some areas of research on earthquake phenomena investigators are limited in the coverage that they can manage and since one does not know where unusual effects can arise, it is useful to have a more complete set of observations. In other cases, there are local measurements that can be made to help calibrate larger scale measurement systems. To be useful, however, these measurements must be as carefully done as those of the researchers who are being assisted by supplementary measurements. In many cases, too, it is out of the question to provide commercial equipment for use by volunteer groups, so one needs the involvement of technically-sophisticated volunteers who are in a position to put together their own instrumentation.

Self-Potential Studies

Self-potential measurements fall in the category of measurements that need to be widely dispersed. They do not need sophisticated equipment and localized anomalies could be detected without cancelling out telluric signals. As in many such studies we have no assurance that these measurements would be useful, but the discovery of self-potential anomalies along the major faults would greatly increase the possibility that one could obtain time variations of the self-potential field related to earthquake phenomena.

Magnetic Variation Studies

The magnetic variation measurements represent a special challenge to radio hams, as the measurement requires a comparison of instrument responses from stations separated by a finite distance. The U.S.G.S. array is the largest such system and it requires the use of dedicated phone lines. A U.C.L.A. study in the Palmdale area will make use of digital storage systems that can be accessed over an ordinary telephone connection for instrument comparisons. Although these continuous recording systems have certain distinct advantages they tend to immobilize the stations. Radio links or ordinary telephone links can be used to make spot comparisons of magnetic field measurements by appropriate signal-to-audio frequency conversions. The loss of resolution that spot measurements give one is somewhat offset by the ability to cover many more areas and the flexibility of focusing on a particular area of interest under short notice. The need to locate the instruments far enough from moving vehicular traffic to avoid their magnetic field signals is a limitation, however. There are many types of magnetic field detectors, some very accurate but costly. The simplest devices are flux gate magnetometers and proton magnetometers. The flux gate magnetometers detect the component of the magnetic field oriented along the axis of the detector, which has advantages and disadvantages. They can, when properly constructed, have good long term stability, but the art of such construction is still a bit of a mystery. They also require accurate orientation for comparison studies because they measure a particular field component. Proton magnetometers which detect the proton magnetic moment rotation frequency of water molecules measure the total field and are inherently a stable instrument, though quite simple. They are insensitive to orientation but since the total field changes are essentially the magnetic field changes in the direction of the total field, it is best to locate the instrument in regions of low field gradients. The simultaneous measurements are necessary because the transient variations due to ionospheric and magnetospheric current systems are much larger than any expected stress induced variations, but since these externally produced fields are very consistent spatially they cancel out to first order when finding the difference between two stations. The stations, of course, must be far enough apart to respond differently to any stress produced changes.

<u>Resistivity Variations</u>

Large scale resistivity measurements are not well suited to volunteer participation because of their cost and because of the long preparation procedures in setting up the measurement systems. Small scale measurements which are more practical can be helpful, however, both to calibrate the local effects of shallow changes which can result from climatic factors and to investigate a wider range of locations than would otherwise be covered. To study shallow resistivity changes one can use an active resistivity system. Such systems must be able to pump 500 m.a. or more at a low frequency through the earth between two electrode sites several hundred meters apart and to determine the proportionality between the current and the electric field set up some distance away (one or two hundred meters) from the current electrodes. Most transmitters are square waves because of their simplicity, and the receivers often employ synchronous detection to improve the signal-to-noise ratio. Such a system must be accurate enough to detect changes in the current:voltage ratio of 0.1% or better and stable enough to ensure that observations of such changes over a long period are real.

Because of the low power of such a system (50 watts) one cannot expect to separate the receiving dipole a great distance from the transmitting dipole and thus these measurements would only sample the near surface. Local near surface variations can influence the results of measurements made at great separations, however, and it would be helpful to have near surface data in interpreting the results of large systems.

The telluric current field, which is a noise source for active resistivity measurements, can also be used to measure the electrical properties of the earth. These fields penetrate through the entire upper crust, so that even a local measurement is influenced by deep properties. By making comparative measurements one can detect very small relative changes. This is the principal we are using on two large arrays along the San Andreas, but the measurement can be simulated with a local or small scale array using shorter period telluric signals. In our system, telluric signals from two different dipoles are used to cancel out a third signal, and time variations of the cancellation settings are used as indicators of time variations of the resistivity. Local comparative measurements are usually insensitive to deep or large scale changes, but if the changes involve the degree of anisotropy of the resistivity, which is likely, even local comparisons will detect such changes. Such local measurements have the advantage of being able to pinpoint areas of special interest and have mobility which is deprived the large arrays. The smaller dipole lengths make the measurements more susceptible to electrode noise, but this is partially offset by the use of shorter periods and reference electrodes.

Summary and Conclusions

We have briefly reviewed areas of electric and magnetic measurements that are being presently investigated as possible sources of information about earthquake-related phenomena and which might be useful in earthquake prediction schemes. Volunteers could contribute to these studies, if they are in a position to apply the necessary technology, although some of the measurements are somewhat less sophisticated. Since the present studies have limited coverage of the areas of potential earthquakes and earthquake-related phenomena, volunteer efforts could widen the scope of these studies. There are two words of caution that I would offer, however, concerning such programs. The first is that the work must be done at a high level of competence or it will be more harmful than helpful. The second concerns the involvement of the scientific community in such programs. All of those with whom I am familiar are already overcommitted and having them organize such a program would be counterproductive for the research and an unfair burden to thrust on them. Any decisions to go about such a program must include the recruiting of an adequate staff to organize the projects and not be added as another request to the duties of the scientists presently doing the studies.

The educational aspects of earthquake-related studies is in a different category as achieving advancements to our understanding is not a requirement as much as just learning about an interesting and important area of natural phenomena.

Seismic Recording in an Indigenous Earthquake Prediction Program

by John Lahr

U. S. Geological Survey

Introduction

There are many reasons why it would be useful to have greater volunteer involvement in seismic recording. It would lead to a greater public awareness of seismological problems and reduce the mystery surrounding earthquakes, the Richter magnitude scale, and earthquake prediction. There may be some instances where a group of trained volunteers could assist seismologists in a temporary earthquake recording program. Following a large earthquake, speed is important in setting up a temporary network, and a local volunteer group could help with tasks such as site permitting, geophone and antenna emplacement, felt report and damage surveys, and reporting surface fault breaks.

The cost of seismic instruments is the limiting factor in obtaining useful scientific data from volunteer seismic recording stations, although for institutions, such as schools, this may be less of a problem. In this paper the type of measurement one needs to make in order to record earthquakes, as well as the cost of various equipment options, will be discussed.

What does a seismic instrument measure?

When an earthquake occurs, sound waves, called seismic waves, are generated which travel outward in all directions in the earth. For small earthquakes, the principal frequencies of these waves are from 5 to 20 cycles per second (Hz). A seismic sensor, called a seismometer or geophone, usually consists of a coil of wire suspended by a spring in the field of a magnet. The slightest vibration of the ground causes the coil to vibrate with respect to the magnet, thus producing a small fluctuating voltage at the coil leads.

This voltage is amplified and used to drive a pen motor. The displacement of the pen turns out to be proportional to the velocity of the coil. Most seismic recorders write a record on a sheet of paper taped to a drum. The drum rotates as the pen motor is moved slowly along the drum, so that a spiral trace is written, showing a magnified version of any ground vibrations.

Earthquakes are located using the arrival time of the seismic waves recorded at four or more stations. For good locations, the relative arrival times must be accurate to at least 0.1 sec. Therefore, accurate and precise timing and uniform drum rotation is required at each seismic station. This calls for a crystal controlled clock to put a time tick on the seismic record each minute as well as periodic comparison between the clock and National Bureau of Standards time transmitted over the radio stations WWV or WWVB.

There are two types of sound waves generated by earthquakes. P (primary) waves are compressional waves and they travel the fastest. S (secondary) waves are transverse waves and their speed is about 1.8 times slower than the P waves. The time interval between the P wave and the S wave, called the S minus P time, is directly proportional to the distance from the station to the earthquake. The distance in kilometers from the seismic station to the earthquake is approximately 8 times the S - P interval in seconds. This time interval can be measured if the drum rotation speed is constant and is known. Although the beginning of the S wave is difficult to pick with sufficient accuracy to be useful in precise earthquake locations, the S - P interval would give the amateur seismologist some idea of the earthquake location, and in conjunction with S - P readings at two or more other stations, an estimate of the earthquake location can be made.

Other parameters of interest are the amplitude of the seismic signal and the duration of disturbance from the P phase to the end of the earthquake coda. The coda is the series of waves recorded on the seismogram following the P and S waves. Both the amplitude and the duration of the seismic signal can be used to estimate an earthquake's magnitude. The direction of first motion of the ground at the onset of the P phase, either up or down, is used in estimating the orientation of the fault plane and the direction of fault movement which produced the earthquake waves.

Instrumental Options

An observatory-grade seismograph system costs about $3,500. Such a system would include a sensor, crystal clock, WWV receiver, calibrated amplifier with switchable gain, and drum recorder with capillary ink pen. Supplies, such as paper and ink, cost about $75 per year.

The cost of a system could be reduced considerably by home or school fabrication of parts at the possible sacrifice of timing accuracy and amplitude calibration. The minimum specifications for a seismograph system would be a magnification of 50,000 to 100,000 at 10 Hz and a paper speed of 30 to 60 mm per minute. One could build a drum and rotate it, using an AC synchronous motor. A mount to hold the pen motor which translates along the drum on a lead screw must also be built. The cost of scrap and/or surplus parts for the mechanical assembly might be from $20 to $40. The seismic amplifier can be built with inexpensive operational amplifiers for about $15. The items which one would probably want to purchase would be the geophone (~ $25), the pen motor (from $100 to $160) and the capillary pen (~$30). Therefore, the total cost would be roughly $200 to $300.

Derivation of Useful Data from Volunteer Recording

In order to obtain useful seismic data, not only must equipment be purchased, but it must be routinely operated and maintained over a substantial period of time. This requires a long-term commitment of about one half hour per day which only the exceptional individual is likely to make. The measurement of data from many non-standardized systems also poses a problem.

For these reasons, the expected result of individual recording efforts is educational rather than scientific.

Institutions, such as schools and museums, however, in many cases have the resources and staff to purchase and operate seismic equipment that would yield data of scientific interest as well as serve educational functions. Data from stations placed so as to augment current government or university run networks and capable of maintaining 0.1 sec timing accuracy would definately be of value. In addition, even if timing accuracy has not been maintained, amplitude, duration and first-motion data could be derived from the records.

Dissemination of Information on Earthquakes and Seismic Equipment

General information on earthquakes is available now at probably every public library. The latest editions of most earth science textbooks for high school now include the fundamentals of new global tectonics, including the global distribution of earthquakes and continental drift. However, more detailed information is not readily available. Of 46 libraries on the San Francisco peninsula, from San Jose to San Francisco, C. F. Richter's book, Elementary Seismology, one of the best texts in Seismology, is available at only five. The Earthquake Information Bulletin, published bimonthly by the U. S. Geological Survey, is carried by only two of these libraries. It is a publication directed at the public and includes short articles of general interest on geophysical topics as well as a summary of current earthquakes around the world. Emphasis will need to be placed on making books and periodicals such as these much more readily available if the public is ever to take a more serious interest in seismological problems.

There have been a number of articles in Scientific American on building amateur seismic equipment, and these are listed in the appendix. None of these is ideally suited, however, to recording local earthquakes. As part of the indigenous earthquake prediction program, it would be helpful to have an instrument designed that would be inexpensive and relatively easy to construct.

Conclusions

The principal value of an indigenous earthquake recording program would be to further the interest and education of the public in seismic problems. In addition, a volunteer group could be quite helpful in some recording programs. It is not expected, however, that a significant amount of earthquake data directly useful to the earthquake prediction program would be obtained.

The cost of seismic instrumentation runs from about $3,500 for a first class setup to about $200 or $300 for a home built version. Institutions, such as schools and museums, should be encouraged to set up and maintain earthquake recording equipment. Someone from the scientific community could act as liaison between the institutions and the seismologists in order to validate that timing and calibration quality was maintained and to make copies of seismograms available to those interested. In addition, the records should be available to the public so that a person interested in local seismicity would have access to locally recorded data.

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March, 1972	226	3	114 - 119	A simple motor with compensating devices is the key to a homemade chart recorder.
November, 1973	229	5	124 - 129	A sensitive mercury tiltmeter that serves as a seismometer.
September, 1974	231	3	192 - 198	A venerable clock is made highly accurate by equipping it with quartz-crystal works.
September, 1975	233	3	182 - 188	Electronic stratagems are the key to making a sensitive seismometer.

Public Participation in Studies of Animal Behavior Prior to Earthquakes - Some Cautionary Remarks

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The last few years have witnessed a growing awareness among biologists, geophysicists, and the general public in the United States of the existence of numerous, primarily anecdotal, reports of unusual animal behavior during the times (seconds to months) immediately preceding moderate and strong earthquakes. While there is yet no conclusive scientific evidence to the effect that animals can in any sense 'predict' earthquakes, the number, variety, and world-wide origin of the anecdotal reports (see, for example, Evernden 1976), the existence of experimental, but nevertheless essentially heuristic, observations by at least three groups of scientists (Hatai and Abe 1932, Kraemer, Smith, Levine 1976, Hayden, Lindberg, Skiles 1977 unpublished) together with the well documented sensitivities of various animals to extremely subtle mechanical, chemical, and electromagnetic stimuli, do not permit arbitrary dismissal of all such reports as simply imagined or coincidental. Moreover, lay observations of animal behavior apparently form an integral part of the Chinese earthquake prediction program (Allen, et al. 1975, Allen 1976), a program which the Chinese credit with as many as 15 successful predictions, at least four of which have been documented to the satisfaction of U.S. seismologists (Allen et al. 1975, Raleigh et al. 1977).

It is not our intention to discuss the relative merits of physical and biological events as they relate to earthquake prediction. Suffice it to say that given the enormous social and economic benefits that would result from a successful prediction program, and the rather primitive state of our present predictive capabilities, the fact that observations of both physical and biological precursors have contributed to successful earthquake predictions compels us to investigate the potential of both classes of events. However, we hasten to add, indeed to emphasize, that there is a feature inherent in any animal behavior program which sets it apart from other potentially useful methods of earthquake prediction - namely the opportunity for the inexperience and subjective bias of the observer to contaminate the original data. In general, the magnitude of this problem increases dramatically with increasing observer inexperience. It is one thing to train a relatively inexperienced individual to operate, maintain, and monitor a scientific instrument, and quite another to train that individual to evaluate the significance of an event. This is particularly true of animal behavior events, events which are often difficult to categorize and even more difficult to quantify, whose significance is frequently unclear even to those most familiar with the species under observation, and which are generally recorded only in the memory of the observer (for further discussion see Lott 1976).

It is against this background that we must evaluate a program promoting public participation in the scientific effort to determine the value of observations of animal behavior to the U.S. earthquake prediction program. As scientists deeply involved in this effort, we believe there are several reasons for soliciting public participation. Each is rather obvious, and none is unique to the animal behavior component of the prediction program. However, none of these reasons is entirely free from caveats, some of which could prove fatal to an ill conceived or hastily implemented program. We therefore believe that it is essential to proceed cautiously in developing a program which involves the public in animal behavior studies, and the following discussion will be directed toward identifying the pros and cons of public participation rather than toward proposing a specific plan of action. Furthermore, because the reasons for soliciting public participation are rather self-evident, we shall concentrate on the problems which are likely to be encountered, with the result that the following discussion may appear negative. Therefore, let us reiterate our belief that a program of public participation can be beneficial, provided every effort is made to minimize the potential problems.

The main reasons for soliciting public participation may be outlined as follows:

I. to educate and continuously inform the public as to the nature, status, and importance of the earthquake prediction program, and to foster public support and cooperation with the program;

II. to increase the number and variety of reports of animal behavior (both normal and abnormal) prior to earthquakes, and to improve the quality and reliability of the reports;

III. to acquaint members of the prediction program with the problems of gathering and interpreting animal behavior observations made by laymen;

IV. to determine whether popular observations of unusual animal behavior are of value in predicting earthquakes, and if so, to lay the groundwork for an eventual large scale network of volunteer observers.

We shall comment directly on I and II only. Reasons III and IV are self-evident, and in any event, much of the discussion of I and II is also pertinent to III and IV.

I. Educating and obtaining the cooperation of the public.

Because a successful earthquake prediction program would be of obvious value to the public, and because that value ultimately depends upon public cooperation in the event a prediction is made, it is clearly essential that the public be fully and correctly informed both as to the extent of the scientific knowledge concerning earthquakes and earthquake prediction, and as to the motivations of the scientists and government agencies involved in the prediction program. The need for public education is underscored by the extent of public misinformation and misconceptions about seismic phenomena. For example, our experience indicates that substantial segments of the public in California believe that animals, and/or psychics, and possibly scientists can predict earthquakes, that scientists have, but are withholding, information concerning where and when the next major earthquakes will occur in California, or that southern California may be in imminent danger of sliding into the sea.

Because a large percentage of the U.S. human population has a fondness for, or an interest in, one or more species or groups of animals (pet owners, ranchers and farmers, hunters and fishermen, bird watchers, etc.) the potential for reaching large numbers of people and obtaining large quantities of data is considerable. Clearly we cannot hope to inform the public unless we first capture their attention. On the other hand, we should not overlook the considerable potential for discrediting the prediction program by emphasizing what is, or what at the very least appears to be, the most qualitative and least scientific of the possible scientific methods of earthquake prediction. Indeed a substantial segment of the geophysical community is disdainful of the possibility that animal behavior may be useful in predicting earthquakes, and a substantial segment of a society which has come to depend upon science and technology to solve many of its problems may be expected to share that disdain. Some might even argue that government sponsorship of a public animal observation program would only give credence to the various psychics and crackpots who frequently issue earthquake predictions.

The latter considerations need not be fatal to a program of public participation in animal behavior studies, but they clearly underscore the need for proceeding with caution. We believe that these difficulties can be largely avoided in a carefully administered program by initially making education rather than participation the primary goal. At the present time, it should be made absolutely clear to both the general public and potential participants that the animal behavior program (and indeed the entire prediction program) is exploratory rather than operational, and that observations by laymen will be of value to the program only if those observations are objective and uncolored by the observer's preconceptions regarding the intelligence, sensory capabilities, etc. of the observed animals. The widespread existence of such preconceptions presents a very real problem which can never be completely eliminated. For example, most dog and cat owners are wellaware that their pets are rather intelligent and possess sensory capabilities that humans do not. But the owner who is deeply attached to his pet and is reluctant to consider it as just another animal, is often not reluctant to endow the pet with extraordinary, even mystical, sensory and intellectual capabilities. It would not be at all difficult for such a person to recall that his pet's behavior prior to a singular event such as an earthquake was unusual, particularly if he is asked to report such behavior after the occurrence of the earthquake. This fact alone makes it imperative that any human observer program emphasize the reporting of unusual animal behavior events at the time of occurrence. Of course, retrospective reports are not without value in an exploratory program, for such reports could supply large quantities of indicative data, i.e. data which might indicate which animals, which types of behavior, and even which types of observers offer the most promise for a large scale operational program.

II. Increasing the number and quality of animal behavior reports.

At the present time the fundamental question regarding animal behavior prior to earthquakes is whether some organisms do in fact anticipate seismic events. If the answer to this question is positive, then a number of other questions immediately arise. These questions must be appreciated if we are to make intelligent decisions regarding the nature and extent of public involvement in the program. In brief, the most pertinent questions are:

1. Can certain organisms anticipate seismic events? If so,
2. To what extent is the ability to anticipate seismic events useful for purposes of earthquake prediction?
    a. How consistent, reliable, and conspicuous is the precursory behavior?
    b. How far in advance of the earthquake does the behavior occur?
    c. To what extent do a and b depend upon the organism's proximity to the eventual epicenter?

3. How does an organism anticipate an impending seismic event?
   a. What physical seismic precursors do organisms respond to?
   b. What biological sensors are used to detect the precursors?
   c. Are these physical phenomena the same as those already being investigated by seismologists?
   d. Does an organism respond to
      i. only one type (i.e. magnetic, electric, mechanical, chemical, etc.) of precursor?
      ii. any of several types of precursors?
      iii. only particular combinations or sequences of precursors?
4. Do any of the biological systems provide useful models for human technology?

None of these questions is entirely independent of the others. However, it is clear that observations by the general public could contribute measurably to the answers to questions 1 and 2, only slightly to the answers to 3, and at best indirectly, and probably not at all, to the answer to 4. Any contributions to 3 and 4 should be largely indirect and consist primarily of the constraints that answers to 1 and 2 place upon the answers to 3 and 4. The only significant direct contribution to 3 would be whether or not the observers themselves had noticed (either directly or via instruments) any nonbiological earthquake precursors which could have or should have precipitated unusual animal behavior.

With regard to question 1, additional anecdotal data will probably be of limited value. Reports from laymen, particularly retrospective reports obtained after an earthquake, would only underscore the need for critical scientific investigation, a need which already appears justified to most biologists and geophysicists who have carefully examined the plausibility of unusual animal behavior prior to earthquakes (see Evernden 1976, in particular Logan 1976). Of course, numerous consistent and dramatic reports of unusual animal behavior issued prior to an earthquake (an unlikely event in light of what we already know) might do much to accelerate the development of what ultimately may prove to be a valuable component of a U.S. earthquake prediction program.

On the other hand, there is a much more sobering scenario. It is entirely possible that a popular observer program would produce little or no evidence of unusual precursory animal behavior, and lead us to conclude that no such behavior exists, when in fact the conclusion is based on poor observations, lack of discipline or sustained interest on the part of the observers, observations of nonresponsive species, or the general subtlety of the precursory behavior.

With regard to questions 1 and 2, obtaining reliable observers will not be very easy. We hasten to add that the term 'reliable' applies to the quality of data obtained and not to the motivation or integrity of the observer. There are many eager and dedicated volunteers whose work must nevertheless be closely monitored because they have had no opportunity to develop the discipline instilled by formal training. On the other hand, it is not uncommon to find amateurs whose performance equals or exceeds that of the professionals.

Here it would be well to indicate a few of the problems that even professional animal behaviorists encounter in evaluating behavior.

i. Limited behavioral repertoire. There are only certain things an animal does or even can do, and the number and variety vary from species to species. For example, it is not unreasonable to expect a chimpanzee to behave differently if frightened by thunder on the one hand or by a predator on the other. But a horse, or a cow, having much more stereotyped behavior, is likely to react to both stimuli in much the same manner. In other words, the response is not stimulus specific. This, in fact, is one of the major problems encountered in assessing reports of unusual animal behavior prior to earthquakes - the behavior reported is almost invariably one which can be elicited by a variety of stimuli.

ii. Subtle and apparently incongruous responses. Some behaviors are sufficiently subtle to go unrecognized except by persons intimately acquainted with the species (or even the individual) under observation or by persons using special monitoring equipment. For example, when mildly frightened, many animals simply increase or decrease their heart rate. On the other hand, some animals run when frightened while others freeze in their tracks. A person accustomed to seeing birds take flight when frightened might ignore the freezing response of an equally frightened bird.

iii. Interindividual and intraindividual variability of response to the same stimulus. It is well known that individuals of different species or even different individuals of the same species often respond to the same signal in entirely different manners. Some may even respond dramatically, while others appear unaffected. Such interindividual differences are often inherent. What is often not fully appreciated is that many individuals will at different times or under different conditions respond in an entirely different manner to the same stimulus. Such intraindividual variability, as well as much interindividual variability, can depend on the time of day, the animal's reproductive state, nutritional condition, previous experience, or upon the context in which the stimulus is presented.

A public participation program which fails to take into account the above considerations will be of little value and possibly even detrimental. If this pitfall is avoided, however, then information obtained from the public could be of immense value in determining the extent to which animal behavior is useful for earthquake prediction (question 2 above). If reliable observers can be found and trained, then the broadest possible observer network is desirable as this would ensure the interception of the greatest number of seismic events and the observations of the greatest number of species and individuals.

This brings us to the operational question of how broad a public participation to solicit. Is the entire U.S. population to be involved? Only Californians? Only persons living in known regions of seismicity? If the primary purpose of the program is to educate the public to the need for earthquake hazard reduction, then a broad participation is desirable. If the primary purpose is to complement more formal scientific research, then a more select population of highly reliable observers is more valuable. One choice does not preclude the other, but even in a program utilizing volunteer observers economics may force a choice.

Ultimately, of course, the responsibility for assessing the validity of the reports received rests with the scientists and administrators of the prediction program, so it could be argued that despite the above caveats, the broadest possible program, involving the greatest number of observers, will provide the greatest number of true reports. This appears to be the philosophy of the Chinese, since there is every indication that they simply solicit and accept reports of unusual animal behavior from almost anyone and everyone. Once the reality of biological earthquake precursors is established and broadly accepted in the United States, then the Chinese system may indeed be the one to use. But until that reality is firmly established, the considerations outlined in the previous discussion argue strongly for a rather modest program of public involvement in the animal behavior program.

POSTSCRIPT

The preceding remarks were prepared prior to the Workshop on a Volunteer Earthquake Prediction Program. Participation in the workshop has not altered our views, but it has given us a much clearer picture of the nature and extent of the public participation which we might reasonably expect to obtain.

Several possible modes of public participation were discussed during the workshop, and we were able to benefit from the comments of representatives from many established volunteer organizations and from the comments of other scientists involved in earthquake prediction research. The possible modes of participation in animal behavior studies comprise four types of volunteers: i) small numbers of carefully selected individuals who work closely with a scientific investigator, ii) persons such as farmers, ranchers, zoo keepers, and veterinarians, iii) members of the general public not necessarily associated with a volunteer or service organization, and iv) members of organized educational, volunteer, and service groups such as 4-H clubs, girl and boy scouts, secondary schools, amateur radio operators, etc.

Type (i) individuals have often made valuable contributions to scientific research and are currently involved in our animal behavior project. However, the number of such individuals who can be usefully employed is extremely small, so that this group is not particularly relevant to the present discussion. Type (ii) individuals are currently being used and/or considered by other groups of scientists involved in animal behavior studies and are discussed elsewhere in the workshop proceedings. Participation of such persons could prove quite fruitful, particularly in terms of questions 1 and 2 on page 5 of this article. The value of the data obtained will be proportional to the breadth of the geographical coverage and/or density of the coverage in a highly seismic region. However, considerable effort must be expended to organize and coordinate a study involving such persons.

At the present time, the participation of type (iii) individuals is the least desirable because they form a completely unstructured, heterogeneous group. The problems of dealing with such a group are obvious and manifold. In all probability, information from this group would have to be solicited via the mass media and would consist primarily of reports of fortuitous observations of allegedly unusual animal behavior. The data would be extremely noisy and consist largely of fanciful, irrelevant, and probably even fake observations. Owing to news media publicity of our research, we have received from the general public many well intentioned, but mostly fanciful or irrelevant, reports of unusual animal behavior prior to earthquakes. We believe that this mode of public participation is best deferred until the usefulness of animal behavior for earthquake prediction in this country has been firmly established.

In terms of educating the public, obtaining information to supplement our formal scientific research, educating ourselves, and laying the groundwork for an eventual large scale network of volunteers (cf. items I, II, III, and IV, p. 3 of this article), we find the participation of type (iv) volunteers most appealing. The large size and broad geographical distribution of the membership and the formal and highly organized structure of many educational, volunteer, and service groups of the kinds which participated in the workshop makes them ideal for an educational and information gathering program. An individual's membership in such an organization often indicates that he or she is probably sufficiently motivated to make a useful contribution to an observational animal behavior program. In other words, the established organization may well have served as a first filter eliminating those whose participation would be of doubtful value to the program. (This is not to say that only members of organized groups can become useful volunteers!).

The ability of the leadership to communicate quickly and personally with the membership and to channel the flow of information from the membership to those analyzing the information are additional valuable assets of an established organization. Furthermore, many members of groups such as 4-H Clubs are already involved in animal care and observe their animals on an almost daily basis. Hence the time required to organize a volunteer program would be minimized and the efficiency of data gathering and value of the data collected would be maximized.

Let us now outline the kind of program and observations that we believe would be most useful. It is designed to maximize the probability of contributing to the answers to questions 1 and 2 posed on page 5. Once such a program is operational, many improvements will undoubtedly be forthcoming.

First, the participant would be expected to observe his animal or group of animals on a regular, daily or almost daily basis. A student with an animal project at his or her school would not be expected to make observations on weekends. Occasional interruption of the observation schedule by illness, vacation, etc. would also be acceptable. Second, the participant would be required to faithfully record the observations as they were made, not several hours or several days later. An important aspect of the study is to record unusual animal behavior events prior to an earthquake. Events recalled after an earthquake can never be entirely objective or convincing.

Third, the observer should never fill in the gaps in the observation record with assumed or manufactured data, and should not turn over the observation and recording responsibilities to someone else (during illness, vacation, etc.) without that fact being clearly recorded. In no case should a volunteer be chastized for recording the fact that he did not make any observations on a particular day. This is to be, after all, a volunteer program in which the honesty of the volunteer is a prime virtue. There is no reward for filling in a record merely to make it look good. Such procedure is clearly inimical to a scientific search for truth.

Fourth, the observer would be required to forward his records to his parent organization or directly to the project manager on a regular basis. He is of course free to keep a copy of the records for himself if he wishes. It would probably prove too costly and time consuming to have the observer forward his records on a daily basis. Once a week or even once a month, depending on the observer's preference, would be adequate. If the observer strictly abides by the preceding faithfulness and honesty procedures, there is little to be gained by a daily reporting effort.

The actual observing and recording can be outlined as follows. Let us assume, for example, that we have a volunteer with a pet such as a dog or a horse which the volunteer regularly visits to feed, groom, ride, etc. At the beginning of the project, the person would be asked to carefully observe and record in detail in his own words his animal's behavior on a daily basis (or nearly daily basis if that is the regular routine) for a period of, say, two weeks. This would heighten the observer's awareness of his animal's behavior, develop in him the habit of taking note of that behavior, and allow him to formalize in his own words what is 'normal' behavior for the animal. At the end of this period, the individual would then write a brief report of his animal's behavior during the period, including a summary of the animal's normal behavior and an assessment of the daily consistency and predictability of that behavior.

Upon completion of this preliminary observational study, the volunteer would begin recording behavioral data specifically for the earthquake prediction study. The observations would be recorded on a standard short form provided by his parent organization. The form would simply list four or five categories (e.g., activity, vocalization, excitability or restlessness, and 'other') for which the observer would rate the unusualness of the observed behavior on a scale of 1 to 4 (1 = normal, 2 = somewhat unusual, 3 = definitely unusual, 4 = exceptionally unusual). Whenever he rated the behavior 3 or 4, the observer would write a brief explanation on the form, explaining what the behavior was, why it was unusual, and how often it had previously occurred.

Using these data, the project director could obtain a daily numerical index of the normalcy or unusualness of the animal behavior in a particular geographical region. When an earthquake occurred in a particular region, the index for that region could be examined and the value immediatly prior to the earthquake compared with the values at times not immediately preceding earthquakes.

The value of the data obtained from such a study would be in direct proportion to the number of regular observers involved, particularly the number of observers located in a region experiencing an earthquake. Broad geographical coverage is also important in order to increase the probability of having observers in a region which experiences an earthquake.

Despite the latter consideration, it would probably be most prudent to begin such a study on a modest scale by confining the study to a few highly seismic regions such as the San Andreas fault zone near Hollister, California.

If begun on too large a scale, the study would soon become bogged down by intractable quantities of data, before efficient data gathering and analysis procedures could be developed.

While such a study would undoubtedly be of greater value if directed by a scientist involved in earthquake prediction research, there is no reason why organizations such as schools and scouting groups could not undertake such a study on their own. The U. S. Geological Survey or other interested scientific organizations could assist such programs by developing a brochure providing background information on unusual animal behavior prior to earthquakes and outlining and suggesting operational approaches to the type of study outlined above.

In closing, let us note that as scientists involved in the study of animal behavior prior to earthquakes, we would be most interested in the results of such a study whether conducted by us or by a group of dedicated volunteers. If carefully designed and conscientiously executed over a period of from many months to several years, the study could provide convincing evidence of unusual animal behavior prior to earthquakes, if such behavior indeed occurs.

A final word of caution to those interested in undertaking a study of animal behavior prior to earthquakes - while the possibility of obtaining valuable information from the study is very real, the potential for disappointment is also considerable. Even in California, earthquakes are in most regions relatively uncommon. Thus it is possible that a study could be conducted for a year or more without ever intercepting an earthquake. Moreover, the reality of unusual animal behavior prior to earthquakes has not been proven, and it appears that many earthquakes are definitely not preceded by unusual animal behavior. Therefore, it is possible that the study will produce only negative results or even no results at all. Perhaps, however, the participant will find, as we have, that this uncertainty adds excitement to the study by enhancing his or her awareness that he or she is truly exploring the unknown.

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THE USE OF VOLUNTEER OBSERVERS TO DETECT ABNORMAL ANIMAL BEHAVIOR PRIOR TO EARTHQUAKES

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An ideal earthquake prediction system would use cheap, sensitive, easily interpreted instruments located everywhere that a damaging earthquake might occur. If animals responded to earthquake precursors in a way that humans could interpret, the animals would serve as just such an instrument. Most areas that are vulnerable to damage from earthquakes have a substantial population of people. Such a population is generally what makes an earthquake significant in human terms, and where there are people there usually are animals.

But even if animals should prove responsive to earthquake precursors, there are several potential obstacles in the way of converting that responsiveness into an earthquake prediction system.

In this manuscript we address the purely technical aspects of using observations of animal behavior reported by the general public to predict earthquakes. Even to address such a question could be taken to imply that animals detect and respond to earthquake precursors, an implication which we think is by no means justified by current information. Consequently, we emphasize that we are speculating about a hypothetical state of affairs. If it were the case that animals detected and responded to earthquake precursors, then a scheme to use that information via reports of the general public would have to solve the following problems:

It is possible and even likely that sensitivity to earthquake precursors will differ from species to species and from individual to individual within a single species. In such a case only a few of the animals in any one area might perceive a precursor. Since it would be rare for the behavior of an individual animal to be recorded prior to several quakes, it would not be possible to "calibrate" an animal as an earthquake prediction instrument. Thus it is unlikely that the response of any one individual animal would be definitive.

The problems inherent in using animals as sensors are amplified by the problems of using humans as interpreters of the animal behavior. People rarely have difficulty in interpreting animal behavior which signifies anger or sexual motivation. The reason for this is that animals have easily recognized behavior patterns especially evolved to communicate such important social information. There is no reason to believe that animals will have a similar well-developed pattern of behavior for communicating their perception of earthquake precursors.

Since the behavior of animals is determined primarily by their natural selection history, they are not selected to respond to indications of events that are of little or no consequence to them, and humans are almost the only animals whose lives are ever significantly influenced by earthquakes. Consequently, the response of animals to earthquake precursors might take the form of an anticipation that something were going to happen without any sense of what that something might be. An example of this problem might be an animal's uneasiness upon perceiving a completely unique sound in the distance. This uneasiness might be a characteristic response to the occurrence of an uninterpretable stimulus. However, the animal might make the same response to the sight of a predator very far away. A human observer of an uneasy animal might fail to spot the predator in the distance and so mistakenly believe that there was no usual cause for the animal's behavior. He or she might then attribute the behavior to an earthquake precursor thus leading to a false positive prediction. On the other hand an animal might respond to an earthquake precursor by behaving uneasily. The observer might then attribute the behavior to the presence of a predator which the observer mistakenly thought he or she saw thus leading to a false negative report.

Thus we would expect that there would be difficulty in interpreting the record even if the whole record of animal behavior were available. Unfortunately this problem is further confounded by the fact that the whole record is not likely to be available. Most of the behavior of most animals goes unobserved, so it is rather likely that if responses did occur, many of them would go unnoticed.

All these features of the system are noise which will lead to grave difficulty in detecting any existing signals. Therefore the possible approaches that we will outline below are designed to enhance our ability to separate any existing signals from these sources of noise.

We will be concerned only with the animal population as it currently exists in California. We will not discuss any plans which involve "instrumenting" the San Andreas fault with rodents, insects, fish, etc.

One way to remove some of the problems inherent in human observations of animal behavior is to utilize some quantifiable measure of animal behavior. Two such measures suggest themselves: egg production and milk production. Both chickens and dairy cattle are known to be sensitive to changes in their environment, and in some cases the change in environmental factors has been shown to affect egg and milk production. Thus if these animals are sensitive to seismic precursors, the effect of this sensitivity may show up as a change in production. This change would probably involve a decrease rather than an increase.

The simplest approach to the use of volunteer observers would be to obtain daily reports of egg and milk production on farms along a portion of the San Andreas fault. However, such an approach overlooks many important factors. In the first place since production can be affected by a variety of factors, it is important to obtain a more complete report than simply total production. Such variables as herd or flock size, nature of feed, weather, and the introduction of new (and hence socially disruptive) animals must also be reported.

In the case of dairy cattle, the fluctuations in herd size can be significant. In order to obtain useful data, it is probably necessary to monitor the daily production of individual cattle. This can be done through the use of a flow meter placed in the milking line. We envisage a monitoring system in which ten cows per herd in five herds in a particular area would be monitored on a daily basis through a central office. Each farmer in the study would be furnished a flow meter for the cows being monitored. In addition he would be equipped with an extension telephone service and data transmitting console so that from the milking parlor he could relay his farm number, identity of the cows, and their production twice a day. Although such a system would be considered voluntary, we recognize that farming is a commercial venture and that we must reimburse a farmer the additional time he must pay his milker to assemble and transmit the data. A possible alternative would be for a member of the farmer's family to volunteer to collect and transmit this information.

A monitoring system of the type proposed for either egg or milk production would have two main objectives. In the first place, it would determine whether specific quantifiable variables can be used as a means of detecting earthquake precursors. Secondly, it will provide information and insights into any monitoring system involving the precursory response of domestic animals. To some degree the first objective depends on the type of seismic activity which does occur in the region being monitored. Even if no seismic activity were to occur over a period of time, it should be possible to reach a definite conclusion as to whether it is worthwhile to continue to consider these quantifiable variables as possible indicators of earthquake precursors or whether there is too much inherent "noise" in these records to be able to hope to sort out fluctuations due to earthquake precursors.

An alternate approach would be to encourage a selected group of volunteer observers to report all observations of apparently abnormal animal behavior. In practice this could be accomplished by providing a toll-free number which observers could call at any time in order to tape record the nature of their report.

The nature of reports received by such a system would range from normal behavior improperly interpreted as abnormal by the observer, to abnormal behavior resulting from non-seismic causes, to abnormal behavior actually related to pre-seismic precursor events (if such a phenomenon does indeed exist). Any attempt to assess the content of these reports would pose an immense problem. It is highly likely that few if any observers will provide sufficient information to permit an animal behaviorist to properly evaluate both the nature of the behavior which has been observed and the ability of the observer to report animal behavior accurately. Thus to evaluate properly the value, accuracy, relevance and significance of each report would involve extensive and time-consuming follow-up. Furthermore such follow-up would have to involve personal interviews in the field rather than telephone call-backs because there are aspects of the evaluation of an observation which can only be analyzed by actual on-site examination of the relationship between an individual and his animals.

Therefore, rather than evaluate each individual report, we would propose that the number of abnormal reports received each day be treated as an input signal consisting of a true signal, that is, all reports which might be caused by a seismic-related precursor, and noise, that is, all reports which are not relevant as possible seismic precursors. The initial analysis of the data would then involve analysis of the number of reports received in any twenty-four hour interval and comparison of significant changes in the number of reports with the occurrence of seismic events. As in the case of the analysis of milk and egg production, the critical question is whether the number of reports related to seismic precursors will generate enough of a signal to be distinguishable above the general level of non-seismically generated noise.

There are many problems related to this approach to the use of indigenous observers to report abnormal animal behavior. One general problem bears directly on distortions of the very signal which we would be trying to measure. Many people in California appear to be quite willing to accept the belief that abnormal animal behavior does indeed precede earthquakes. Given that fact, it is necessary to raise the question of whether the publicity associated with the use of volunteer observers will lead not only to the stimulation of useful reports but also to the generation of many real and erroneous reports of abnormal animal behavior which are unrelated to seismic precursors. Thus the effect of the project may be to increase the level of noise to the point where the signals are obscured. Another aspect of the problem of distortion involves the effect of the effort required to make a report. The initial level of awareness of abnormal animal behavior merely involves making a mental note of an animal's behavior. Quite often the realization that this behavior could be interpreted as abnormal only occurs after some other event such as the discovery of a predator or the occurrence of an earthquake. A higher level of awareness arises when the behavior is in some sense so unusual that at the time of the behavior the observer is moved to comment on the behavior to someone else. Presumably an even higher threshold must be reached before an individual will be moved to phone in a report. Although these considerations apply to both those observations which are noise and those which are signal, the degree to which each is affected may be different. Indeed if seismic precursors are in some sense "subtle" then the proposed system may actually filter out the signal which is being sought.

Other problems relate to the number and distribution of the reports which might be forthcoming. At the present time it is impossible to predict how many reports can be expected daily from a given region as a function of its areal extent, number of telephones, human population or animal population. Clearly public awareness of the abnormal animal behavior will be highest when publicity about the system is greatest. Thus we would expect that a large number of reports would be received initially, but that with time there would be a significant decrease in the number of people who would be moved to report an observation of abnormal animal behavior. In the absence of additional and continuing publicity, there is no way to estimate to what level the number of reports will fall. Furthermore to some undetermined extent the responses may be susceptible to stimulation by external factors such as the occurrence of a large and/or deadly earthquake elsewhere in the world. These questions relate only to the willingness of observers to report animal behavior. Another variable concerns the actual behavior of the animals. We do not yet know what is the normal level of abnormal animal behavior and to what degree it can vary. The important questions arising from these considerations of both observers and animals is not only the level of reports which can be expected but also the daily fluctuations in that level. It may well be that these natural fluctuations are so large that it would be difficult to distinguish them from changes due to earthquake precursors.

Another related problem involves the regional extent of abnormal animal behavior which may be associated with earthquakes. The range of such phenomena for moderate earthquakes may only be within a few kilometers of the epicenter of an earthquake. In that case, even if reports are being counted from a small region of 100 square kilometers, the few important reports from the 5 square kilometer zone around the epicenter may well be lost in the background level of other reports from the entire region. On the other hand, if the 100 square kilometers are analyzed in terms of 5 square kilometer cells, the daily fluctuations within each cell may be great enough again to obscure the desired signal.

We are not very optimistic about the utility of either of the plans which we have presented. We feel that at the present time they represent the two best approaches to the use of volunteer observers to detect abnormal animal behavior prior to earthquakes. However each approach contains many serious problems as well as large areas of uncertainty which must be resolved before these approaches can be tried.

MOBILIZING THE MASSES IN CHINA*

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Mobilizing the Masses

(Ralph H. Turner)

The Chinese speak of "mobilizing the masses" to identify the involvement of the community at large in the earthquake-hazard mitigation enterprise. The involvement of lay people in prediction is something we have not seriously attempted in the United States. We may have much to learn from the Chinese experience. It is recognized in both countries that implementation of a hazard-reduction program after the prediction has been made can only succeed through successful involvement of the entire community. We have attempted to look at mass involvement in the Chinese effort both before and after the prediction.

Amateur Groups in Prediction

One of the most striking contrasts between Chinese and American earthquake prediction progams lies in the emphasis on mass participation in China. There are two aspects to this emphasis. One is the use of volunteer observers, organized into "amateur groups." The other is the explicit recognition and use of traditional folk wisdom. Although amateurs usually receive at least a modicum of training in scientific conceptions of earthquakes, and many are taught to use modern equipment, the relationship is not one of simple cooptation. The majority of the amateur groups are chiefly engaged in making observations based on folk wisdom, and many of those making observations based on scientific conceptions have devised or at least manufactured some or all of their own equipment for making observations. Thus there is a comprehensively "grass roots" component that plays an integral part in Chinese earthquake prediction.

Nature of Amateur Groups

Although they have not been used in earthquake prediction, volunteer groups play an important role in American Society. Nearly every important public service sphere has its volunteer component. In post-disaster crisis, most of the Red Cross workers are volunteers, though many are not strictly amateurs. During and immediately after World War II an army of civil defense volunteers was maintained in readiness, and a recent study has reported widespread readiness to volunteer in case of need. The closest parallel to earthquake prediction is found in the extensive and long-standing use of volunteers by the United States Weather Bureau, as substation operators and as tornado spotters. Since there is abundant precedent for the use of volunteers in the United States, it is useful to examine the Chinese experience with an eye to the possible use of volunteers in American earthquake prediction.

Problems in the use of volunteer amateur groups include incentive, control, and communication. What incentives are there to insure dependable performance of repetitive and often unchallenging tasks without work credits or pay? What controls are there against irresponsible and inaccurate reporting? What system of communication is established to insure timely receipt of all reports and referral of significant information to decision makers? Answers to these questions are derived from two sources: discussion with officials from the State Seismological Bureau concerning organization of amateur groups on a national basis and in the Peking area; and meetings with members of amateur groups in the southern Liaoning region.

State Seismological Bureau officials identified three types of amateur groups. "Backbone" groups are large in scale, have sophisticated seismic instruments, engage in some research, and sometimes even make predictions of earthquakes. While members of these groups are volunteers, they have considerable technical knowledge. More common are the "Ordinary" amateur groups. These groups have simplified instruments, often of indigenous design or manufacture. They frequently exchange data with other amateur groups and professional stations. Still more common are the "Macroscopic observation" groups who work without special equipment and with little if any training. These groups, sometimes consisting of only one or two people, watch for anomalous animal behavior, changes in level and clarity of well water, meteorological changes, and earth lights and earth sounds. While the first two kinds of groups keep daily records of their observations, the macroscopic observation groups merely report when anomalies are observed.

An important feature of the amateur group network is a system of dual lines of authority and responsibility. Amateur groups report to the local seismic station and receive technical training and advice from there. But each amateur group is also an integral part of some functioning civil unit. Many amateur groups are attached to schools, especially middle schools, and are responsible to the school's revolutionary committees. In cities a street committee or factory community or other work unit may have an amateur group. In the country a commune or brigade may be the unit. The group may already exist as a functioning part of the larger unit, as in one instance we observed in which the telephone exchange operators were constituted as the amatueur earthquake prediction group. Special-purpose amateur groups are located in significant organizational settings, such as the amateur group to watch for anomalous animal behavior in the urban zoo and a two-person group to record radon-content and water level at a famous hot springs. If we employ the analogy of line and staff, line authority is from the parent unit's revolutionary committee to the amateur group. The seismic station serves a staff function, supplying technical advice but having no direct authority over the group.

The dual authority system contrasts with the single line of authority employed by most American agencies that use volunteers, and adds substantially to the basis for both incentive and control. With a single line of authority a volunteer's activities are of little concern to his neighborhood or work associates, who neither take credit nor feel responsible for his performance. In case of flagging interest, the volunteer can withdraw, experiencing social disapproval only from persons who are peripheral to his life. In case of notable achievement and diligence, there may be no carry-over of prestige from the segmented context of volunteerism to the neighborhood and workplace. Under a dual system the opposite is true of each observation. The entire brigade, commune, or factory takes pride in the accomplishments of <u>their</u> amateur group and the revolutionary committee is continuously apprised of the group's activities. In keeping with this observation, the great majority of people who engage in regular volunteer work in the United States do so through church or school, both of which provide more of a parallel to the Chinese arrangement than detached volunteers do. The recommendation for the United States would be to attempt to establish volunteer units in schools, Four-H clubs, and similar organizations, rather than to solicit individual volunteers who would report only to the seismic authority.

Chinese amateur groups are organized in either of two ways. Initiative may be taken by seismic stations, whose professional personnel go out to factories, schools, communes, etc., where conditions are favorable and an observation point is needed, to secure cooperation from the civil unit in organizing a group. In other instances the initiative comes from the grass roots, and the factory, brigade, or school organizes its own group, with help from the seismic station. In either case, the group is established as an integral part of the sponsoring unit. When costly equipment must be purchased or maintained, the State Seismological Bureau makes funds available. But the expectation is that the parent unit and members of the amateur groups themselves will make whatever contribution they can. Revolutionary committee spokesmen at Shenyang Middle School Number 13 were proud that much of the equipment and even the building were constructed by students and school personnel.

American experience indicates a preference for volunteers who already possess specialized knowledge or skills or equipment relevant to the volunteer activity. The U.S. Weather Bureau relies increasingly on owners of citizen band radio equipment for their corps of tornado spotters, and the American Red Cross recruits medical and paramedical personnel into their disaster volunteer ranks. Although we could not locate or conduct a census of amateur group members, there may be some tendency of this sort in China. In cities the amateur groups are mostly located in factories and schools where there are resources, technical equipment, and relevant skills, rather than in street committees. Some of the most impressive groups are adjuncts to Middle School science programs. Examples of vocational proficiency applied to earthquake prediction include an engineer from a mineral exploration firm making geomagnetic observations and two doctors analyzing radon content of water at a public spa. Rural groups are more likely to use the ordinary peasant, whose intimate familiarity with animals and the wells in his locale give him a different kind of expertness.

An obvious problem with volunteer workers is to maintain continuity of effort. In times of obvious crisis such as war and disaster there is no shortage of willing volunteers. American experience indicates that volunteer tornado spotters are easily recruited and reliable in part because they are used in areas where there are annual tornado seasons. Amateur weather observers who make daily reports on a year-round basis are more difficult to keep motivated, but relatively good success is achieved in part because the amateur observations make a recognizable contribution to the continuously useful weather reports. With many years between serious earthquakes and no call for daily reports making use of amateur observations, the question is how a routinized, disciplined pattern of observation and record-keeping or anomaly-reporting is possible. That the Chinese recognize this problem is suggested by the choice of a motto by workers at the Shipengyu Seismological Station of Yinkou City, namely: "Rather a Thousand Days with no earthquake than one day with no precaution."

The decision to "mobilize the masses" in the earthquake prediction effort was made nationally in China in 1966, but the program to establish amateur groups did not get under way until 1970. Amateur groups were first organized in the Yingkou area in 1972. However, within the impact area of the Haicheng quake, the serious effort leading to the organization of several thousand amateur groups occurred between June and December, 1974, immediately after issuance of the medium-term earthquake prediction for the area. Thus, most of the groups were crisis groups, motivated by the imminent prospect of local disaster. The readily perceptible 4.8 shock at Liaoyang in December, and the December and January regional conferences bringing intensified earthquake prediction, would undoubtedly sustain the volunteer incentive. There is little difficulty in understanding the continuation of backbone and ordinary groups for the sixteen-plus months since the main Haicheng quake. Systematic information on the current status of macroscopic observation groups was not secured and may not be readily available, though we were assured that many are operating in the Peking environs even though no predictions have been issued here. Macroscopic observation groups are probably most vulnerable in sustained periods of normality. There has been insufficient time for an adequate test of the staying power of amateur groups in China, but we have a clear example of the effective mobilization of many such groups in sufffficient time to contribute materially in the prediction.

A prototype pattern of communication was suggested for the Peking area. Amateur groups normally report their observations to the Peking Seismic Office and nearby seismic station, substation, observatory, or other unit. In some instances macroscopic observation groups report to a backbone group. Very few groups report regularly: the usual practice is to report only when an anomaly is observed. When such reports are received, especially when the source is a macroscopic observation group, seismic station and office personnel check on the spot to verify the amateur observations, if they seem serious. The amateur group also reports to the revolutionary committee of the civil unit in which it is lodged, so that the communication involves both lines of the dual authority discussed earlier.

The pattern will be different in other areas, depending upon the available units. Brigade or commune officials may verify well-water and animal-behavior reports and then relay them to the seismic station, that is likely to be more remote in rural areas. At the peak period before the Haicheng quake there were many reports from individuals who were not members of designated groups. These were sometimes made to amateur groups and entered into the same communication channels. It seems unlikely that all such reports could actually have been verified in the peak period. But the normal practice of confirming observation as the next step in the communication sequence undoubtedly imposes some control on irresponsible reports and provides an occasion for on-the-spot training of amateur observers.

Besides the function of generating information for prediction purposes, and in some cases suggesting a prediction to civil authorities, amateur groups play a considerable part in mass education concerning earthquake and sometimes play a supporting role in earthquake protection activities, especially in rural areas. Representatives from the more sophisticated groups often make trips to other brigades and communes, or to factories and other schools, to conduct public meetings to foster understanding of earthquake prediction and appropriate responses. This combination of functions undoubtedly contributes to stability and persistence of the groups.

In the United States recently there has been an attack on volunteerism as promoting the exploitation of women, and there is considerable evidence of women using volunteer activities as stepping stones to paid employment. We were not able to ascertain the sex distribution of amateur groups in China, nor did we hear of any such tendency. Nevertheless, in an urban "new workers village" we were reminded that wives were entitled to work for pay and noted some of them employed in the village day-care centers, in what might formerly have been volunteer activity. We are in no position to say whether the future will bring pressure to count work with an amateur group as part of the work for which people are normally paid.

<u>Folk wisdom</u>

As in the field of medicine, a virtue of the Chinese approach to earthquake prediction is an open mind toward traditional folk wisdom. We are in no position to evaluate claims that the people have predicted earthquakes for centuries. But the reliance on animal behavior, water-well anomalies, meteorological changes, earth lights, and earth sounds is based on folk tradition. This approach contrasts with the American experience, in which animal-behavior anomalies preceding earthquakes have often been reported popularly, but are held up to ridicule and dismissed without serious investigation.

There has, however, been a careful sifting process through which Chinese earthquake scientists have rejected some aspects of folk tradition while retaining others. Educational programs impress this distinction on the people. The basis for accepting these folk signs in predicting earthquakes is the mutually supportive relationship between scientific and folk signs.

At the same time, it is difficult to rule out entirely a plausible alternate hypothesis, that the crescendo of reports of well-water anomalies and animal behavior anomalies shortly before the Haicheng earthquake were a phenomenon of collective behavior rather than a reflection of physical changes premonitory to the quake. Anomalies are relative: animals like humans have good and bad days without apparent explanation, and water content and level frequently vary. With variable phenomena such as this, the frequency of decisions to report an anomaly should be systematically affected by the number of people looking for anomalies the seriousness of the event the anomalies are assumed to presage, the expectation of seeing anomalies because others are reporting them, and the public attention and social approval which follow such reports. The very fact of establishing several thousand new groups between June and January would have produced many reports, though it should also be noted that the groups remained in operation after the quake and reports dropped. Mass education concerning these fold indicators combined with reports indicating the approach of an earthquake would certainly make people take these phenomena more seriously. The ambiguity of just what constitutes an anomaly provides scope for the emergency of a situational social norm which would undoubtedly induce some of the socially more susceptible people to see for themselves what others were reporting. And the effects of psychological reinforcement by social approval are too well known to need elaboration. If the policy of sending scientifically trained observers to confirm amateur reports was extensively followed in practice, the collective behavior explanation would become less plausible. In light of the extent to which we found sophisticated scientists persuaded of the importance of these folk-observed anomalies, we are disposed to conclude that collective behavior processes might have explained some but not all of the crescendo of anomaly reports. But until systematic, routinized observation and record-keeping concerning animal behavior replace the simple reporting of anomalies, or until quakes are correctly predicted on the basis of animal behavior alone, a modicum of doubt is bound to remain.

We have noted that amateur groups work in collaboration with professional groups, and folk wisdom is employed to complement scientific understanding in Chinese earthquake prediction. The relationship is facilitated by a sort of specialization between amateur and scientific groups. Amateur groups look to scientific units for long and medium-term prediction, for technical advice and assistance, and probably for indications of whether the anomalies they observe are signs of coming earthquakes or something else. The latter is strictly an inference, based on a strong impression that individual reports of anomalies are taken seriously at some times and not at others. The amateur groups have a recognized function in blanketing the area at risk to facilitate identification of the precise time and place of a predicted earthquake. the scientists readily acknowledge there are too few scientists and too little sophisticated equipment to perform this function. In addition, the amateur groups served as an important agent in educating the local cadres and the people at large concerning earthquakes and earthquake prediction.

Making the Decision

A major focus of concern in the United States is how the weighty decision will be made to issue a public warning and institute a program of coordinated community response in case of earthquake prediction. Chinese accounts of the decision-making are bland, matter-of-fact statements of accomplishment that convey no impression of a difficult, emotion-laden, potentially divisive process. Yet the upshot of the decision is a drastic moratorium on normal work and play in community, considerable discomfort and even risk to health for most people, and the inescapable possibility that the prediction may be erroneous. Research in western nations has consistently shown a disposition on the part of public officials to avoid or postpone issuance of imminent disaster warnings, and to institute only modest response programs so as to minimize disruption to normal community activities. Yet it is clear that decisions were made and decisive action taken in many -- probably most -- of the civil units in the Haicheng earthquake impact area. It is therefore a task of potential significance to learn as much as possible about how the decisions are made.

Decisions to warn the people are made by the principal civil authorities rather than by the professional and amateur seismological network. The familiar distinction between line and staff is clearly the model. State and Regional seismological bureaus and more local units participate and even initiate decision-making procedures, but the decisions are made and warnings issued by the revolutionary committees and Party units.

Although we did not encounter explicit discussion of the difference between prediction and warning, the distinction was implicitly recognized and used. Predictions are made by units ranging from the most sophisticated amateur groups up to the regional seismological bureaus. As best we could judge, these agencies do not announce predictions directly to the public, but to the civil authority at the corresponding level. Thus, predictions are reviewed by civil authority and coupled with warnings before being given more general exposure.

The distribution of authority among local, county, and regional jurisdictions remained somewhat unclear to us, perhaps because there is considerable actual discretion. The initial policy decision in 1966 to assign priority to earthquake prediction was made at the national level and the decisions that led to fuller implementation of the policy after the Cultural Revolution were national. National conferences were also called to identify regions of high risk. But authority to make the decisions leading to public warnings and evacuations is decentralized to the regions, counties, and smaller units.

The normative procedure consists of a continuous two-way flow of communication between local and regional authorities with some kind of group consultation and decision-making at each relay point. But as the issue becomes one of notifying the masses of the people rather than selected agencies and of ordering drastic steps such as vacating structures and discontinuing normal work in the factory or field, the focus of discretionary authority seems to be local. In early February it appears that rural communes, factory committees, and uban street committees received information and advice from higher levels (county and city), but made their own decisions. It is even possible that decisions were made at the brigade level. For example, we were told by leaders of a rural production brigade that they received word from the Guantun Commune officials on February 2 that an earthquake was probably imminent. On February 3, leading cadres of the brigade met to discuss the appropriate action, taking account of local observations as well as information relayed from the commune. It was the brigade decision to stop work in the field at once, to put all brigade members to work building temporary shelters, to order all members out of their homes for the night of the third, to establish an all-night patrol by leading members, and to repeat the same program on the fourth. As a result of the decentralization, some brigades and other units began vacating homes on the night of the third while others did not sleep outdoors until the fourth. We were not able to ascertain whether other units decided that the quake signs were not strong enough to warrant evacuation on the fourth. Nor could we determine what pressure or authority might have been imposed from above on units making such decisions.

Two examples of independent local decision-making were related to us. In 1970 a production brigade in Sichuan Province is reported to have issued its own prediction, on the basis of signs known from traditional folk wisdom. Homes were vacated and a magnitude 5 earthquake occurred. In Panjin, on December 30 (?), 1974, a warning was issued locally and structures were vacated for one night, in a false alarm. In one interview we were told that earthquakes of less than magnitude 5 may be predicted and acted upon locally. Above magnitude 5, local authorities must report the prediction and their action to higher authority, where it will be reviewed.

While the initiative stimulating the critical local decision came from higher levels in most instances, we were told that in Pan Shan a district conference of professionals and people was called at the request of local residents, on the basis of their own observations. The conference included representatives from three counties and issued a prediction and warning that were released to the masses of the people and relayed to higher authority.

It should be noted that a preliminary and partial briefing on the successful prediction of the May, 1976, earthquake in Yunnan Province suggests that crucial decisions may have been made at the county level, though it was not possible to explore this question to a firm conclusion.

Whether there is or is not much effective discretion in making the climax decisions at the local level, the pattern may facilitate the taking of a difficult decision. Higher-level units are relieved of some of the onus for disrupting the lives of the people when the final decision-making link is the local authority. And the latter group is close to the people, better able to communicate the reasons for their decisions to doubters and more likely to be viewed with understanding in case the warning becomes a false alarm. Needless to say, if a commune or brigade is already riven with factionalism, there may be little or no advantage to local decision-making. But the benefits from "coopting" local groups into the decision-making machinery of large communities and organizations have long been well known in the United States.

Wherever the final decision is made, it comes at the conclusion of an extended process during which the relative input from seismological and civil units and from remote and local units changes. While amateur groups and seismological stations are supposed to report significant anomalies to more central units whenever they are observed, the serious steps leading towad the imminent prediction were initiated by state and regional seismological bureaus. The June, 1974, meeting instituted communication from the region to counties and local units for the purposes of establishing amateur observation groups. Only as these groups came into operation and observed anomalies and reported them to higher level seismic units and parent-unit revolutionary committees did the reverse order of communication become important and decision-making at the local level become a possibility. After meetings of December 28 (?) and January 13 initiative and responsibility shifted increasingly to the local level and the involvement of revolutionary committee and Party leadership became intense. In this process at least two things of importance had happened. Scientifically-based medium and short-term predictions from the national and regional arenas had been discussed by many county and local leadership groups, preparing them to respond to the local signs of earthquake imminence. And many of the leadership groups had become responsibly involved in the impending decision process when they joined in establishing amateur observation groups within their own units and began to receive reports from them. Presumably both of these developments would have contributed toward the readiness of Civil unit leaders to make the difficult decision of February 3 and 4.

Another notable feature of decision-making in China, applied to the development of earthquake prediction and warning, is the liberal punctuation of the process with conferences that bring together varied groups and perspectives. If amateur groups report what seem to be significant anomalies, the seismic station calls a conference with amateur groups in the area. If the conference decides the information is important, it is referred to the city or county seismological office or bureau, which may then call another conference. A similar sequence of conferences beginning on the national level and moving to province and county levels marked the trend toward even more pinpointed prediction. Even at the commune and brigade levels, decisions are made by leading members rather than by single executives. Although Americans might view such conferences as delaying tactics and obstacles to decisive action, there is reason to believe that the opposite may be true.

During the past twelve years there has been considerable experimental evidence for a phenomenon know as the <u>risky shift</u> gathered by western and Japanese social psychologist. When a choice must be made between more and less risky courses of action, groups will under any circumstances make riskier decisions than the component individuals would have made separately. Research further indicates that the discussion process is crucial to the shift in risky direction, possibly because of the diffusion of responsibility among individuals, and because of the illumination of the need for relinquishing conventionals cautiousness in the course of discussion. Because of the novelty and acknowledged uncertainty of earthquake prediction, and a popular disposition to weigh the certain risks and inconvenience of disrupting production and spending nights outdoors in below freezing weather more heavily than the uncertain risks of an earthquake, decisive action may be perceived as more risky than delay. Collective decision making following extensive discussion may play a significant part in enabling the community to make decisions that might be too risky for a single exposed executive to make boldly.

There is a parallel worth noting in the book by the British surgeon who worked in China for many years, Joshua Horn, entitled Away With All Pests (1969). Dr. Horn notes how discussion of a seemly hopeless casualty case led to a fuller understanding of Chairman Mao's dictum of being wholly rather than minimally responsible. As a result the doctors adopted the riskier course of treatment, which also offered the greatest hope for the patient if it succeeded. Without discounting the impact of Chairman Mao's wisdom, there may be a judicious use of the risky-shift potential in the system of collective decision employed in connection with earthquakes in common with many other types of crisis.

A final circumstance that may facilitate resolute decision making concerning earthquake warning is the bridging function of less technically trained workers in scientific institutions and amateur observers between scientists and civil authorities. In difficult situations in the western world there is sometimes a polarization and inability to communicate between the two groups, undermining mutual understanding and trust. Perhaps, too, the policy of encouraging scientists to comingle with nonscientists and to respect folk wisdom may facilitate the fuller exchange of views necessary to reach difficult conclusions with a minimum of ambivalence.

Strategy for Response

The payoff for prediction and warning is a hazard-mitigation program that saves lives, reduces casualties and property loss, minimizes disruption, and also minimizes the new costs introduced by the fact of prediction. In contrast to California, little progress was made in China until quite recently in employing earthquake resistent construction. As a consequence the expected death and destruction is much greater in China than in California for comparable earthquakes, and accurate prediction and effective response become much more crucial.

The organizing strategy in anticipation of the Haicheng earthquake appears to have been to accept massive destruction and property loss as inevitable and to concentrate effort and resources on saving lives when the quake occurred and restoring agricultural and other productivity as promptly and fully as possible after the quake. The former was achieved by vacating structures, and depended on pinpointing the time of the earthquake. Had the prediction involved a time window of a week to a month, rather than twelve to forty-eight hours, it is unlikely that so many lives could have been saved. Prompt community restoration was facilitated by readying medical and other emergency teams and preparing People's Liberation Army units to assist in post-quake rehabilitation. In accordance with priorities, reconstruction of housing was often not undertaken until terracing of fields, irrigation systems, removal of sand and silt, and other steps necessary to restore agricultural production had been completed. Plans and materials for constructing temporary shelters were available before and immediately after the quake.

In accordance with this strategy, the principal organized response to the medium-term prediction in June, 1974, was to institute the intensive amateur and professional observation network in the area at risk, needed to narrow down the time and place of impact. Unfortunately we did not secure information from urban jurisdictions where more complex preparations should have been undertaken except from one Yingkou City Street committee whose concern was limited to vacating residences.

Popular Compliance

Because of the much-documented reluctance of western populations to take disaster warnings seriously, and a common though usually unjustified fear of such counter productive responses as panic and community conflict, the success of the Chinese in securing popular cooperation when warnings were issued is of great interest. It is not possible to say just how effective the response was since casualty figures are not released and only spokesmen for successful units were available to the delegation. One published statement indicates that "In 72 percent of the brigades in the epicenter not one person was killed." (China Reconstructs, 25 (July, 1976), p. 30). This gives us no clue to the magnitude or cause of casualties in the remaining 28 percent. However, it is impressive that full cooperation could have been attained in so large a majority of units.

A major variable known to facilitate adaptive response to warnings is prior experience with similar disasters and existence of a "disaster culture" through which accumulated experience and wisdom are passed along. No such earthquake culture existed in southern Liaoning. Many years had elapsed since the last destructive earthquakes in the region, and many people had been lulled into a false sense of security by the occasional experience of minor quakes. We heard repeated accounts of difficulty in persuading elderly people to evacuate their homes, because they "knew" from experience that only minor quakes occurred in that region.

On the other hand, the integrated authority structure in China no doubt suppresses dissent and nonconformity of all kinds efficiently. The impressive compliance with earthquake instructions may require no special explanation. Casual observation of Chinese society also suggests a slower pace in work and community life than we are accustomed to in the United States. The slower pace makes interruptions less frustrating, and makes it easier to compensate for lost time and effort by temporarily intensified effort. Likewise, individual well being and success are less acutely dependent upon <u>individual</u> effort than in the United States. Thus, there are several significant features of Chinese society and culture that lessen the proclivity for individuals to resist cooperation in programs for public good.

The almost complete absence of earthquake resistent construction in much of the area at risk may have fostered community-wide cooperation. In southern California where the majority of people live in homes that are unlikely to collapse in an earthquake, it is easy for each resident to conclude that the probability of his being in a vulnerable location at the moment of impact is very small. Hence it is easy to discount even a high-probability earthquake prediction as a low-probability event so far as personal risk is concerned. It is equally easy to overlook the more serious plight of the minority who live and work in vulnerable structures. But in the area of projected impact in southern Liaoning Province, very few people could feel secure in their homes or workplaces. Hence the threat was harder to discount, and a firmer basis existed for development of a sense of common concern.

The nature of the events may also have worked in favor of Chinese efforts. American research has indicated a compelling tendency for people to seek confirmation of warnings through the testimony of their own senses before taking adaptive action. It is anticipated that earthquake prediction will constitute a special problem in this respect because of the absence of perceptible premonitory signs. But two kinds of perceptible signs were experienced in Liaoning. First, there were foreshocks during the two or three days before the main quake. In California as well as China, there is a widespread popular view that a small earthquake and especially two or more small quakes may presage a larger quake. This folk wisdom has been refined and given an official stamp of approval in China, as a "law of earthquakes," namely, "close successive foreshocks followed by a period of calm, and then the big shock." (China Reconstructed, 25 (July 1976), p. 40). Although any such formula would not have applied to California quakes in this century, it worked in southern Liaoning. It is noteworthy that we received several reports of people vacating their homes on their own initiative before any community order was issued.

Second, the escalating popular reports of anomalies in animal behavior, well-water, and other natural phenomena supplied apparent confirmation. Whether these phenomena were valid premonitory signs or not, their occurrence coupled with the belief that earthquakes are preceded by such signs, surely played an important part in enhancing the credibility of official predictions. These were signs that people could see for themselves or hear about from their neighbors.

If event and Chinese culture and social structure fostered compliance, there were also ways in which the Chinese earthquake program was wisely conceived. First, earthquake prediction was established and advertised as a national policy of the highest priority. Earthquake prediction was not a minor experiment, viewed with a sceptical eye in ruling circles. Indeed, belief in earthquake prediction was made an element of ideological orthodoxy that distinguished the true Party-liners from right-wing deviationists. Repeatedly we heard disbelief in earthquake prediction attributed to bourgois class interests. The propagation of earthquake knowledge became one of the responsibilities of proletarian theory study groups. And criticism of those who doubt the feasibility of earthquake prediction was linked to everyone's duty to criticize the idealist concepts and revisionist lines of Confucius, Liu Shao-chi, Lin Piao, and retrospectively Teng Hsiao P'ing.

Second, it is well known that involvement in supportive action enhances a person's commitment to associated beliefs. On a limited scale people were instructed on reinforcing their homes against earthquake damage. But on a much larger scale they were incorporated as significant contributors to the prediction effort. Besides the amateur groups, sponsoring unit leaders and members were involved vicariously and through their responsibility for the amateur groups. And as the date of the quake neared, all of the people in many communities were called upon to assist the prediction effort by reporting any significant anomalies they witnessed. The active solicitation of amateur observations undoubtedly contributed strongly to community cooperation in the last-minute hazard mitigating program.

Third, units generally sought compliance from the people through a comprehensive use of authority, support, and persuasion. In several places we were told that the first step after the local warning decision was to set the people to work building temporary shelters. They were shown how to warm the shelters against the below-freezing temperatures. Responsible officials arranged to have shelters built for some of the elderly and others who could not handle the task. Persuasive efforts were concentrated on the disbelievers and, in some locations, the latter were bodily removed from their homes. The local militia were typically assigned the responsibility for ordering people to evacuate, with leading cadres making personal calls on the most reluctant. How much authority was ultimately applied no doubt varied according to the brigade or other unit. But we do have reports of individuals who resisted all blandishments and eventually became casualties. The Chinese take considerable pride in the widespread use of outdoor motion pictures as a positive inducement to keep people out of doors. Besides the interest in seeing the movie, the opportunity to assemble with friends, neighbors, and coworkers may have constituted a welcome experience of group solidarity to counter the otherwise isolating effects of fear and uncertainty. We are reminded of the morale-inducing function of air-raid and hurricane parties.

One of our current American concerns is the possibility of counter-productive responses to the quake warning. The most serious of these consist of economic disruption, based on operation of the free marketplace. The substitution of community ownership for private control of capital eliminates the pattern whereby one person's loss is another's gain. One urban informant did acknowledge a rumor that the heavens would drop down, the ground would sink, and all the people would die during the disaster. Such rumors are attributed to class enemies. To what extent this one admission is the tip of an iceberg we can only guess.

False Alarm

One frequently expressed fear in the United States concerns false alarms. Besides their concern for unnecessarily disrupting normal life routines, public officials often defer warnings of uncertain disaster because a false alarm may (a) provoke a rash of blaming and scapegoating and, (b) undermine the credibiity of the next warning. Although our hosts admit there have been several false alarms, we were able to secure little detail concerning responses to these events. We were constantly assured that the people know that earthquake prediction is not yet perfected, that precautionary evacuation is in their interest, and that they don't mind the inconvenience. Because of the slower pace of life and reduced individual fate control already mentioned, and the diffusion of responsibility for the warning decision, the people may be more tolerant of this kind of error. (Parenthetically it should be noted that some research has found scapegoating less common in the United States than popularly supposed).

Whether the false alarm affects response to the next warning we could not determine. The Panjin false alarm lasted one night. When local anomalies subsided, the warning was cancelled the next day. We were not able to talk to people with first-hand knowledge of the subsequent Panjin response to the warning of February 4. The leader of one rural brigade in which homes were ordered vacated the night of February 3 acknowledged that a few older people refused to stay outdoors the next night on the ground that they had spent one night outside without an earthquake.

With inadequate data at hand, we can only note that the Chinese authorities uniformly discounted the supposed negative consequences of infrequent false alarms of brief duration.

The Catfish Club

by

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There is presently an amateur earthquake prediction effort in south-central Honshu covering the area from Tokyo to the Izu Peninsula (Fig. 1). The amateur workers measure water level in shallow ground water wells and report on barometric pressure and rainfall. The group, called the "Catfish Club" has been organized by Dr. Yashue Ohoki, a geologist and the director of the Hot Springs Research Institute in Hakone, Kanagawa Prefecture. Funds for equipment and publications for the organization are now provided by the prefectural and federal governments.

Equipment is supplied free of charge to the volunteers for the measurements. Included are a rack to mount over the well with a float and pulley arrangement attached to a digital counter which displays the water depth to a tenth of a millimeter. A good barometric pressure gauge and very simple rain gauge are also included. Measurements of these three quantities are made up to four times per day by the volunteers. Dr. Ohoki points out that the digital display is preferable because it is considerably more error free than reading off a scale. Also, he believes that the volunteers grow to have a much greater appreciation for the behavior of the well if they make several daily observations rather than simply pulling a chart from a drum recorder once a month. He suggests that the personal daily observations help to keep the volunteers' interest at a high level. The data is recorded on a card printed for the purpose and transmitted back to the Hot Springs Research Institute. The data from all volunteer workers are plotted on a uniform base at the Institute by research assistants.

The club's membership is mostly composed of retired people, housewives, farm families and the like. There are no student organizations or schools involved. For amateur observational schemes to be useful, particularly where water wells measurements are involved, a long unbroken period of recording is required. Student organizations or even school physics classes are unable to maintain a continuous record of observations. The membership receive from the Hot Springs Research Institute a bulletin called "Catfish Letters". The bulletin includes reports of major earthquakes, volcanic eruptions, data from workers (Fig. 2), synoptic data plots, discussions of how anomalies are recognized and perhaps most important, letters from and photographs of the individual volunteer workers. The tone of the periodical is humorous and folksy, but the data presented are taken quite seriously. Anomalies in water level preceding earthquakes are given special attention and the observer receives a frameable statement that he or she has made such an observation. If the observer has submitted the prediction of an earthquake based on a water well anomaly he receives an even more elegant, frameable letter of commendation. On our visit to Hakone we were shown several water level changes prior to earthquakes, which appeared anomalous because of the absence of barometric pressure changes and rainfall.

The membership of the organization seems to be active and enthusiastic. They meet yearly at Hakone, a hot-springs resort area. There are no scientists involved other than Dr. Ohoki and it appears even that the volunteers enjoy competing with the professional earthquake predictors. Dr. Ohoki encourages the members not to make public predictions of earthquakes to the newspapers but to keep them internal to the Catfish Club. He does plan, nevertheless, to publish the results of the observations up to this time in a scientific journal.

Distribution of Observation Wells

「なまずの会」水位観測井分布図

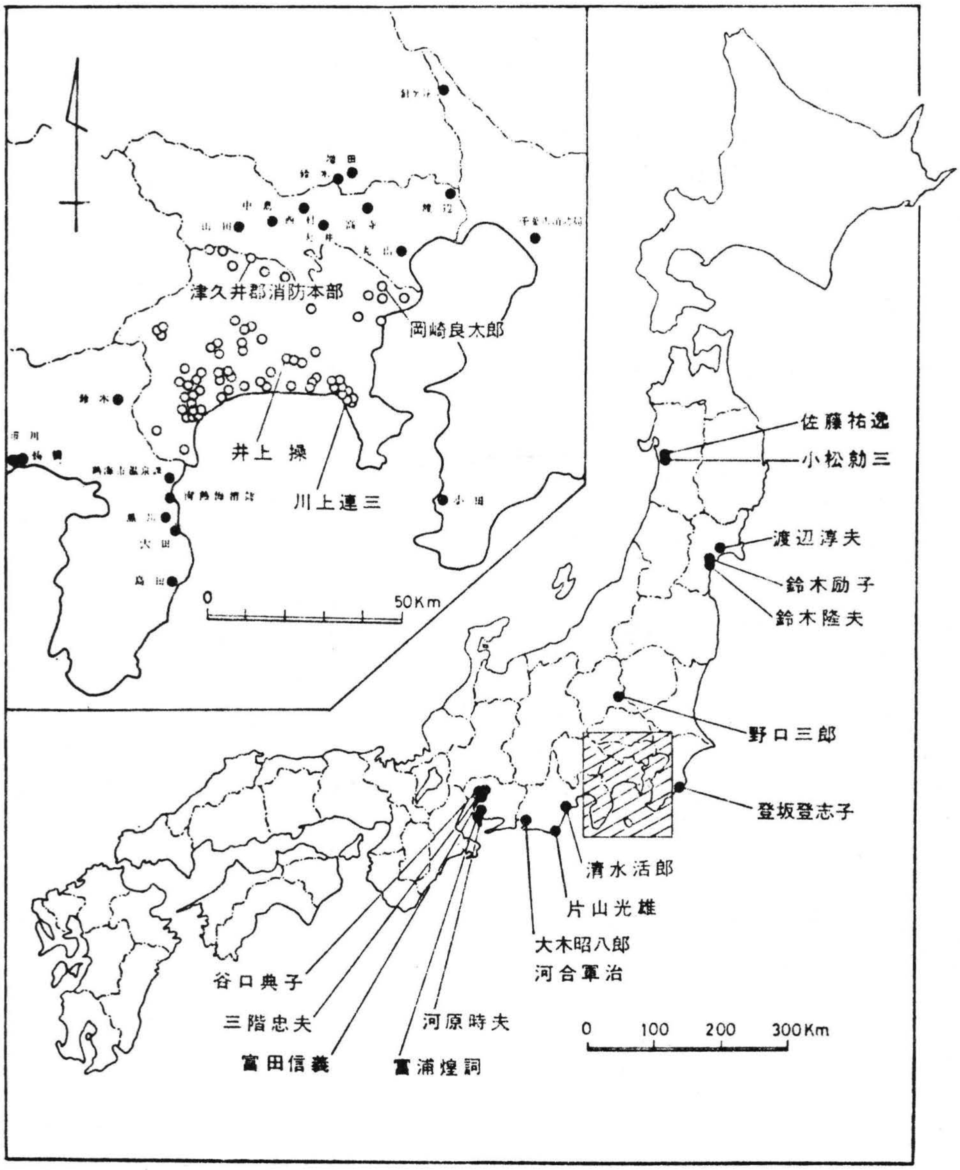

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Fig. 1. Map of Japan showing area where volunteer water level measurements are conducted. Inset shows localities of individual wells.

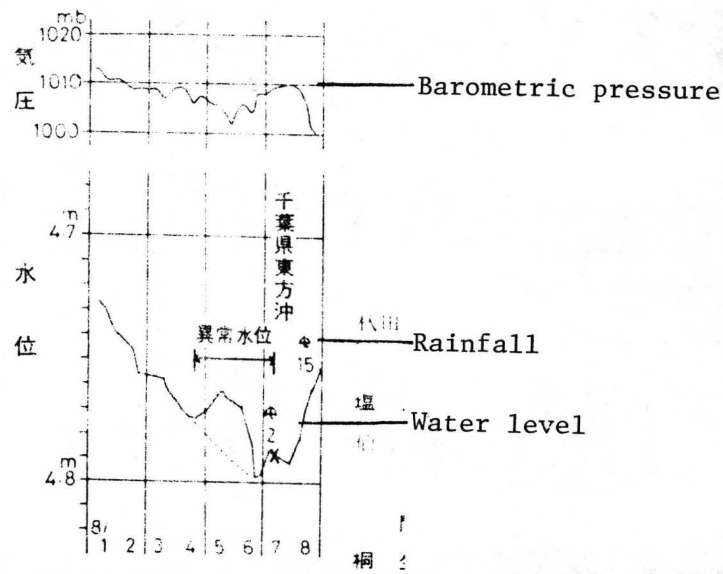

Fig. 2 -- Plot of water level, barometric pressure (at top) and rainfall in mm given beneath small umbrella. Anomaly in water level shown above dashed line.

USE OF VOLUNTEER ORGANIZATIONS IN EMERGENCY OPERATIONS

by

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INTRODUCTION

The idea of utilizing the skills of lay volunteers in the prediction of earthquakes on a broad basis has not, up to this point, been considered seriously in the United States. This is true despite the fact that other nations have recognized the contributions of volunteers in this area of endeavor over a considerable portion of recent world history. In fact, one of the recommendations of a study of the prediction of the February 4, 1975 earthquake which occurred near the town of Haiching, Liaoning Province, in the People's Republic of China states, "...An earthquake volunteers program should be initiated through existing institutions and organizations." (1).

Yet the involvement of lay personnel in other scientific and educational endeavors is not new in this country. Our history is replete with examples of volunteer involvement in activities either directly involved in scientific programs or in technical activities (of varying degrees of complexity) which ultimately supply data used to derive scientific conclusions.

Over the past several years, the Office of Emergency Services (OES) has involved volunteers in many of its activities. This paper will describe four examples of the use of volunteer organizations in OES operations, outline the criteria under which they have been utilized, and offer some observations as to how these procedures may be transferred to the task at hand.

OES UTILIZATION OF VOLUNTEER ORGANIZATIONS

This section will describe the utilization (and intended utilization) of four, quite different, volunteer organizations, each of which offers important contributions to emergency and recovery operations.

American National Red Cross (ANRC)

In California, involvement of the American National Red Cross in emergency operations is based upon a written statement of operational relationships between the two organizations (Attachment 1).

Generally, ANRC assistance during natural disasters encompasses two phases--emergency, and recovery/rehabilitation. During the emergency phase the ANRC provides the immediately needed basic necessities of life, consisting primarily of food, clothing, shelter, and supplemental medical and nursing care, on the basis of evident need. Frequently this assistance is given to large numbers of people on a mass care basis; but, whenever possible, the ANRC deals directly with each family on an individual basis.

In the rehabilitation phase, the ANRC assists individuals and families to return to a predisaster standard of living by meeting recovery needs (not losses) which disaster sufferers cannot meet with their own resources. Assistance by grants (not loans) is unrestricted by rigid relief categories and includes such programs as family maintenance; purchase of furniture; repair, building, or purchase of homes; payment of medical bills; and procurement of occupational equipment.

Civil Air Patrol (CAP)

The California Wing of the Civil Air Patrol, consisting of 20 Groups, comprises a considerable volunteer resource (aircraft,communications equipment, motor vehicles and manpower) which is available and ready to assist State and local emergency services agencies in coping with major disasters and other emergencies.

Civil Air Patrol involvement in emergency operations is also governed by a Memorandum of Understanding (Attachment 2). Under the terms of the Agreement, all resources of the California Wing are available to OES for use during a State of Emergency due to a major natural disaster.

Civil Air Patrol aerial mission support (e.g., for search and rescue purposes) may be furnished by any CAP unit to any emergency services agency, regardless of geographical location, depending upon the nature and extent of support required and as determined by the California Wing Commander. The California Wing, Civil Air Patrol, has agreed to make its resources available to the State Office of Emergency Services and local emergency services agencies without compensation, except for reimbursement for the cost of fuel and lubricants expended on specified missions and commercial communications which may be required.

A required element of control in the conduct of CAP missions flown in support of State or local emergency services agencies is the joint sanction of a mission by the Office of Emergency Services and the California Wing, and the assignment of a Mission Authorization Number. The assignment of this number establishes, for purposes of state indemnity compensation covering Disaster Service Workers, that CAP members are participating in an authorized emergency mission. This further serves to establish a documentary basis in support of claims for reimbursement for fuel, lubricants and commercial communications expended.

Radio Amateur Civil Emergency Service (RACES)

The Radio Amateur Civil Emergency Service is part of the State Emergency Organization (2) and is comprised of licensed amateur radio operators who help provide radio communications needed by Federal, State, and local governments in time of emergency. It was created primarily to serve in a civil defense emergency, and has since enabled amateur radio operators to perform emergency communications functions as an important supplement to State and local civil defense communications systems. The RACES operating procedures are prescribed in the State of California, Radio Amateur Civil Emergency Service Plan (3).

The RACES communications system may be called upon by the legally appointed Director of Civil Defense (or his authorized representative) for a particular area in accordance with an approved Civil Defense Communications Plan in any emergency concerning safety of life, preservation of property, maintenance of law and order, alleviation of human suffering, dissemination of enemy attack warning, and any disaster or other incident endangering the public welfare. Natural disasters often cripple or destroy communications facilities and equipment. RACES members may then be asked to handle messages for police, fire, public welfare, public utilities, and other emergency services.

RACES stations are assigned to one or more radio nets. Each net is under a Net Control Station. RACES nets operate under the direction of authorized government officials in accordance with approved communications plans. These nets are capable of connecting city emergency operating centers to outlying areas, and providing command and control communications between EOCs at various levels of government.

A RACES plan is prepared in accordance with the needs of a particular area to be served, and the facilities--including licensed radio operators and stations--available in that area. The plans need not be uniform, but must be clearly described in writing.

Structural Engineers Association of California (SEAOC)

The Office of Emergency Services has requested, and received, an opinion from the Office of the State Attorney General as to the feasibility, including liability considerations, of using volunteer engineers to perform assigned emergency missions, such as determining the safety of damaged buildings and conducting general damage assessment. The opinion rendered was highly favorable, yet unprecedented.

With the receipt of this opinion, OES will proceed to publish and distribute a Plan for the Utilization of Volunteer Engineers for Post-Disaster Damage Assessment, prepared with the cooperation of the Structural Engineers Association of California. Following this action, more than 300 volunteers from SEAOC will be registered by this office as Disaster Service Workers, issued Identification Cards, and given general orientation and training in damage assessment. The volunteers will be used as a statewide pool available to be dispatched to support local disaster related efforts.

OBSERVATIONS

In the preceding section of this paper I have attempted, in addition to providing a description of how volunteer organizations have been used by the California Office of Emergency Services, to impress upon the reader the importance of agreements and/or plans which set forth WHAT task is to be undertaken, by WHOM it is to be performed, and WHEN (or under what conditions) it is to be accomplished.

Planning, especially good planning, requires effort. In order to mount an effective, uniform, coordinated response, responsibilities and procedures must be defined, tested, evaluated and verified prior to their being placed in an operational mode and expected to yield meaningful results.

Several basic planning tenets imply that it is considerably easier to use existing hierarchal structures to accomplish specified tasks than to create new ones. Even if new tasks are to be introduced, it is often more advantageous, both economically and administratively, to expand the functions of previously established executive, informational and operational organizations.

STATE EMERGENCY ORGANIZATION

The State Emergency Organization could easily be adapted to perform some of the more precise observations required to gather data on possible earthquake precursors. The Emergency Organization is an extention of the normal governmental structure augmented to combine extraordinary activities with business as usual. The Office of the Governor, OES, and certain State agencies are assigned emergency responsibilities and procedures which are specifically prescribed in the State Emergency Plan (4). Further, the State is divided into six mutual aid regions for more effective administration, communication, and coordination of mutual aid (see Attachment 3). Each Region is headed by a Regional Manager who is directly responsible to the Director of OES. The regional offices maintain communication links with jurisdictions within their respective regions, with other regions, and with OES headquarters in Sacramento.

Existing legislation designates each County as an Operational Area. During emergencies the Operational Area serves as a link in the system of communications and coordination between State emergency operations and the emergency operations of the political subdivisions comprising the Operational Area at the option of the County and the political subdivisions within the county area.

The local emergency organization generally consists of the existing governmental agencies of a jurisdiction, augmented by auxiliary and public service organizations and by special purpose districts within the community area. Channels for direction and/or coordination of mutual aid and other emergency-related activities are illustrated in Attachment 4.

This organizational structure lends itself well to performing and reporting the type of observations required for use in a volunteer earthquake prediction program. The individuals involved (at both State and local government levels) are public employees highly motivated in the various aspects of public safety, including earthquake safety. In fact, many are particularly interested in earthquake phenomena (especially prediction) and I feel certain would not hesitate to become involved in an organized, meaningful monitoring program, if headed by a responsible agency such as the U. S. Geological Survey.

STATEMENT OF OPERATIONAL RELATIONSHIPS BETWEEN THE AMERICAN NATIONAL RED CROSS AND OFFICE OF EMERGENCY SERVICES

(This statement supersedes all previous agreements)

I. PURPOSE

This statement will:

A. Outline the natural disaster programs of the American National Red Cross and the Office of Emergency Services, which coordinates the emergency activities of all state agencies;

B. Show the relationship between the Office of Emergency Services (OES) and the American National Red Cross (ANRC) in conducting these programs;

C. Recommend working relationships between Red Cross chapters and local emergency (civil defense and disaster) organizations* for natural disasters: and

D. Include an attachment defining ANRC activities for war disaster and civil disturbance. (This information is treated separately because of distinct legal and operational differences.)

II. LEGAL BASIS FOR OPERATIONAL RELATIONSHIPS

A. The OES, local governments, and the ANRC are among the several agencies having statutory responsibilities in connection with natural disasters.

B. Red Cross responsibilities derive from Public Law 4 (33 Stats. 599).

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* The term "civil defense" connotes government response to an emergency. References throughout this statement to state and local civil defense are synonymous with state and local government.

C. OES and local government responsibilities derive from the California Emergency Services Act and related codes, ordinances, resolutions, agreements, and plans.

D. Nothing contained in the California Emergency Services Act is construed to alter the ANRC statutory obligations.

III. BASIS FOR AGREEMENT CONCERNING NATURAL DISASTERS

ANRC and OES responsibilities in natural disaster have a close relationship. Therefore, ANRC Western Area and the California chapters will plan and act in unison with the OES, the emergency plans of the State and local governments, pertinent federal statutes, and this agreement.

This unified action denotes coordination between government and the Red Cross but does not impose any administrative authority or fiscal control by government or its emergency organizations over the Red Cross corporation, its policies, volunteers, or employees.

IV. RED CROSS PROGRAM IN NATURAL DISASTER

In accordance with the foregoing statements, ANRC will provide and finance services to meet human needs in natural disaster. Specifically, these services, extended on a grant basis, are listed and explained in paragraphs A through D below.

A. Emergency Congregate Care

1. Provision of emergency lodging for disaster victims in public or private buildings suitable for congregate occupancy.

2. Provision of food and clothing for persons in emergency congregate facilities.

3. Provision of food for disaster workers if normal commercial feeding facilities are not available.

B. Emergency Individual Assistance

1. Providing food and clothing for disaster victims not lodged in congregate facilities.

2. Providing basic necessities other than food, clothing, or lodging for disaster victims either in or out of congregate facilities.

3. Receiving and answering welfare inquiries regarding persons in the disaster area, to the extent that communications are available.

C. Emergency Medical and Nursing Care

1. The ANRC will provide medical and nursing care in all Red Cross-operated shelters.

2. The ANRC can provide the following medical and nursing requirements to supplement existing community plans and resources, recognizing that the primary obligation is vested in local emergency organizations by virtue of ordinances and plans, and further recognizing state resources under the Master Mutual Aid Agreement and U. S. Public Health resources.

   a. Providing blood and blood derivatives for the ill and injured as a result of disaster;

   b. Recruiting nurses to supplement hospital staffs;

   c. Assigning nurses to hospitals for bedside care of disaster victims; and

   d. Establishing first aid stations.

D. Family Recovery Assistance (after the emergency period)

This assistance (based upon individual application) is designed to assist families or individuals who lack sufficient resources to effect part or all of their own recovery. The program, based on need, not loss, includes the following types of assistance:

1. Food, clothing, and maintenance;

2. Construction, purchase, or repair of owner-occupied homes;

3. Extended medical and nursing care;

4. Household furnishings; and

5. Occupational equipment and supplies.

E. In providing the above-described services, the ANRC will not duplicate the programs of other public or private welfare agencies, nor will it assume financial responsibility for their actions.

F. If a local government needs assistance with rescue or voluntary evacuation, the ANRC will, when requested, assist to the extent practicable, recognizing however that these functions are the responsibility of the concerned government.

V. STATE AND LOCAL GOVERNMENT RESPONSIBILITIES IN NATURAL DISASTERS

State and local governments have inherent and statutory responsibilities in mitigating the effects of natural disaster. The more important of these responsibilities are as follows:

A. Dissemination of danger warnings;

B. Designation of dangerous areas;

C. Ordered evacuation from endangered areas;

D. Law enforcement;

E. Fire suppression;

F. Light and heavy rescue operations;

G. Provision of safeguards to public health and sanitation;

H. Identification and disposition of the dead, including the operation of temporary morgues;

I. Institutional care for the sick, aged, and orphaned;

J. Repair and restoration of public facilities and buildings;

K. Debris removal from public property;

L. Salvage of unclaimed property; and

M. Arrangements with federal agencies for assistance under federal disaster relief programs.

VI. COORDINATION OF EMERGENCY HEALTH AND WELFARE PROGRAMS

A. Public Health and Sanitation

Government is responsible for public health and sanitation. Public Health authorities should provide health inspection and sanitation controls in Red Cross shelters as required by appropriate public health officials.

B. Welfare Programs

The ANRC considers tax source benefits provided by state and local welfare departments (and other state and federal agencies) for disaster victims as resources, and the Red Cross will not duplicate or underwrite these programs.

VII. NATURAL DISASTER OPERATING PRINCIPLES

A. Financing

A Red Cross principle is that its administrative and fiscal controls are inseparable. Therefore, the Red Cross does not assume costs for commitments made by other agencies or organizations.

B. Personnel

1. In some instances, individuals represent both government disaster organizations and Red Cross disaster committees. Dual representation is inadvisable, because of conflicting administrative and financial responsibility.

2. Red Cross volunteers may register with local disaster councils as disaster service workers, in which case they become eligible for workmen's compensation benefits while engaged in activities authorized and carried on pursuant to the California Emergency Services Act, including training necessary and proper to engage in such activities.

C. Supply

1. The Red Cross does not stockpile large quantities of supplies for disaster preparedness. Its requirements are met by purchase, rental, or borrowing. The Red Cross will assume fiscal responsibility for loss, damage, or destruction of all equipment under its operational control, unless otherwise agreed to by the vendor of loaned or rented property.

2. The ANRC has an agreement with U. S. military forces for obtaining military supplies, equipment, and personnel to supplement its disaster activities and is financially liable for certain services, and for loss, damage, or destruction of borrowed material. Therefore, any government or private agency request for military assistance, including air or surface transportation for accumulation of used clothing and other commodities should not be channeled through the Red Cross.

3. A memorandum of understanding between the ANRC and the U. S. Public Health Service makes available to ANRC the USPHS stockpile of cots and blankets for mass care purposes. The ANRC is fiscally responsible for loss or damage of the equipment.

D. Communications and Liaison

1. The ANRC will provide liaison personnel at OES State Headquarters, affected mutual-aid regional offices, and the civil defense and disaster operating headquarters of

affected local governments, to the extent necessary to effectuate the terms of this agreement.

2. The ANRC will furnish or authorize the use of the communications necessary to effective liaison.

E. Disaster Declarations

The Red Cross considers a catastrophic situation, which involves five or more families, to be a disaster. Therefore, Red Cross chapters will act in certain situations which constituted government may not consider sufficiently severe to proclaim the existence of a disaster. Chapters may, however, assist in disasters involving fewer than five families if they can finance such assistance without funds from the National organization.

Approved Nov 25, 1970

Emil F. Lewis
EMIL F. LEWIS, Deputy Manager
Western Area Office
American National Red Cross

Approved November 25, 1970

John J. McCoy
JOHN J. McCOY, Director
State of California
Office of Emergency Services

MEMORANDUM OF UNDERSTANDING
BY AND BETWEEN
THE CALIFORNIA WING, CIVIL AIR PATROL
AND THE CALIFORNIA OFFICE OF EMERGENCY SERVICES

Whereas, Public Law 79-476 provides that one of the objectives and purposes of the Civil Air Patrol is to provide an organization of private citizens with adequate facilities to assist meeting local and national emergencies; and whereas, under the California Emergency Services Act, whenever any person, firm or corporation shall offer to the State of California or to any political subdivision thereof services, equipment, supplies, materials or funds for the purposes of civil defense or the mitigation of disaster, the State, or such political subdivision, may accept such offer; and

Whereas, cooperation between the California Wing, Civil Air Patrol, and the Office of Emergency Services is within the powers and duties of these organizations to ensure that preparations of the State will be adequate to deal with a state of emergency or natural disaster as defined in the California Emergency Plan. Now, therefore, it is hereby agreed as follows.

1. That participation by the California Wing, Civil Air Patrol, in civil defense and disaster relief operations will be in conformance with the California Emergency Plan to ensure the most effective utilization of the proffered manpower and resources. The provisions of this agreement apply to all levels of state and local government in California and to all subordinate units of the California Wing, Civil Air Patrol. (CAP)

2. During a civil defense emergency or natural disaster, the services of the California Wing, Civil Air Patrol, will be employed locally on a priority basis, with first priority being given to civil defense and disaster relief. Consistent with its mission as a civilian auxiliary of the United States Air Force, the California Wing, Civil Air Patrol, agrees to make available to the Office of Emergency Services certain of its personnel, services and equipment to serve without compensation except for reimbursement for the cost of fuel and lubricants and commercial communications expenses expended on specified missions in support of the Office of Emergency Services and local civil defense/emergency services forces.

3. Each subordinate unit of the California Wing, Civil Air Patrol, located within the jurisdiction of a county or city civil defense/emergency services agency may participate in the civil defense/emergency services organization of the local jurisdiction as a unit within a specific emergency service or to perform a special function. Civil Air Patrol units serving with emergency service organizations will serve under their own unit commander under the operational control

of the local civil defense/emergency services director, subject to orders of the California Wing, Civil Air Patrol.

The detailed manner in which Civil Air Patrol personnel, property and equipment will be utilized within organized units in execution of missions assigned by the California Office of Emergency Services and requested by local civil defense/emergency services directors will be as determined by the Commander, California Wing, Civil Air Patrol.

During a state of war emergency, state and local directors of civil defense/emergency services will establish priorities, assign missions, and effect coordination within the state emergency services structures for the employment of units, personnel, services and equipment of CAP units subject to the provision of paragraph 4 above.

6. The California Wing, Civil Air Patrol, will be available upon request to perform the following missions for the Office of Emergency Services:

   a. Aerial radiological monitoring
   b. Courier and messenger service
   c. Aerial surveillance of surface traffic
   d. Light transport flights for emergency personnel and supplies.
   e. Aerial photographic and reconnaissance flights
   f. Radio communications
   g. Ground search and rescue
   h. Other services within the capability of the Civil Air Patrol, as agreed upon by the Director, Office of Emergency Service, and the California Wing Commander.

7. Civil Air Patrol support of the California Office of Emergency Services, under war emergency, natural disaster, or search and rescue contingencies, will be accomplished as follows:

   a. <u>State of War Emergency</u>

   Use of CAP resources will be as provided for in USAF Regulation 46-5, the Federal Aviation Agency Plan, "State and Regional Airlift Planning" (FAA Advisory Circular No. 00-7), the California Department of Aeronautics "State & Regional Defense Airlift Plan" (short title: SARDA) and the Civil Air Patrol Manual 50-15.

   b. <u>Major Disaster</u>

   California Office of Emergency Services requests for USAF/CAP assistance in support of disasters of sufficient severity and magnitude as to warrant federal major disaster assistance under PL 93-288 will be directed to

Region Nine, Federal Disaster Assistance Administration. USAF/CAP support will be governed by the Western Sea Frontier Command Plan, "Joint Plan for Military Assistance to Civil Authorities in Natural Disaster in the Western United States" (short title: MACA-ND) and USAF Regulation 46-5.

c. Search and Rescue

Requests for search and rescue support are normally initiated through FAA or USAF channels and are implemented under provisions of the National Search and Rescue Plan.

The United States Air Force is responsible for search and rescue of the inland region of the continental United States, and in turn has directed the USAF Rescue Coordination Center, Scott Air Force Base, Illinois, to fulfill its executive agents responsibility that is assigned to the USAF in the National SAR Plan. As an auxiliary of the USAF, the CAP provides the primary resources to RCC in fulfilling that responsibility.

d. State of Emergency - Local Emergency

Emergencies may occur that are not of sufficient magnitude to warrant federal disaster assistance under Public Law 93-288, or that otherwise do not warrant military assistance, but in which the use of CAP resources would be desirable. In such instances, the California Wing, Civil Air Patrol, is prepared to assist or render aid to State or local jurisdictions upon request through regular organizational channels of communications.

8. Requests from the State of California for CAP assistance will be transmitted from the Director, OES, to the Commander, California Wing, CAP. When the urgent nature of an emergency dictates expediency, California OES regional managers or division chiefs may request assistance through the local CAP commander. In all cases the OES warning controller will be notified immediately and will assign the mission number. Normally, all requests for assistance will be in writing. However, if verbal requests are made through specific channels, such requests will be confirmed in writing within twenty-four hours.

9. All members of the California Wing, Civil Air Patrol, will be registered as disaster service workers with the California Office of Emergency Services, within the meaning and intent of the California Emergency Services Act. Additionally, individual CAP members residing within the jurisdiction of a local civil defense/emergency services agency, county or city, will be registered as disaster service workers with the local disaster council. Workmen's compensation coverage

for CAP members within the meaning of Division 4, Part 1, of the State Labor Code, Sections 3211.92, 4351, 4353, and 4386 is applicable only during those training periods or on those missions performed at the request of the OES or a local civil defense/emergency services organization.

10. Members of the California Wing, CAP, registered as disaster service workers with the OES or a local disaster council, will be furnished with an official civil defense identification card. It is the responsibility of the California Wing, Civil Air Patrol, to withdraw these identification cards from personnel at time of separation from the CAP or upon termination of status as a disaster service worker. The placing of civil defense decals on CAP equipment is permitted and desirable in the interest of speedy identification and for prevention of undue delays during an emergency.

11. The Office of Emergency Services will provide training guidance and will assist the California Wing, CAP, in developing and coordinating aerial radiological monitoring plans with local civil defense/emergency services agencies.

12. Designated CAP units will be called upon to participate in a minimum of one practice alert and/or aerial radiological monitoring exercise annually. These practice alerts/exercises will be as determined by the Commander, California Wing, and the Director, Office of Emergency Services. The exercises will be observed by a joint evaluation team, followed by a post-exercise critique. A Mission Effectiveness Report will be accomplished for each practice exercise conducted.

13. State and locally owned civil defense property, equipment, and supplies may be loaned and/or issued to CAP units on a memorandum receipt. Such property, equipment and supplies will normally be issued through the California Wing. Title to property, equipment and supplies will be retained by state or local civil defense/emergency services agencies. Civil defense decals must be affixed to property and equipment in accordance with federal regulations prescribed by the Defense Civil Preparedness Agency. Property, equipment, and supplies will be used and/or operated in accordance with written agreements executed at the time the property, equipment or supplies are loaned and/or issued to CAP units. CAP units will be responsible to civil defense/emergency services agencies for items for which they have signed memorandum receipts.

14. California Wing, Civil Air Patrol, Unit Commanders will appoint civil defense/emergency services coordinators and establish plans and programs for assistance to local civil defense/emergency services directors in their areas. Such plans will be established in close coordination with the local director of civil defense/emergency services, as deemed necessary by him. Copies of all written agreements

will be forwarded to headquarters, California Wing, Civil Air Patrol, and the California Office of Emergency Services by the CAP Unit Commander and local civil defense/emergency services directors.

15. The term of this memorandum shall commence on the 1st day of August, 1975 and shall terminate thirty (30) days after the written notice of either of the parties hereto.

16. This memorandum shall be binding upon and inure to the benefit of the successors or assigns of the California Office of Emergency Services and successors or assigns of the California Wing, Civil Air Patrol.

17. This memorandum contains the whole understanding between the parties hereto and shall not be altered or modified without formal action of both parties.

18. Each and every provision of this memorandum is subject to the laws of the State of California and the laws of the United States.

19. Nothing in this memorandum shall be construed as obligating the OES and the State of California or the CAP and the U.S. Air Force in the expenditure of funds in excess of appropriations authorized by law.

20. This memorandum may be terminated at any time or any provisions herein contained may be amended or modified as herein above provided, upon the mutual written consent of the parties hereto.

21. This memorandum of understanding supersedes all previous statements, agreements or memorandums of understanding entered into by the California Wing, Civil Air Patrol and the California Office of Emergency Services.

IN WITNESS WHEREOF, the parties hereto have executed this memorandum as of the date last signed below.

Warren J. Barry, Colonel, CAP
Commander, California Wing

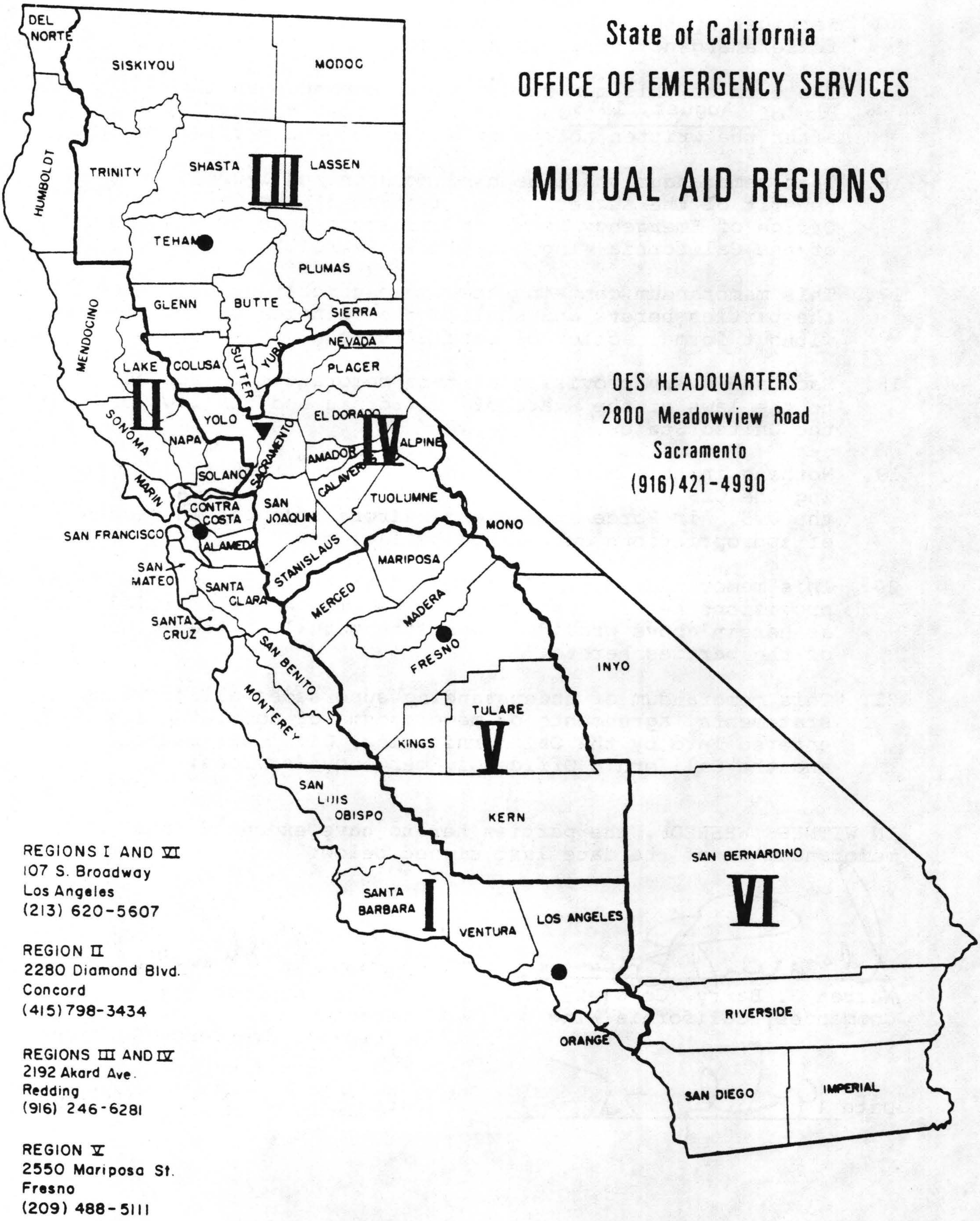
Date 19-July 75

Charles Manfred
Director
Office of Emergency Services

Date July 22, 1975

State of California
OFFICE OF EMERGENCY SERVICES
MUTUAL AID REGIONS

OES HEADQUARTERS
2800 Meadowview Road
Sacramento
(916) 421-4990



REGIONS I AND VI
107 S. Broadway
Los Angeles
(213) 620-5607

REGION II
2280 Diamond Blvd.
Concord
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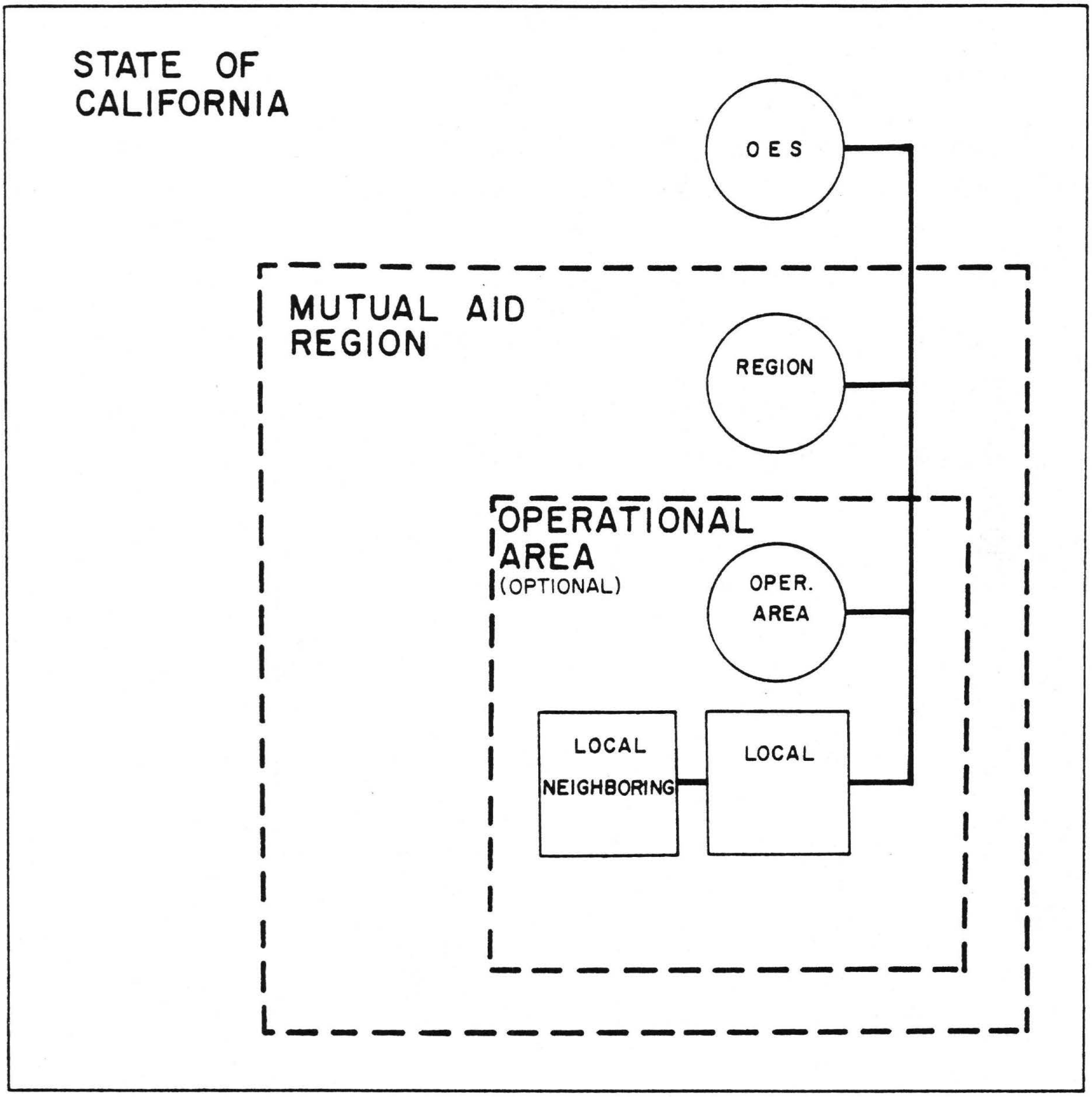
REGIONS III AND IV
2192 Akard Ave.
Redding
(916) 246-6281

REGION V
2550 Mariposa St.
Fresno
(209) 488-5111



INTER - JURISDICTIONAL EMERGENCY RELATIONSHIPS

REFERENCES

(1) Raleigh, Barry, et. al., "Prediction of the Haicheng Earthquake," EOS, Transactions, American Geophysical Union, May 1977, pp. 236-272.

(2) State of California, Office of Emergency Services, Emergency Plan, Sacramento: August, 1975.

(3) State of California, Office of Emergency Services, Radio Amateur Civil Emergency Plan, Sacramento: January, 1971.

(4) *Op. Cit.*, (2).

From: Roy Popkin, Assistant National Director
Disaster Services
American National Red Cross
Washington, D.C.

To: United States Geological Survey
Attention: Peter Ward, Menlo Park, California

Subject: Development of "National Earthquake Detection Corps"

The development of a "National Earthquake Detection Corps" similar to the kind of network which exists in China, should be feasible, but maintenance of such a network over a period of time presents various problems which are not inherent in already existent volunteer "spotter networks" such as those utilized by the National Weather Service in relation to tornadoes and rainfall watchers.

The voluntary resources for such a network do exist, and our experience with the utilization of volunteers leads us to believe that such a network could be established and could, in all probability, function with reasonable effectiveness.

However, we believe the following basic problems need to be addressed in basic considerations prior to the establishment of a network of volunteer earthquake precusor spotters:

1. The "science" involved is radically different. Tornado spotters for example, look at clouds, tornado funnels, rainfall, hail, etc. -- phenomena which are relatively obvious. The rainfall measurers also look at the obvious -- the amount of water accumulating in a rain gauge, the levels of streams. Their observations are triggered by obvious events -- the movement of storm systems and the occurence of rainfall.

Earthquake precursor watching is much more subtle. Earthquake precursors are much less obvious -- changing water levels in wells, radon gas content of well water, animal behaviors, soil uplifts or movements. They are not necessarily accompanied by dramatic or obvious events such as a storm system that automatically triggers either community or individual concern. The level of training and scientific information required by the volunteer spotters could well be much more sophisticated than that required for weather-related spotting assignments. Would some of the spotters be monitoring sophisticated instruments?

2. The time factors are also radically different. Whereas weather spotters have something to measure or watch at relatively frequent intervals, earthquake precursor spotters might go fifty years without ever seeing anything to report other than status quo. Which raises a question: would earthquake spotting be a constant, on-going volunteer activity, or would it be instituted only when seismological instrumentation indicated some major phenomenon such as fault movement, ground uplift, etc., in a given area, or after an earthquake prediction has been issued by USGS?

3. Sense of urgency is also a factor. The frequency of floods, tornadoes, and even droughts, and their relationship to daily living, farming, industry, etc., create an interest in weather spotting, an interest which is intensified when a severe storm system exists. Earthquakes are infrequent and even so highly seismic a state as

California has problems in developing adequate citizen and government concern over earthquake-related problems. In China, with a highly structured and directed society, urgency does not have to be a factor. Other kinds of "incentives" are available in a China-type society which may be lacking in a democratic nation.

With the following as background, it is our belief that an earthquake detection network can be developed, but USGS or whatever government agency is responsible for directing such a network, must be prepared to devote considerable time and effort to keeping its members interested and active.

There are various resources for such volunteers:

Science students in high schools and colleges: earthquake precursor spotting could be built into the curriculum, perhaps with the support of the Red Cross Youth Service Programs. A possible problem might be the discontinuity of supervision due to holidays and summer vacations and the fact that many college students come from distant home locations.

Utilization of teen-agers through existing youth programs on a project basis. The kinds of organizations envisioned are 4-H, Scouts, Red Cross Youth Service Programs, etc. While the membership changes, there is a continuity of program and leadership. In rural areas, the Agricultural Extension Service might provide a channel to 4_H and also, the county agency could provide the leadership continuity in behalf of USGS.

Youth Service Corps, CETA, etc. there are a variety of government-funded jobs programs which might fund spotters on some kind of part-time job basis. A disadvantage here would be the possibility that funding is highly variable and could be discontinued at any time.

Adding the spotter function onto existing jobs or organizational functions. Depending on the desired frequency of observations and how technical they need be, the spotter function could be added to the responsibilities of the police, county agents, volunteer or regular fire departments, road crews, Red Cross disaster volunteers, church welfare groups, etc.

If the spotters are to be other than official employees (police, county agents) -- volunteers, for example -- it would be our recommendation that the program must include a regularized reporting and acknowledgement system, whether it involves postcards or phone calls; that each volunteer be given some kind of special kit (like the small rain gauges) and special forms to use, a patch that can be put on a shirt or jacket; that there be regular meetings or workshops of some kind to give them interesting information about earthquake-related matters; and that there be some kind of recognition for service at regular intervals.

Also, someone in USGS must keep in touch with the spotter groups as a regular function so that reports are read and that spotters have someone to talk to if they have questions, think they have seen something unusual, etc., on a regularized basis rather than whoever answers the phone at a given time. This will help provide a continuity of relationship if they feel there is someone at home base who identifies with them.

We do not believe this need be a particularly costly kind of operation but believe a basic investment in what it takes to maintain continuity of interest would be more important, perhaps, to earthquake spotting than to weather spotting because of the factors mentioned in the earlier part of this paper.

SOME NOTES ON

PUBLIC INVOLVEMENT IN EARTHQUAKE MONITORING

--Preliminary Discussion Paper--

Contact: John Whitman
Director
Center for Public Involvement in Science
School and Society Programs
Education Development Center, Inc.

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21 December 1977

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Exhibits:

1. Partial list of meetings on earthquake monitoring and education
2. Center for Public Involvement in Science

1. Introduction

Having just returned from the People's Republic of China in mid-1975, Carl Kisslinger told some members of the Natural Hazards Research and Applications Workshop about the Chinese effort to involve students, school teachers, farmers, workers, and others in their earthquake monitoring and prediction program.[1] We discussed the desirability and feasibility of developing a network of students in California to replicate the Chinese experience.

Since that time, much attention has been given to the Chinese model of involving the public in earthquake monitoring and prediction.[2,3,4,5,6,7] While a great deal may be learned from the Chinese experience, tentative assessments suggest that their program may not be directly replicable in the United States, perhaps due to a variety of differences in social, political, and attitudinal characteristics between the Chinese and American people.[2,3,4]

Nevertheless, the United States has a long history of amateur involvement in science.[8] The possibility of involving citizens in the American effort to monitor and predict quakes is challenging, exciting, and potentially rewarding.

A well designed program of public involvement could provide significant scientific results, particularly in testing the validity of certain precursor phenomena. Such a program could have valuable educational benefits, as well. The educational benefits are twofold:

(a) Participants could learn about some of the dynamics of Earth--geophysics in general, and earthquakes in particular--and about how humans are affected by natural environmental changes taking place around the world; and

(b) Participants and others could learn about earthquake hazard mitigation measures that can be taken to plan and prepare for an earthquake event or prediction.

A program to involve amateurs in the earthquake monitoring and prediction effort should be closely linked to a broader and strategic public education program. We present a tentative framework for such a comprehensive program in a separate paper.[9] This paper presents several items for consideration in conceptualizing a program to involve the public in monitoring.

The following section recounts a few relatively large and small, past and present efforts to involve networks of amateurs in scientific research or monitoring in the United States. The next section offers some network features and assumptions that may be made in the design of an earthquake monitoring network.

2. Public Involvement in Science

We should not let the apparently successful Chinese experience eclipse attention to the long history of amateur involvement in science in the United States. This involvement has not been limited to a few individuals acting out of their own curiosity; it has included organizing large-scale networks of citizens, whose interest in a particular problem combined with their enthusiasm to contribute to honest science creates a valuable, volunteer research resource for the scientific community.

A few examples of such networks of amateurs may suffice to point out the possibilities of organizing a network of volunteers in an earthquake monitoring program:

- In the late 1800's, Joseph Henry, the first secretary of the Smithsonian Institution, organized laymen along the first transnational telegraph line to report local weather conditions. This network collected and reported to Washington, DC basic weather data, such as temperature, precipitation, wind speed and direction, and sky conditions. The network, which operated nearly 130 years ago, combined the latest communications technology with voluntary amateur assistance to create the world's first weather monitoring system. This laid the basis for weather prediction.[10,11]

- In 1911, the American Association of Variable Star Observers was created to involve amateur astronomers in observing, collecting, and transmitting data on variable stars. Over 3.5 million observations have been contributed to date. In addition, the volunteers collect data on sunspots and search for nova and super nova events. Such efforts undertaken by amateurs free up vast amounts of time in the lives of professionally trained astronomers, who can better spend their research hours making scientific use of the data, instead of being laboriously involved in collecting them.[12]

- In the late 1950's, Fred Whipple, then director of the Smithsonian Astrophysical Observatory, organized amateur astronomers around the world in the world's first observational satellite tracking network, called Moonwatch. Parts of Moonwatch were operational just in time to track Sputnik when it was launched on 4 October 1957.[13,14]

According to James Cornell, information officer at the Harvard-Smithsonian Center for Astrophysics,[14]

> Obviously, Whipple's original conviction about the value of amateur astronomers had been correct, despite predictions to the contrary by the military and other government agencies. Indeed, the unique effort demonstrated what amateurs could accomplish when properly inspired and led. Furthermore, although involving over 5,000 individuals, Moonwatch was probably the least expensive operation of the space program. Officials have estimated that the 400,000 observations may have been worth more than $14,000,000, when compared with the cost of other tracking systems such as Minitrack.

- In 1973, two botanists in the Smithsonian Institution worked with the author to utilize a network of thousands of students throughout the United States to collect samples of bamboo in a study of the rare flowering phenomenon in a certain species.[15]
- In 1977, another Smithsonian botanist worked with the author to utilize a network of students and teachers to monitor and record the flowering dates of plants in the U.S. and Canada as part of a phenological study.[16]
- Several other recent or current efforts involving large-scale networks of amateurs to assist science include:[17]
  - collecting fireflies for medical research
  - measuring the acidity of precipitation
  - monitoring hawk migration patterns
  - mapping the location of wild mushrooms
  - collecting agricultural weather data
  - collecting cabbage butterflies for research on folic acid
  - mapping the location of snow algae
  - growing and monitoring amaranth
  - monitoring water pollution

These and other efforts show that volunteers, if organized effectively, can contribute significantly and relatively inexpensively to scientific research or monitoring. All of these cases were initiated and undertaken in the United States (although some of these efforts included participants in other countries).

3. Network Features and Assumptions

One feature stands out in every case mentioned in the previous section: amateur participation was voluntary and not dictated. (This may be somewhat qualified with respect to the involvement of certain students, who may have had to take part as part of class activities determined by the teacher.) In many cases, such as weather monitoring, satellite tracking, and pollution monitoring, the nature of the effort appeared to be exciting and in the broad public interest. In the Moonwatch program, participants initially infatuated with the idea of tracking satellites soon dropped out; however, the more serious members remained, many throughout the life of the program, which ended in June 1975.

Some projects were goal-specific, such as collecting samples of bamboo. These programs were over once the goal had been reached. Others were on-going, such as weather monitoring, variable star observing, and satellite tracking. In the case of weather monitoring, amateurs gave way to trained meteorologists. In the case of satellite tracking, people gave way to newly developed tracking technology, involving lasers and degrees of unprecedented accuracy.

In all cases, participants needed little or no training. Different networks involved people with different levels of skills; ages ranged from children to retired, elderly adults.

Some networks appealed to people who aspired to be specialists, and these people desired an exclusive nature in their network's membership. Other networks were open to all, and attracted a variety of people with a range of degrees of interest and commitment.

A key ingredient in each case that resulted in success was at least one person whose determination, imagination, and energy propelled the program and sustained the interest of participants. This person did not need to be the principal scientist, whose work the volunteers were supporting.

Feedback to participants has been of two kinds. First, there is immediate satisfaction in having found and collected a sample, or having spotted a bird or a satellite. Second, there is the reward in seeing one's contribution made a part of a final report or collection of data, either or both of which the principal scientist sends to each participant or team of volunteers. This feedback is not of an evaluative nature.

Channels of communication have been based on existing postal, telephone, or other telecommunications systems (e.g., telegraph or telex). Feedback follows the same or other routes as the initial communication of data.

Evaluation of results may be formative, conducted continuously or periodically during the life of the program, or summative, conducted upon conclusion of the program, or both. In satellite tracking, observations could be confirmed within an acceptable degree of confidence by mathematical calculation. In sample collection, the scientist receiving the samples makes the final identification. In other efforts, redundancy of reports offers some measure of reliability. In unprecedented cases, such as satellite tracking, reliability improved as the bugs were worked out of the procedure.

In no case, to our knowledge, was an effort made to evaluate the educational results of such programs. The assumption has been that the principal purpose was to assist science, and any educational value may be inherent in the bromide, "people learn by doing." However, an explicit or implicit evaluation of educational results may prove valuable to the participants as a means to show what and how much is learned about a particular subject or process. Such evaluation may encourage and sustain interest in participation. Indeed, having some idea of the educational results may encourage even more people to take part in an effort.

These have been a few observations of the features of past and current networks of amateurs. With respect to earthquake monitoring, different strategies and different methodoligies will be required by different efforts, which currently have not been selected. Based on our discussions with a variety of people around the country, possible efforts may include observing unusual animal behavior, measuring the conductivity in the earth, measuring fluctuations in water levels, measuring changes in the magnetic field, and measuring horizontal and tilt changes. An additional, non-geophysical effort might involve people in searching historical accounts, such as newspapers, for references to previous anecdotal accounts of seismic events. At least one student, an eighth grader in Santa Barbara, already has begun assisting USGS in studying radon gas emission at two faults in her area.[18] Although we are interested in such cases of individual projects, we are primarily concerned

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with the network approach, which involves many people located over a broad geographical area.

Until we know exactly what type of effort or efforts will be required to assist the earthquake monitoring and prediction program, we will not be able to prescribe a particular proposed project. Nevertheless, based on our experience and discussions with others, some features may be assumed:

- The network should be an integral part of a credible scientific effort.
- It should also be a part of a comprehensive and long-term program of public education and information dissemination regarding earthquakes.
- While some activities may be undertaken nationwide, a pilot effort should be started in an area where scientific research on earthquakes is underway.
- The network should be directed by an individual with a personal and professional commitment to making the network succeed, and with superior drive, energy, and imagination that can be brought to bear on the program. This person need not be the principal scientist, or even have scientific qualifications; however, he or she should be regarded as an integral member of the earthquake studies team.
- The network should be built, to the greatest extent possible, on existing, credible, and well-known groups, such as schools, religious centers, geological societies or clubs, 4-H Clubs, Boy and Girl Scouts, and so on. However, membership in such a group should not be a qualification for inclusion in the network. New groups might be formed in areas not covered by existing groups.
- All members should have an unambiguous understanding of the nature of the task. If they are not participating in a proven scientific procedure, (such as observing unusual animal behavior), they should know it. For instance, in the case of observing animal behavior, participants should know that they are taking part in a scientific

experiment, namely that they are a part of the process of verifying, modifying, or refuting the hypothesis that unusual animal behavior is an indication of an imminent earthquake. This will ensure that participants are not led to believe that unusual animal behavior is a scientific means by which to predict earthquakes, however, they will understand that they are taking part in a scientific process of inquiry.

- A responsive feedback process will be critical in maintaining the interest of participants. They must continually feel that their effort is worthwhile, particularly if earthquakes are not to be common events. (Monitoring an event that persists in absence may prove, like "Waiting for Godot," absurd.)

- It may be desirable, depending on the nature of the effort, to couch it in the context of activities that offer more immediate results, such as micro-climate or weather studies in a particular region.

- Evaluation of the reliability of the data will be critical, especially in that the ultimate test of such reliability will be an earthquake event itself.

- Participants should be apprised of earthquakes taking place elsewhere around the world, and of quakes that have happened in the past. An excellent publication exists that could be used in this feature, Earthquake Information Bulletin, compiled and published by USGS. However, weekly or daily news and reports could be compiled based on a variety of sources, including the National Earthquake Information Service. Such reports also should inform participants of developments in the network and activities being undertaken in various areas of the network.

- All aspects of the program--planning, design, implementation, and evaluation--should include members from the target population from the beginning stages. This feature is described in our paper dealing with a framework for a comprehensive public education program.[9]

- A program of public involvement in monitoring should be dynamic and long-range in nature. Implementation of a program should not be delayed until there is unanimous agreement over methodology and procedure; indeed, as with the satellite tracking program, procedure will be refined in the process of operations. Sputnik was launched during the Moonwatch testing stage. Similarly, an earthquake could take the public monitoring program by surprise, but it would be more preferable to have an effort underway than not. (However, a prediction or warning based on data collected by amateurs, regardless of how long the program is in operation, may prove damaging if false, and could hamper continued involvement of amateurs in future efforts.)

These are some assumptions about the nature of a public effort to monitor earthquake-related phenomena. The assumptions are not final, and may be revised upon further discussion and analysis of needs.

4. Conclusion

Involving the public in the earthquake monitoring and prediction program can prove scientifically and educationally valuable, if appropriately designed, responsively managed, and effectively evaluated. Education Development Center, Inc., a publicly supported, non-profit organization with nearly two decades' experience in developing educational programs around the world, is concerned with earthquakes as an international problem. However, the passage of the Earthquake Hazards Reduction Act of 1977 offers us a strong foundation on which to begin to build a rational and comprehensive approach to earthquake monitoring and education in the United States.

We hope to share our experience in public involvement in science (see Exhibit 2) as well as public education in working with federal, state, and local agencies and citizen groups and individuals. The entire social and economic justification for supporting and encouraging the work and research called for in the Earthquake Hazards Reduction Act of 1977 and the Newmark report[19] is to mitigate the consequences of the earthquake problem. Public involvement in monitoring earthquakes can help to achieve this end.

Hopefully, this paper will contribute to the discussion of the problem and the development of an appropriate public program.

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Center for Public Involvement in Science

The Center for Public Involvement in Science was established within the School and Society Programs cluster of Education Development Center in April 1977. The Center specializes in developing large-scale networks of amateurs who collect data and samples for scientific research and monitoring within the context of a program that offers educational benefits to the volunteer participants (see next page).

The director of the Center, John Whitman, has undertaken similar efforts in the past. In 1973, he developed a network of 50,000 students in 800 schools throughout the United States, including limited membership in 30 other countries. This network, called the International Environmental Alert Network, was developed under the auspices of the Smithsonian Institution. It served as a means to increase student awareness of environmental events taking place around the world, and to involve participants in scientific projects, such as collecting samples of bamboo for botanical research led by Smithsonian scientists.

In 1976 and 1977, he developed an international environmental education network, called Internet, in cooperation with the Unesco/UN Environment Program office of environmental education. Internet has been developed in prototype form, and includes over 5,000 students reached through 68 teachers in 20 states and four Canadian provinces. Mr. Whitman has transferred his management of Internet to Education Development Center. A follow-up contract may be received from Unesco or the UN Environment Program to develop the program into a fully-operational and on-going activity and to extend or replicate it in other countries. Internet involved the network of students and teachers in monitoring the flowering dates of plants in the spring, as part of a phenological project led by a Smithsonian botanist.

The Center also houses a file on past, current, and planned efforts to involve large-scale networks of amateurs in science.

Prior to joining Education Development Center, Mr. Whitman worked with the Smithsonian National Museum of Natural History to develop the Scientific Event Alert Network, an international network of scientists reporting and receiving current information on natural science events taking place around the world.

edc school and society programs

CENTER FOR
PUBLIC
INVOLVEMENT IN
SCIENCE

The Center for Public Involvement in Science (CPIS) specializes in developing large-scale networks of amateurs who collect data and samples for scientific research, monitoring, and assessment.

CPIS offers:

- A unique opportunity for public participation in science.
- A large-scale data gathering resource for scientific research, monitoring, and assessment.

CPIS is identifying scientific programs that could benefit from the participation of volunteer data gatherers organized over broad geographic areas. Once specific programs are selected, the principal scientists define the data requirements, formats, and methodologies for collection and transmission. We then develop and tailor a network of interested public participants to collect the data or samples according to the specified needs of the particular program. We may identify prospective volunteers through existing organizations and groups, such as schools and school systems around the country and the world; membership associations, such as the National Science Teachers Association and the American Association of Retired Persons (with a membership of 10 million); service organizations, such as the National Center for Voluntary Action (with 300 Volunteer Action Centers around the country); 4-H Clubs; Boy and Girl Scouts; and readers of large-circulation magazines.

We develop an approach that builds the data collection and reporting effort into an educationally-oriented program that would have greater value to participants than an otherwise mechanical activity would offer. We utilize newsletters, reports, multi-media presentations, and other appropriate means to put the principal scientists and their research in touch with their volunteer assistants, and to sensitize other members of the public who may not be participating.

This approach offers science a new tool for research, and the public an opportunity to participate in science.

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SUGGESTED ROLE OF RETIRED VOLUNTEERS IN EARTHQUAKE PRECURSORY PROJECT

The National Retired Teachers Association (NRTA) and American Association of Retired Persons (AARP) are non-profit institutions which currently serve a national membership of over eleven million elderly citizens. Among the manifold activities of the local chapters and units, of which there are over 5,000 in the country, are numerous volunteer projects in which members enthusiastically and competently serve without compensation, save for expenses. These include participation in Red Cross services, visitations to shut-ins and convalescents, Tax-Aide assistance, Drive Improvement courses and Nutrition programs. Local AARP chapters are encouraged to become involved in at least one community service project each year.

The manner in which these volunteer programs operate is illustrated by the Driver Improvement Program and the Tax-Aide Service. The NRTA/AARP Driver Improvement Program, offered in cooperation with the National Safety Council, helps older persons improve their driving skills and "defensive driving" habits. The course consists of two four-hour classroom sessions that include films and other visual aids demonstrating safe driving practices. Persons who complete the course are eligible for a premium discount on Driverplan Plus auto insurance available in most states.

Defensive Driving Course instructors are NRTA/AARP volunteers trained by the associations and certified by the National Safety Council. To qualify for instructor training, individuals must have a valid operator's license, drive regularly, and have the ability to speak effectively before groups. They must agree to plan and conduct with another instructor at least two defensive driving courses in their communities each year.

The Driver Improvement Program recently graduated its millionth "student."

NRTA/AARP Tax-Aide volunteer counselors help older taxpayers prepare their returns, assisting with the special tax problems that often come with retirement. All older persons are invited to make use of the service or to volunteer as counselors or coordinators.

Tax-Aide coordinators recruit volunteer counselors in their communities, arrange for their training by the IRS, and set up counseling sites and work schedules. Coordinators also serve as liaison with the NRTA-AARP National Tax-Aide Coordinator. Each coordinator receives a copy of the "Handbook for Tax-Aide Coordinators" for guidance.

Tax-Aide counselors attend training sessions conducted by the U.S. Internal Revenue Service and commit a minimum of three hours a week to the program during tax filing season. Counselors advise taxpayers about how to prepare returns and about special credits for which they may be eligible, but they do not actually fill out the forms nor accept responsibility for forwarding them to the IRS.

In 1977, the associations' tax counselors assisted over half a million elderly taxpayers with their returns.

A tentative role for our members in the Earthquake Precursory Project would be that of rendering volunteer service in collecting information which can be used to make the optimum response to an earthquake prediction. Additionally, the bi-monthly publications of our associations conceivably could be used to disseminate public and educational information about earthquake prediction.

The potential for our associations' involvement is illustrated by the situation in the State of California which numbers over a million members. Over 250 local chapters and units are distributed throughout the entire state. These groups, together with their leaders, are quite sophisticated. With respect to their orientation to volunteer community service, the volunteer network includes about 30 volunteer officers throughout the state. Many of these members have spent their careers in the fields of science and education, which admirably fit them to play important roles in an earthquake hazard reduction program.

SUGGESTED ROLE OF RETIRED VOLUNTEERS
IN EARTHQUAKE PRECURSORY PROJECT

NRTA/AARP welcomes the opportunity to consider ways in which our members could serve as volunteer observers and information collectors in this important project.

A Program Utilizing Amateur Radio Operators

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Amateur Radio Operators (HAMS) are licensed by the Federal Communication Commission (F.C.C.) to operate on a wide range of frequencies for the purpose of personal communication. This license is earned by means of passing an examination administered by the F.C.C., and includes basic electronic principles, radio theory, electric-magnetic wave propogation, and a demonstration of ability to communicate using the International Morse Code. As the ham increases his ability he is encouraged to take additional examinations so as to further expand his allocation of available frequencies.

The Amateur Radio Service is not to be confused with the Citizen's Band Radio Service. C.B. operators are restricted to a narrow portion of the 11 meter band containing 40 crystal-controlled frequencies and are limited to less than 5 watts of transmitted power. Under favorable conditions this allows the C.B. operator to communicate over distances of up to 5 miles. In the urban areas, as the result of u.f. interference by illegal C.B. transmitters, lack of discipline by a small but vocal element, and the shear preponderance of utilizers, communication is frequently unreliable at distances of more than 1 mile. Another difference is that most HAMS are members of a local club that conducts monthly meetings Club activities include educational lectures, workshops on equipment improvement, discussions of civic responsibilities such as emergency communication services, and social events.

Many clubs also build, operate and maintain repeater stations. These repeater stations operate in the U.H.F. 2 meter band and allow a HAM operating a low-powered radio transmitter to access the repeater which then rebroadcasts the signal at a much higher signal strength. This rebroadcast signal then carries over a much wider geographic area and reaches many additional stations. In southern California there are about 50 repeater stations in operation at this time. Some of the repeaters, as a result of their favorable locations, provide communication links between low-powered stations operating in the high desert area and throughout the greater Los Angeles Basin. Because of the large number of HAMS licensed to operate on the 2 meter band (about 50,000 in Los Angeles, Orange, and Riverside counties) a high degree of discipline is required so as to maximize the regional communication capabilities of the repeater stations. This discipline is soon apparent to anyone monitoring the repeater frequencies. The HAMS are courteous, relinquish control of the repeater upon request, and demonstrate radio communication procedures that are highly efficient as well as effective.

A recent and even more impressive demonstration of the communication and technical abilities of HAMS has been provided with their involvement in satellite communications. HAMS have designed and built a series of satellites for providing repeater-type communication links over nationwide geographic areas. A new satellite (OSCAR VII) about to be launched in the Spring of 1977, will provide an intercontinental communication link for about 20 hours per day. These satellites are piggy-back-launched by the U.S. Airforce at no cost to the HAMS. The development, design, construction and testing is supported entirely by contributions from the amateur community throughout the world.

The question of utilizing HAMS as a component of an observational data gathering system must concern itself with their apptitude for long-term participation. Several examples of HAM-organized networks for reporting observational data may be helpful.

In the late 1950's, a scientist of the Moscow Academy reported to the world that he had observed a flash of light and a bright cloud emmanating from the lunar surface in the vicinity of the crater Aristancus. He suggested that this transient phenomena which lasted for less than 2 minutes may be of volcanic rather than meteorite impact origin. Dr. Jack Green, a major proponent for the volcanic theory of origin for the lunar craters, was very interested in this Soviet disclosure and decided to organize a systematic search for additional short-lived lunar phenomena. Because of the lack of available manpower at the established Lunar Observatories he decided to enlist the aid of a group of HAMS with an interest in astronomy. In 1959, the group organized themselves into a net they called the Astronet and commenced operations in the 80 meter band (3750 Khz).

The Astronet was structured so that the HAMS, located throughout the seven western states, were in continual voice contact with one another as they observed the lunar surface through their home-built telescopes. Their objective was to provide continuous observations of the entire lunar surface throughout a favorable viewing period. If a HAM observed what he believed was a transient phenomena he could quickly notify the other viewers and multiple observation of the same phenomena could be simultaneously observed from widely separated vantage points. This, of course, would eliminate the Earth's atmosphere as the causitive agent.

Prior to the formation of the Astronet, transient lunar phenomena were extremely rare and sitings had never been corroborated. In the first year of operation the Astronet achieved almost instant success. The HAMS were able to simultaneously view and photograph three different lunar transients. Interestingly, since there was no official government channel through which to report these observations one of the HAMS, Bill Kohlenberger of Fullerton, California, decided to contact the Smithsonian Institute in Washington, D.C. The Smithsonian was prompted by the Kohlenberger report to perform the service of transient phenomena reporting and shortly thereafter the Center for Short Lived Phenomena became established, continuing to use the reporting format used by Bill Kohlenberger.

The Astronet is still in operation and has provided numerous reportings of lunar and other types of transient phenomena. One of their most startling (and intriguing) successes has been in the area of earthquake phenomena. In 1969 several HAMS were immersed in conversation on the Astronet, when the Borrego earthquake (magnitude 6.1) suddenly took place. As the surface waves propogated outward from the epicenter and passed through the various stations that were on the air "felt" reports were quickly relayed to one of the HAMS who had quickly assumed the role of Net Control. This gentleman dutifully recorded the time and geographic position of the "felt" reports as well as preserving the transpiration of events on magnetic tape.

Fortunately this observational data collected by the HAMS as a result of their own scientific curiosity was put to good use. One of the members of the Astronet was Dr. Robert Wallace of the Office of Earthquake Studies of the U. S. Geological Survey in Menlo Park, California. Dr. Wallace learned of the earthquake from a commercial radio station in the San Francisco Bay area and quickly tuned in the Astronet on his amateur radio. Felt reports of the earthquake were still coming into the Astronet from HAMS in southern California and Baja, Mexico. Following the earthquake, Dr. Wallace was briefed by the net control operator and was able to ascertain the approximate epicenter of the earthquake as well as closely estimate the magnitude. Armed with this information he was in a position to act more quickly in dispatching a group of scientists from Menlo Park to the effected area to initiate post earthquake strain studies.

Dr. Wallace recognized the potential of the HAMS for providing meaningful input into the earthquake reporting system. On an informal basis he informed the Astronet operators about the Mercalli Scale and the subjective criteria used to assess the intensity of an earthquake. When the 6.4 magnitude Sylmar earthquake suddenly struck southern California in 1971 the Astronet again jumped into operation.

Network control was assumed by an operator away from the damaged area and incoming felt reports as well as intensity estimations were again recorded. During this earthquake Dr. Wallace connected the Astronet by telephone to the U.S.G.S. in Washington, D.C. so that they could also be quickly informed as to the location and damage estimations of the earthquake. Once again, the input by the HAMS was useful information and provided a quick estimation of the location of the area damaged by the earthquake.

HAMS have also organized a network for reporting meteorological observations. This network became established prior to W.W.II and has continued to grow since that time. The weather is reported on the Weathernet each morning by several hundred HAMS scattered throughout the western states. To my knowledge this information is not utilized by any official organization. Each morning HAMS communicate to each other and the listening public real-time weather information such as temperature, barometric pressure, wind direction and velocity, and cloud cover. When weather conditions are changing rapidly, the Weathernet remains in operation for longer time periods, and during conditions of severe weather such as thunderstorms and tornadoes, the net remains in operation for the duration of the emergency. The main strength of the Weathernet is that it provides information about the weather on a real-time basis. There is no lag-time between the observation and the report as is the case with daily weather synopsis provided by newspapers and radio stations.

Although not so long term as the above examples, HAMS in Orange County California have been providing assistance to the California State University at Fullerton Seismology Lab for the past 5 years. Amateurs have donated equipment and time to the day-to-day operation of the lab, as well as gathered information potentially related to earthquake premonitory phenomena. For example, one of the local HAMS has been monitoring a section of the Orange Freeway where it occasionally shows sign of distress in the vicinity of the Whittier-Elsinore Fault zone. This data has been systematically collected and documented since the Freeway opened in early 1974. HAMS are also being used to solicit "felt reports" from their friends and neighbors following local earthquakes in the Fullerton-Anaheim area. This service by the HAMS was initiated January 1, 1976 as the result of interest generated by a local 4.2 magnitude earthquake in the Fullerton area. Immediately following the earthquake HAMS began calling into Cal State Fullerton on a locally utilized channel in the 2 meter band (147.50 mhz). The information was plotted on topographic maps and within 1 hour an isoseismal map had been constructed. This information was fed back to the HAMS along with the instrument recorded data and a surface search for visible surface distress was initiated. Even though the search turned out to be negative, an effort was made that was not possible utilizing the resources of only the trained geoscience community from Cal State Fullerton. As the result of the two-way communication provided by the 2 meter HAM radios, many amateurs were quickly deployed, a systematic search was carried out, and the challenge provided by an event with no warning was met.

In summary, the amateur radio community is a highly organized, well-disciplined, technically capable group of amateurs. They are dedicated to public service and improving the state-of-the-art of their chosen hobby. Their fundamental strength is their extraordinary power to provide two-way communications within the public sector. An expansion of this role to provide an information link between the scientific and public communities may be beneficial to both groups. Earthquake information observations can be collected by HAMS and other amateurs and communicated to regional data collection centers. In return earthquake education information can be provided to the HAMS for dissemination into the public sector at the "grass roots" level.

POSITION PAPER

Girl Scouts of the U.S.A.
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REGARDING THE POSSIBLE DEVELOPMENT
OF AN EARTHQUAKE MONITORING PROGRAM

Girl Scouts of the U.S.A. is a girl-centered organization that is an integral part of the community. It provides a sharing, among youth and adult volunteers, of an informal education process based on proven ethical values that help expand a girl's horizons. It is also the largest volunteer organization for girls (6-17 years of age) in the world.

The organization is committed to providing a program that is relevant to today's girl. Therefore it seems very feasible that some type of relationship can be established between Girl Scouts of the U.S.A. and the Geological Survey, Office of Earthquake Studies.

Before any type of brainstorming on possible program development can take place, it may be helpful to understand the structure of the Girl Scout organization. The national headquarters is in New York City with six regional offices throughout the country. Region VI encompasses 10 western states and Guam and offers consultative services to 40 councils within that area. The national organization is responsible for developing all basic program design for all councils. However, decisions on specific program cannot be made by the national branch offices. Instead, each council which is a chartered corporation, is responsible for those decisions. Planning is done by both volunteers and staff.

The major portion of Girl Scout membership is composed of first through sixth grade girls. Some of the programs that were developed for the national organization are. . .

- In 1977 the national "Worlds to Explore" program was launched. This program focusing on five "Worlds" are entitled: the "World of People," the "World of Well-Being," the "World of Today and Tomorrow," the "World of the Arts," and the "World of the Out-of-Doors." It is very evident to me that a program dealing with earthquake monitoring and public information would relate to all of these "Worlds."

- A new program that is soon to be implemented for older girls is called, "From Dreams to Reality." This program focuses on career exploration in many diversified fields. Exciting development in the scientific fields would be an outstanding way of involving girls in the earthquake area.

The national branch offices (regions) provide training on program material and also do consulting work with specific councils. At times it is possible to provide council-wide training in specific fields, i.e. earthquake monitoring.

Besides developing programs, councils also sponsor national Wider Opportunities that focus on specific subject matter for girls ages 14 to 18. This may be an area where the older girl could be provided training in a specific field.

In addition to the council, troops also develop programs that are specifically designed for the girls. "My Own Troop's Badge" provides a loose framework for girls to design their own requirements and badge design.

All program, whether it is designed for the national organization, council, or troop level is based on the girl's interest and the volunteer's ability to deliver program. No one can make commitments for an individual troop or council to any specific project.

From my perspective, there appears to be two different areas of focus that the Girl Scouts could take in dealing with an earthquake program that would encompass volunteers . . .

1. <u>Observation/Monitoring:</u>

   This might be an area that could especially attract girls. With properly developed material and guidelines developed for the leaders, an exciting monitoring program could be developed. Though the manuals or the program could not be too technical. It would need to appeal to the girls and be possible for them to easily take part in it.

   It may be necessary to limit this area of monitoring to our older girl membership. A possible idea would be for councils to co-sponsor a Wider Opportunity that would focus on the earth sciences, career development, and documentation in the scientific field.

   Younger girls, Brownies through Juniors, might be able to have many workshops in day camp situations, established camps, or on the troop level. These workshops could focus on informing the girls on earthquakes, how they should react and how they can help observe earthquake signals. It would also be advisable to have visual approaches for this younger age group and it would be necessary to have materials geared to their level.

2. <u>Public Information Dissemination:</u>

   This area could lead Girl Scouts into informing the public on earthquake information.

People need to be made aware of the earthquake information. We could work through the girls to educate the adults. The girls could take information that they have learned and educate their parents.

Another step would be to branch out to other adults and organizations - possible presentations to organizations (speakers' bureaus), mall displays and various trainings could be established with a community.

The Girl Scouts also have had a great deal of experience working with projects in the scientific field. Enclosed is a copy of a "troop's own badge" that focuses on earthquake awareness. It was developed by a troop in the San Francisco Bay Council. Two requirements that were not required in this badge, but may be necessary to include deal with:

1. What do you do in a car, especially on a highway?

2. What types of secondary efforts should you be aware of, such as landslides and floods caused by dam breaks and especially fire?

Enclosed are excerpts from a Girl Scout publication entitled, "Blueprints for Action." This environmental resource was produced by the Educational Services Department, Girl Scouts of the U.S.A. on a grant from the Department of Health, Education and Welfare, Office of Education, based on the Environmental Education Act. This report gives us a step-by-step approach to developing successful Girl Scout environmental projects. This resource may provide a tremendous framework for developing a Girl Scout earthquake program.

The Girl Scouts have also had a great deal of experience in working with the elderly in a project entitled, "Hand-in-Hand." Enclosed is a copy of the material for your information.

In my estimation, there are two paths to pursue in developing a project of this scope.

- <u>A Girl Scout Project</u>:

  If the Girl Scouts were to develop an earthquake program, listed below are some possible ideas.

  (a) Need to develop criteria for establishing an overall pilot and project.

  (b) Need input from experts in the scientific field.

  (c) Probably form a task group among Girl Scout members and experts in the earthquake field to develop a leader's guide and program materials (the program material cannot be to technical).

(d) Training must occur for adults/leaders on the developed earthquake program.

(e) Implementation should be done at first on a small scale and then expanded in the future.

(f) There must be a long-term commitment by any Girl Scout unit taking part in the earthquake program.

- <u>An Interagency Task Group</u>:

Listed below are possible methods for establishing a task group and developing a focus to the project.

(a) Select members from various volunteer organizations and experts from the field of earthquake prediction and public education programs to serve on task group.

(b) The people of the task group would work cooperatively in establishing criteria, materials, program, and methods to implement the earthquake program.

(c) It would be the responsibility of this task group to plan, implement, and evaluate a joint program dealing with earthquakes.

I see many ways that the Girl Scouts could become involved with this type of a project. It will be my pleasure to work with the other interested members at the workshop in Menlo Park in February. I hope at this time, many ideas will be shared and some fantastic plans can be established for the future.

by Kris McCann
Program Consultant

Girl Scouts of the U.S.A.
National Branch Office

December 16, 1977

The following five pages are exerpts from <u>Blueprints for Action</u>, an environmental resource produced for the Girl Scouts. These examples show how the National Organization might provide examples of projects to local Councils.

Blueprints for Action is a report of how to achieve change. Some of these exciting accounts are just beginning—some are without an ending. These are about young people and adults who are working together to make positive changes in their communities because they are concerned about the people, the water, the air, and the land around them. With high hopes for the future, they are working on long-range goals, undaunted by problems and obstacles they may encounter. Their plans are **Blueprints for Action.**

In the summer of 1972, a group of 80—boys, girls, and adults—from 24 Girl Scout councils in 18 states—participated in a conference on "Quality Living Through Ecological Understanding." Students came in teams of three, each team from a Girl Scout council, to learn about major problems facing man in his environment. A special team from the Missouri Youth for Environmental Quality—a coalition of young people from many organizations in the state—also participated.

The scene was the campus of the University of Wisconsin-Green Bay, popularly known as Survival U because of its total concentration on problems evolving from environmental crisis. Participants met with the Survival U faculty in a series of workshops, lectures, and field trips, to study four major problem areas:

1. The Ecology of Towns and Cities

Interrelationship of housing, employment, population, transportation, and recreation as factors in a rewarding life for all people.

2. Population and Environment

The effect of geometric progression of human population on the quality of life and the survival of mankind.

3. Visual Art

The impact on the emotional aspects of life of form, line, color, scale, texture, light, space, shape, and pattern of one's surroundings.

4. Significance of Increased Leisure Time

Ways of preserving and nurturing the natural resources we all must share in the face of rising demands for recreation.

In a special session, career opportunities were examined with emphasis on the concept of environmental ecology.

THE PARTICIPANTS

Each team included an adult, one Girl Scout, 15 to 18 years of age, and one young man, also 15 to 18, selected by the council they represented. These young men came from environmental movements or high school ecology clubs, had worked with Girl Scouts on Eco-Action projects, or were planning for careers in the environmental field. Adult members of the teams were not necessarily Girl Scouts, although often they were the Eco-Action chairmen for the council. Adult members were usually involved in ecological activities in their home communities. In some instances, the adult member was a Zero Population Growth member, or a horticulturist.

Before coming to Survival U, each team was asked to do some research and to prepare a commitment to action for implementation upon returning home. An advance reading list was sent to team participants, along with an outline for assembling facts about their community which would aid in the selection of the backhome project. Their research was to include:

Population figures for the community or area in which they lived; past figures and projections for future growth.

Trends revealed in these statistics.

Effects of population size on housing, transportation, open spaces, recreation, water supply, need for power, waste disposal.

Elements of change—Was anything being done or contemplated? Was change just ignored? Who was planning change? What could the team do to help or initiate it?

Then each team evaluated its own plan for positive action, dissemination of environmental concepts, the practicality of the plan for a particular community, and for coordination with other efforts. The plans were to contain facts and figures to substantiate their importance to the community, a timetable, a list of interested people, a budget, and means of financing. Teams were asked to consider ideas for other groups to follow in planning similar projects.

The teams brought this material to Survival U. There, in workshops, discussions, and team sessions, commitments were polished, refined, and brought into focus.

The following pages describe the results of that careful dissection and reconstruction and can serve as **Blueprints for Action** for other groups.

Missouri Youth For Environmental Quality

COMMITMENT

To develop an effective structure for a statewide organization of Missouri youth for environmental action

The MYEQ was formed in 1970 to correlate all activities of young people throughout the state, and to maintain and improve the quality of Missouri environment. The team believes that a decentralized structure of four geographical areas will increase and broaden youth participation.

PLAN FOR ACTION

The team plans to redesign the structure of MYEQ and to provide environmental training and action at a regional level.

SPECIFICATIONS

1. Establish four regions, each with its own structure, guidelines, and leadership.
2. Regional conferences will focus on skills for teaching environmental concepts, methods of implementing action projects, and disseminating information on current status of legislation.
3. A newsletter will be published by MYEQ to report local and regional activities, and provide information for local youth groups.
4. MYEQ will expand representation from Girl Scouts, Boy Scouts, Boys Clubs, Camp Fire Girls, 4-H Clubs, Future Farmers, Future Homemakers, Red Cross groups, and Y's.

MEMBERSHIP OF AN ENVIRONMENTAL COORDINATING BOARD

Representatives from:

Education

School Board
Diocesan Education Department
Minister of Education of Church
University Administration
Student Government Association

Finance

Bank

Community Business, Service, and Civic Organizations

Chamber of Commerce
Mass media
Library
Community Council
Service clubs
Other youth agencies

Religion

Religious and lay leaders

Regional Planning Boards

Regional Planning Administrator

Environmental Agencies

Environmental Protection Agency
Soil Conservation Service
U.S. Forest Service
Other governmental agencies

National Environmental Organizations

Audubon Society
Sierra Club
Other environmental organizations

Girl Scout Council

Team members
Executive Director
Board member
Trainer

BUDGETING FOR AN ENVIRONMENTAL INFORMATION OR COORDINATING CENTER

1. Ask postal authorities about nonprofit mailing permits.
2. Get office space, equipment, and office supplies donated. Try the Girl Scout council office, offices of other agencies, City Hall, business owners, corporations, schools, or religious groups.
3. Seek use (at odd hours) of typewriter and reproduction equipment from businesses, schools, religious groups.
4. Recruit volunteers with secretarial, public relations, and other necessary skills.

A typical budget might include:

Mileage for staff
Rental of office space, if not donated
Rental or purchase of office equipment, if not donated
Office supplies
Telephone
Production of instructional materials
Production of informational materials
Postage

Mid-Island Council Girl Scouts, Inc.

Bethpage, New York

COMMITMENT

To provide safe, easy, traffic-free bicycle routes, and encourage more people to use two wheels instead of four

In 1954 there were 3,000 bicycles in use on Long Island. Today, there are 40,000 bicycles and this figure will double in the near future. With the large growth of population on Long Island and the increase in the number of cyclers, there is clearly a need for more and better bicycle routes and to encourage safe bicycling practices.

PLAN FOR ACTION

The team proposes to build community support for new bike paths, utilizing state-owned land which could be maintained under the highway maintenance program. The land for the path would be a 6-foot-wide swath following the side of the highway.

SPECIFICATIONS

1. The team investigated existing bicycle routes and determined that 30 miles of additional bike path would provide good transportation to various points on the island. They will develop a plan to coordinate old and new bike routes.

2. Team members learned that a path with a 5-inch gravel base covered by ¾-inches bituminous plant mix was the most practical surface for this area. The path would be built with a slight rise in the center for drainage.

3. A petition to the Town Board will be drawn up, asking for a hearing on the Bike Transportation System plan.

4. A mass meeting will be held to rally support, and to obtain signatures on the petition. Local officials will be invited to attend. Representatives from Girl Scouts, 4-H Clubs, Boy Scouts, Youth Council, American League of Wheelmen, Sierra Club, and the Long Island Environmental Council (a coalition of 71 organizations) will be asked to join forces to work on the Bike Path System. The rally will be open to the public, held in a local school, and advertised through posters and fliers in schools, stores, and churches, and through announcements on radio, television, and in newspapers.

5. Registration of all bicycles in the county will be proposed to the police department. The revenue could be used to build and maintain more bike paths.

6. Cooperation in construction of the bike paths will be sought from the American Society of Landscape Architects, the American Institute of Architects, the Department of Agriculture, the Department of the Interior, and from local colleges and universities.

Cumberland Valley Girl Scout Council, Inc.

Nashville, Tennessee

COMMITMENT

To hold a seminar, "The Crisis"

The team believes that the present world population crisis points to a need for new social values and responsible controls of population growth. Their immediate goals are to make a critical analysis of overpopulation and its relationship to pollution, consumption of non-renewable resources, and personal ethics and to educate others about these relationships.

PLAN FOR ACTION

The team will work with Zero Population Growth members to hold a three-to-five-day seminar for high school students and adults. The seminar will analyze social values inherent in the problem of overpopulation and the threat the population crisis poses to environmental quality. The team hopes to stimulate participants to conduct similar population education programs in their own communities.

SPECIFICATIONS

1. The team gained support of the local Girl Scout council to hold the conference at the Girl Scout camp. To be called "The Crisis," the seminar will be in three parts:

I. *Population and Environmental Degradation.* Population facts and fiction.

II. *Population and Ethics.* History and religion, sexual morality, the family unit.

III. *Population and Government.* Roles and responsibilities, political action.

2. Experts invited to be discussion leaders include Dr. John Shier, population authority from Survival U, and local resource people—clergymen, conservationists, medical professionals, civil rights spokesmen, and women's liberation proponents.

3. Games, films, literature, and displays will dramatize environmental conflicts.

4. Group discussions will facilitate informal exchange of ideas and information.

5. Participants will be in teams of three—a teenage Girl Scout, a Boy Scout, and one Girl Scout adult. Invitations will be sent to religious youth groups, to Planned Parenthood staff members, school teachers, clergy, and legislators. Youths are to comprise two-thirds of the participants.

6. To support the project, the planning group is seeking funding from governmental and/or private sources.

7. After returning home from the seminar, each team will be asked to initiate and develop a population-related project in its own community.

Taconic Girl Scout Council, Inc.

Westchester County, New York

County Planning

Every morning at 6 a.m. a 14-year-old girl gets up, dresses hurriedly, and goes to the Pocantico River near her home, for a water sampling. Her performance is matched by dozens of other Cadette and Senior Girl Scouts at prearranged vantage points along the river. Their efforts are the result of a massive Eco-Action campaign by the Girl Scouts of the Taconic Council in Westchester County, New York.

In April of 1971 three Senior Scouts planned a council-wide Eco-Action Day involving thousands of girls and adults. They reported on activities ranging from cleaning beaches to clearing woods of trash, from collecting aluminum to locating abandoned cars, from town clean-ups and beautification to distributing posters and hand-bills telling how to build compost piles. So successful was the day that a group of conservation scientists and county and state officials agreed to help form an advisory committee to work with Girl Scouts on environmental projects. Together with the council's Eco-Action Task Force, a major program was planned to inventory the county's natural resources.

Working with the County Planning Department and Federated Conservationists of Westchester County, the girls for the past year and a half have been developing an inventory of the watershed — wetlands, bogs, marshes, swamps, and their effect on Westchester County.

The program gained such major proportions that the two other councils in the county, Post Roads and Sackerah Path, asked to participate.

The county geologist, Soil Conservation Service, and the president of Federated Conservationists helped the participants set up schedules and showed them how to keep records. Trained by experts, they started an inventory of all the factors which contribute to the change in a river, such as geology, industry, land use, upriver dams (both man-made and animal), the river banks, the flora and fauna. A booklet resulting from this survey describes the river course and details the industry, population, construction, and growth in the watershed area — all of which will affect the life and economy of Westchester County for generations to come.

The efforts of Eco-Action task forces continue. Participants now include school and other youth groups, biology and ecology clubs, and adult organizations such as the Audubon Society, Westchester Recycling Commission, the Board of Cooperative Educational Services, and the Soil and Conservation Department.

The most significant result of the Girl Scout-initiated program is the emergence of a Central Coordinating Commission which serves as a clearinghouse for county action, and which sponsors an entire network of projects. One such project is an inventory of the Saw Mill River. This study of the social and economic as well as environmental aspects of the river was prepared by college students for credit.

Another project concentrates on pollution and environmental quality. Eco-Action projects are not limited to girls of high school and junior high age. For example, teams of younger Girl Scouts have recorded the source of polluting a stream, inventoried a city block, cleaned up an abandoned cemetery, and prepared a "walk book" of what one can expect to find within specific areas of the watershed. One Junior troop takes orders for praying mantis eggs, as a natural way to control insects and halt the use of insecticides.

The Girl Scout activities are part of an entire community program—one which started with Girl Scout action and then fanned out to include groups from all over Westchester County. Now most people are either directly involved in environmental projects or are thinking environmentally.

The County Commissioner of Planning announced that he had never before considered Girl Scouts as "a moving force." Little did he know that Girl Scouts could move mountains—if they felt it was ecologically sound.

Epilogue

Now that you have seen the well-developed plans of other groups, forces corralled by youth—Girl Scouts and other young people—you may want to develop your own plans for action. In defining a project of action, it is important to assess whether the project will make an impact on the community and contribute to environmental quality. An important measure of any such project undertaken is the extent to which those who participate develop a deeper understanding of the environment, and of the underlying causes of environmental problems. **Ask yourself these questions:**

- Is the project based on accurate facts and full understanding of cause and effect?
- Does it take into consideration any projects or actions already underway to meet the same needs? Is there coordination with, or supplementation of, the efforts of others with the same ecological concerns?
- Does it identify the people who need to be involved in the action?
- Will the plans include maintenance, continuity, follow-through, and community support?
- Are up-to-date environmental materials in use for planning and gaining background for the project?
- Will the project help participants broaden their understanding of the environment and ecological activities by stimulating them to:

Become aware of their surroundings and possibilities for improvement.

Discover sufficient facts about environmental problems to understand why the problems exist, what is involved in finding solutions, what solutions are being tried and by whom.

Test and observe environmental relationships and effects of change and action on existing conditions.

Experiment with their own solutions.

Explore and use resources of the community, environmental agencies, and other groups with similar concerns about environmental quality.

Interpret facts, information, and/or plans to appropriate groups within the community.

An important result of involvement in any group's environmental action project is the increased awareness of personal responsibility which can lead to wise action now and to informed action in the future.

EARTHQUAKE AWARENESS

COURTESY

OF

OUR LADY OF PERPETUAL HELP GIRL SCOUT TROOP 1542

1. Visit a place where you can learn about Earthquakes
   J. D. Randall Junior Museum, 199 Museum Way, San Francisco.

2. What you can do before an Earthquake occurs.
   1. Check your home for earthquake hazards.
      bolt down or provide strong support for water heaters and other gas appliance.
      place large heavy objects on lower shelves.
   2. With your Family talk about earthquakes
      hold drills to avoid injury and panic during an earthquake.
      teach family how to turn off utilities
      keep immunization up to date for all family members.

3. Things to do in case of an earthquake.
   1. Keep calm
   2. Indoors..stay indoors, take cover under desk, table or bench, under doorways.....stay away from windows or falling objects.
      Outdoors..get away from buildings, go to clear area..stay away from utility poles and wires.

4. A list of what you can do in your own home, to help during earthquake.
   1. Keep calm
   2. Turn off Utilities....gas main, water main and electric box.
      everyone in the family should know where they are and how to turn them off.
   3. Turn on Portable Radio to KFRC or KYA for instructions.

5. A list of supplies you should have in your home for such emergency.
   1. Food...can supplies, things you can use without electricity.
   2. Water..have supply of water to last your family for 5-7 days.
   3. Portable Radio..have extra batteries...KFRC or KYA.
   4. Flashlight....have extra batteries.
   5. First Aid Kit.

6. What is an earthquake?

The Role of the University and Undergraduates in a Volunteer Program for Earthquake Prediction

by

Jon S. Galehouse
Professor of Geology
San Francisco State University

At San Francisco State University (SFSU) we have used student volunteers successfully over the past seven years in a continuing survey of residents living along the San Andreas fault in San Mateo County (see attached article). The volunteers were undergraduate students enrolled in a course entitled "Earthquakes and the San Andreas Fault". The surveying was done as part of a term project and was supervised by the course instructor.

Any successful volunteer program involving observations and the collection of data that can be used in the earthquake prediction process must include components that are particularly appropriate to a primarily undergraduate institution. Potential precursor data must be collected accurately and with the optimum periodicity over an extended period of time. Certain aspects of the observations and data collection will certainly be more complex than others. Undergraduate students would provide a degree of scientific sophistication intermediate to that of the lay person and the graduate student/professional. The faculty at an undergraduate institution can provide the supervisory stability needed in a volunteer program that may last for years. The accompanying flow diagram summarizes the following discussion and shows how various aspects of the volunteer program could relate to one another.

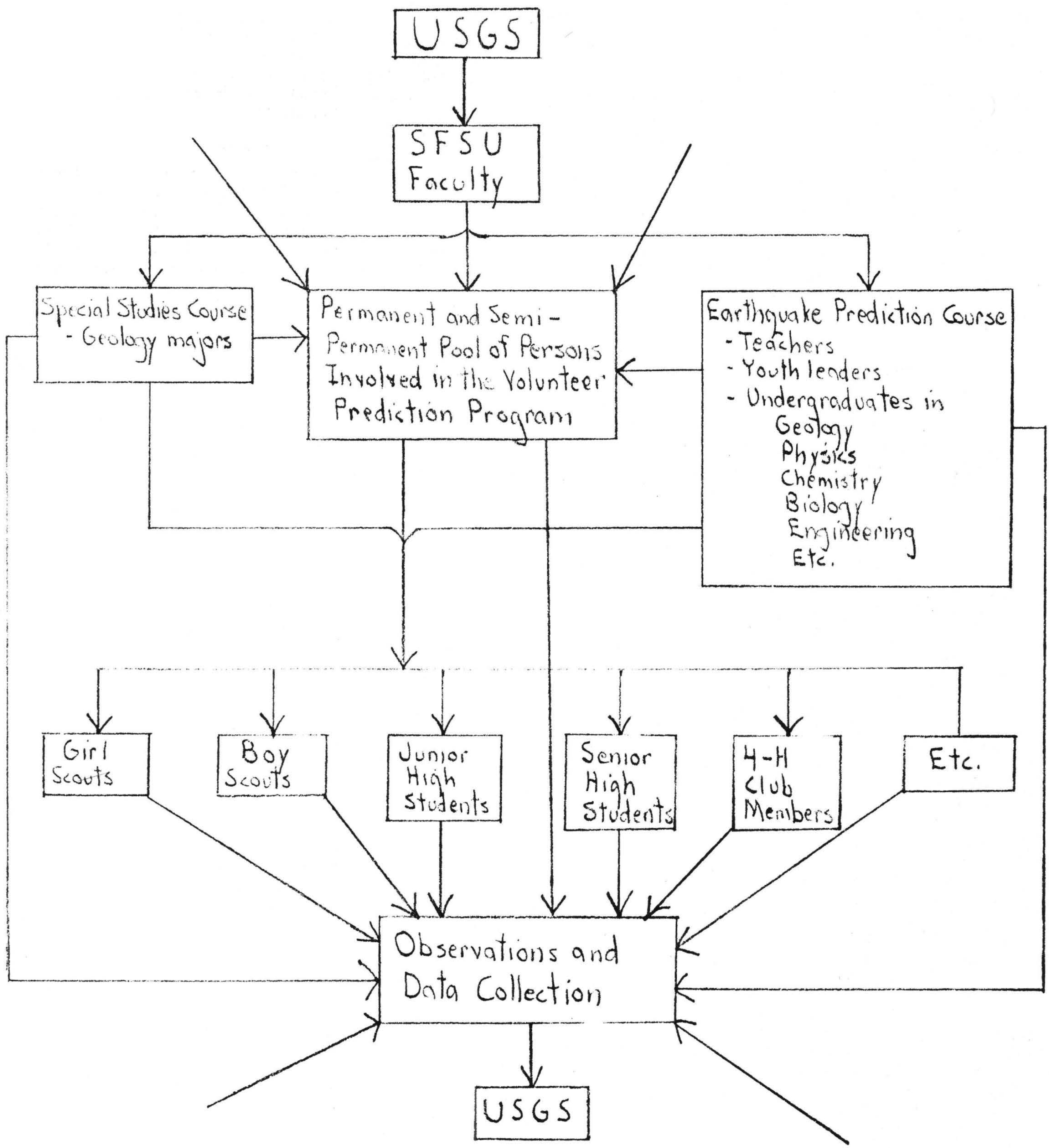
If it appears that a volunteer program concerning earthquake prediction will be established by the United States Geological Survey (USGS), the Geology Department at SFSU intends to introduce a new undergraduate course entitled "Earthquake Prediction" that would have participation in the volunteer program as a permanent field project. Although the lecture portion of the course would be given only one semester a year, the field project would extend throughout the calendar year with certain students participating at different times.

We already have a "Special Studies" course which is for individual undergraduates to do laboratory or field work under the personal direction of a faculty member. With more than one hundred undergraduate geology majors at SFSU as well as large numbers of undergraduate majors in other areas related to earthquake prediction, there should be no problem in finding students interested in participating in the various aspects of the volunteer program. In fact, many students have already indicated their interest to me and are eager to be involved. This involvement, however, does not need to be restricted to observations and the collection of data. Many of our students are planning teaching careers and are interested in helping supervise junior and senior high school students, girl or boy scouts, 4-H club members, or other young men and women who are participating in the program.

Regarding the supervision of youthful participants, it may be desirable to offer the lecture portion of the Earthquake Prediction course in the evening so that some junior and senior high school teachers and other youth leaders could enroll, obtain some background level of knowledge concerning prediction, and then supervise their own students or club members in the volunteer program.

I believe that some of the people who take one or both of the above-mentioned courses will have a continuing interest in the volunteer program and along with other persons form a permanent or semi-permanent pool of individuals who would continue in the program.

Volunteer Program for Earthquake Prediction



LIVING IN EARTHQUAKE COUNTRY

A SURVEY OF RESIDENTS LIVING ALONG THE SAN ANDREAS FAULT

By
RAYMOND SULLIVAN, DAVID A. MUSTART, AND JON S. GALEHOUSE,
Department of Geology
San Francisco State University

In 1970 a survey of residents of the San Francisco peninsula who resided in the area of the San Andreas fault zone was initiated. The objective of the survey was to evaluate the awareness of, and attitudes toward, earthquake hazards in a densely populated area close to the San Andreas fault.

As government agencies and the news media focused increasing attention on the potential destructiveness of a major earthquake, a second study objective became the evaluation of any effect that this publicity had in changing public awareness and attitudes (Algermissen, 1972; Wallace, 1974; and Turner, 1975). Hence, additional surveys were made in 1972, 1974, and 1976 in the same residential area.

SURVEY AREA

The area selected for the survey covered a narrow strip of land in San Mateo County approximately ½ mile wide and 6½ miles long, extending northwest–southeast through parts of Daly City, Pacifica, South San Francisco, and San Bruno, along the San Andreas fault zone from Mussel Rock on the north to San Andreas Lake on the south (figures 1, 2). The area includes parts of the communities of Westlake, Fairmont, Edgemar, Westview, Serramonte, and Westborough. This is the most extensive residential development to straddle the 600–mile long San Andreas fault.

Although the boundaries of the study area were defined in 1970, they closely correspond in this region to limits of the "special studies zones" that were established after passage of the Alquist–Priolo Special Studies Zones Act of 1972 (Hart, 1976). The "special studies zones" enclose faults, such as the San Andreas, which have been determined to be active and, therefore, present potential fault–related hazards (front cover).

Residential Development

The development in the study area is almost completely residential (figure 3). About 80% of the buildings are single family units with the remaining 20% made up of apartments and townhouses. Residences are chiefly 2 story wooden frame buildings with stucco exterior and with a built–in garage beneath the living area. Most of the buildings were constructed during 1956–1973 and some building activity has continued to the present time.

Physical Setting

Prior to suburban development, the topography of the study area was characterized by rolling hills and stream–eroded gullies with a prominent erosional fault valley and numerous sag ponds marking the location of the San Andreas fault zone (figures 1, 4). At its northern end, the fault valley subsequently has been greatly modified by suburban development (figures 2, 4, 5, 6; Sullivan, 1975). Many of the hills were leveled, gullies filled, and marshy sag ponds drained. The geologic formations exposed in the area include poorly consolidated sediments of the Colma and Merced Formations of late Cenozoic age and highly sheared rocks of the Franciscan Formation of Mesozoic age (Jennings and Burnett, 1961).

Earthquake History

The only detailed historic record of a major earthquake in the area is that of the 1906 San Francisco earthquake estimated to have been Richter magnitude 8.3. At that time, the study area was sparsely populated, and only a few farms were

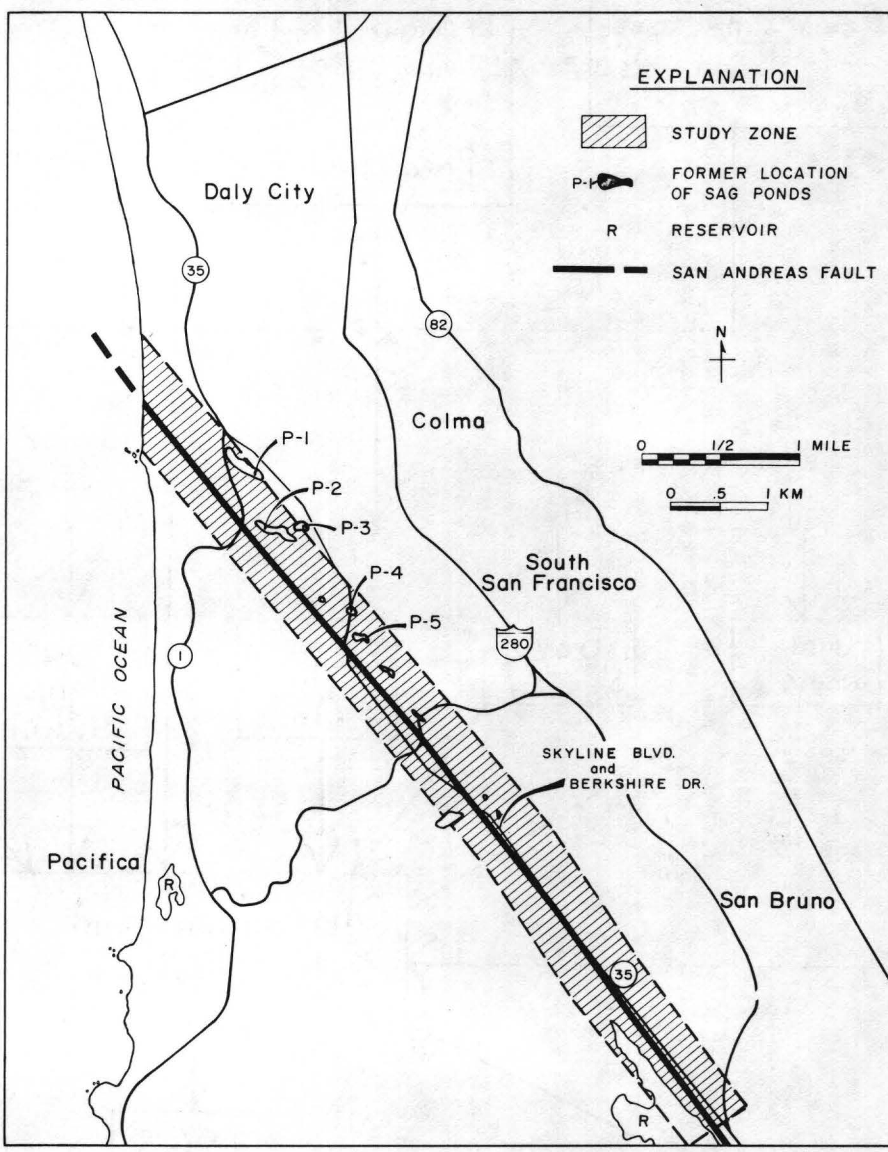


Figure 1. Location of the study area and distribution of sag ponds along the San Andreas fault in northern San Mateo County. (*From San Mateo quadrangle map, 15 minute series, 1899 edition, reprinted 1913, U.S. Geological Survey*).

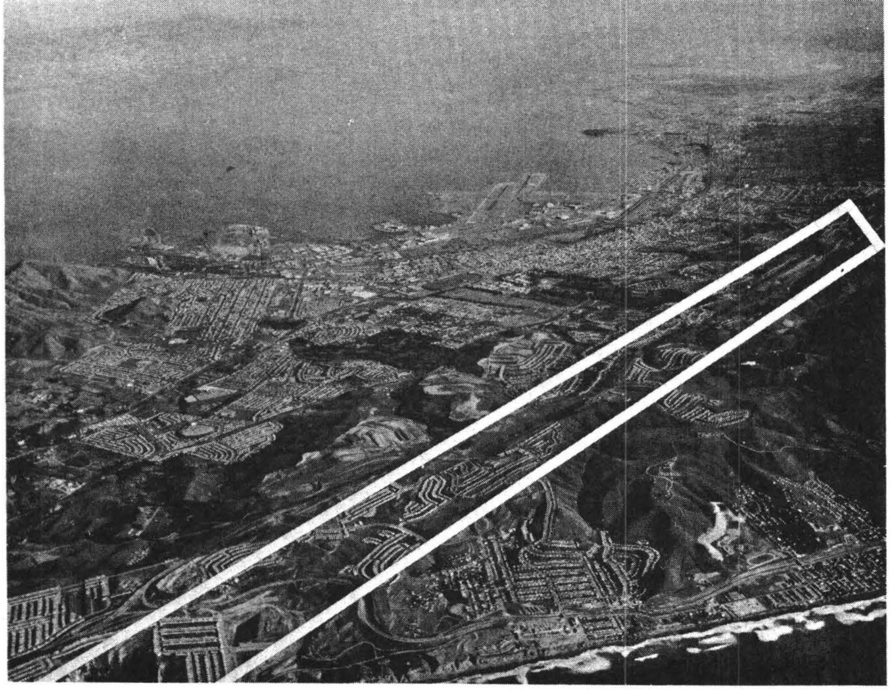
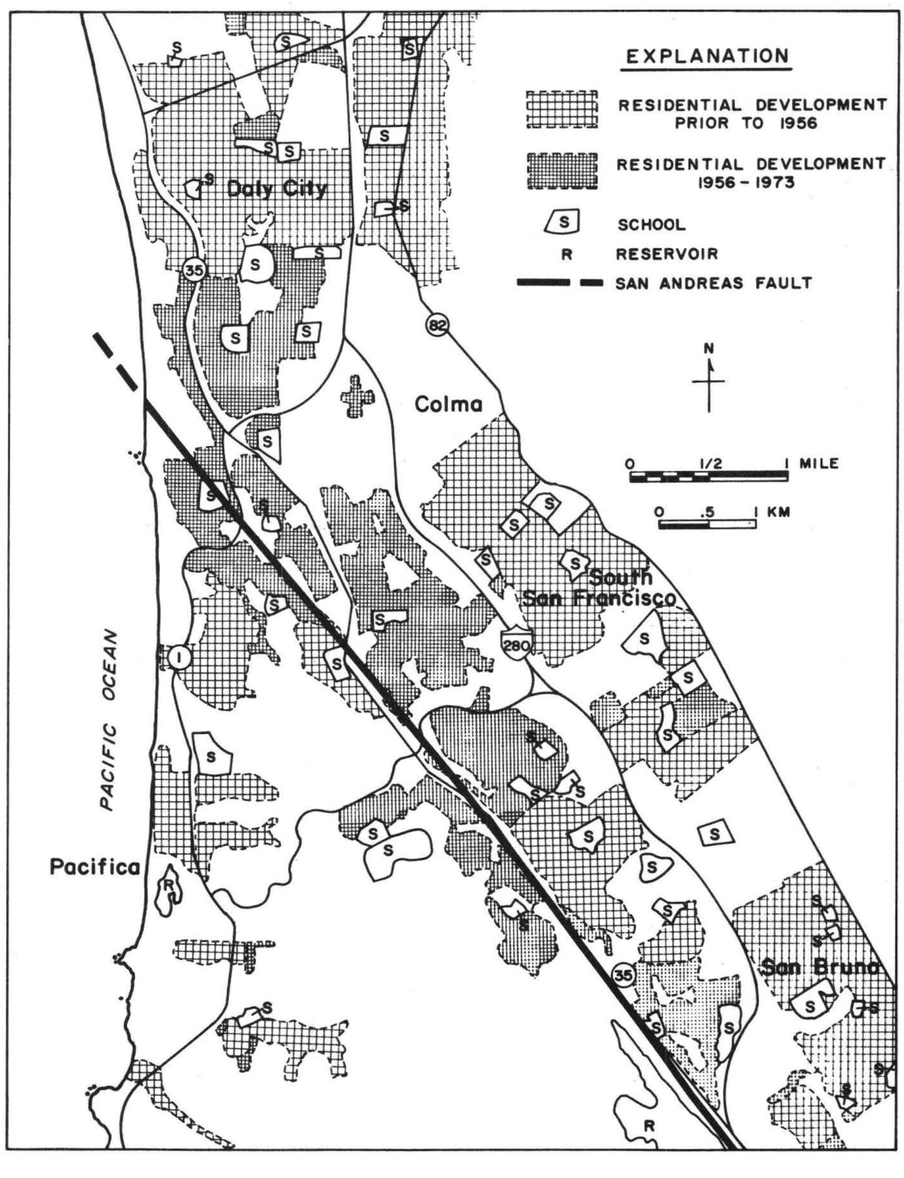


Figure 2. Aerial view taken in 1964 looking eastward over the study area (outlined). Residential development in the suburbs south of San Francisco has expanded to the vicinity of the San Andreas fault. In the lower right-hand corner of the photograph is the city of Pacifica situated along the ocean. In the upper half is San Francisco Bay and the communities along its margin. *Photo by Raymond Sullivan.*

Figure 3. Patterns of residential development in northern San Mateo County. *From San Francisco South and Montara Mountain quadrangles, 7.5 minute series, 1956 edition, photo-revised 1968 and 1973, U.S. Geological Survey.*



EDITOR's NOTE

Readers of *California Geology* will be interested to know that since this study was accepted for publication, another study forecasting public response to earthquakes was released in December 1976. That study, by J. Eugene Haas and Dennis S. Mileti and entitled "Socioeconomic Impact of Earthquake Prediction on Government, Business, and Community," was conducted and released by the Institute of Behavioral Science, University of Colorado, Boulder, Colorado.

The Haas-Mileti study took a broader approach, involving the expected reactions of key elements of government, business, and citizens, to several detailed earthquake scenarios. *California Geology* will carry further news of that study.

A basic conclusion of both studies is that as increased public information programs make the people of California more aware of the realities of the earthquake threat in California, their expected responses will change significantly.

scattered over the rolling terrain. Records of the 1906 event indicate violent ground shaking and an almost continuous line of rupturing along the San Andreas fault valley. Maximum local displacement occurred in the vicinity of what is now Skyline Boulevard and Berkshire Drive (figure 1) where fences and water supply pipelines were offset up to 13 feet (Lawson, 1908, v. 1, p. 94). In addition, small scale landsliding was reported throughout northern San Mateo county with most severe sliding concentrated along the coastal bluffs near Mussel Rock where the San Andreas fault enters thePacific Ocean (Lawson, 1908, p. 92).

In 1957, before most of the present homes were built (figure 5), this same area near Mussel Rock marked the epicenter of a moderate earthquake measuring 5.3 on the Richter Scale (Oakeshott, 1959). During this earthquake no significant rupture occurred on the land surface, but ground shaking and landsliding above the coastal bluffs in theWestlake Palisades area caused an estimated $1 million damage. Since that time, several earthquakes with distant epicenters have been felt in the area but none has resulted in significant damage. This portion of the San Andreas fault has remained locked for about 20 years. Some earth scientists consider that temporarily locked areas of the San Andreas fault are more likely to produce major earthquakes than portions of the fault that are creeping (Allen, 1968, p. 77).

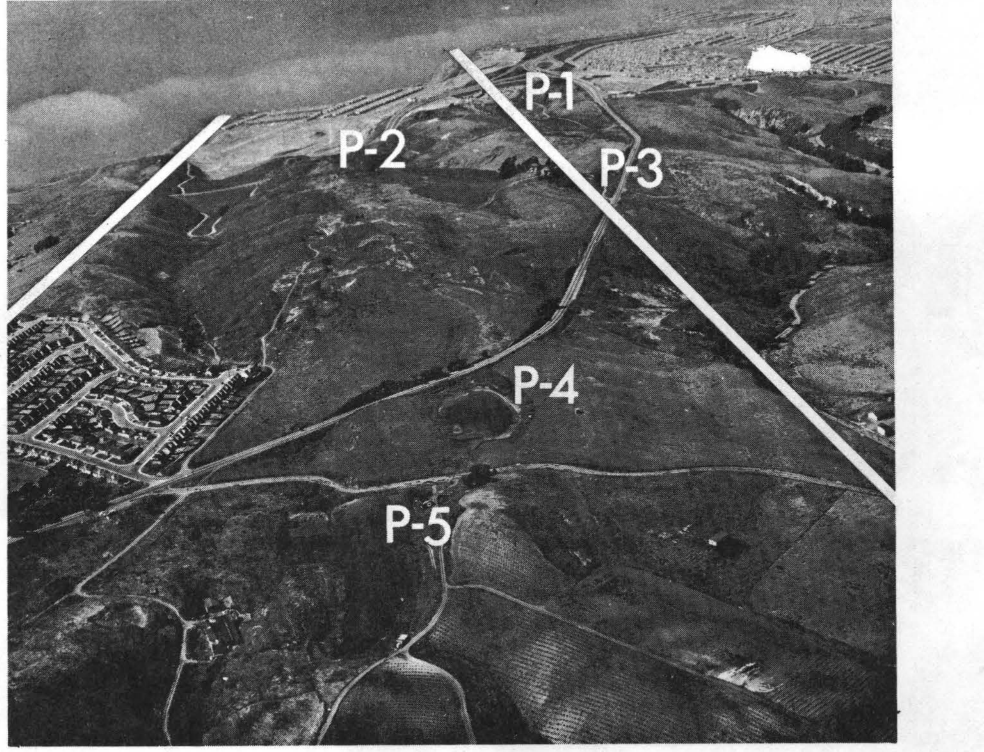


Figure 4. Aerial view taken in September 1960 looking northwest over the study area (outlined) before widespread residential development. The locations of former sag ponds within the San Andreas fault zone are identified as in figure 1. The main highway extending approximately northwest–southeast is Skyline Boulevard, and the road extending east to west between sag ponds P–4 and P–5 is King Drive. *Photo courtesy of the California Division of Highways (Caltrans).*

QUESTIONNAIRES

During the surveys, San Francisco State University students enrolled in a course entitled "Earthquakes and the San Andreas fault", interviewed residents and recorded their responses to a series of questions related to earthquake hazards (table 1). Results of over 1400 questionnaires were transferred to computer cards and tabulated on the CDC Model 3150 computer at San Francisco State University. Two questionnaires were used during the course of the 6–year study. In 1970 and 1976, a detailed set of questions was asked; whereas, in the intervening years, an abbreviated form was used. Information collected in the survey can be summarized into the following categories: characteristics of respondents; awareness of, and attitudes toward, earthquake hazards; attitudes toward earthquake prediction; and awareness of public agencies' information policy.

DATA ANALYSES

The data represent an average over the entire study area because no well- defined local characteristics were apparent. In discussing the data, percentages are always given for 1976 responses (indicated by 2 asterisks). In most cases percentages for 1970 responses (indicated by 1 asterisk) are given for comparison. Information for the intervening years is not presented because those responses are generally consistent with, or intermediate between, those of 1970 and 1976. The awareness of, and attitudes toward, various earthquake–related information, legislation, and action are discussed below and are summarized in table 1.

Respondents

The persons interviewed were generally adults (94%**) with about equal representation of females (56%**) and males (44%**). Many residents owned their homes (93%*, 82%**) and had lived in the San Francisco Bay area for much of their adult lives. Approximately half of those interviewed had lived in the Bay area for more than 20 years (51%*, 48%**). A large percentage of residents had occupied their current dwelling for less than four years (67%*, 50%**), indicating the mobility of residents in the survey zone.

Awareness of, Attitudes toward, Earthquake Hazards

Almost all the residents (96%*, 98%**) of the study area had at least heard of the San Andreas fault, although about one–third (31%*, 38%**) were unaware of the direct relationship between fault movement and earthquakes. Residents were generally aware (77%*, 77%**) that the fault was situated within 1 mile of their homes. A somewhat lower percentage (72%*, 63%**) knew of the fault location before taking up residence. A common attitude seemed to be that the entire San Francisco Bay area is vulnerable to earthquake damage and most people (82%*, 74%**) would feel no safer if they lived 5 miles further away from the fault. Only about one–fourth of those interviewed (20%*, 26%**) felt that the building industry was doing all it could to make their homes safe from earthquake damage.

With the passage of the Alquist–Priolo Act in 1972, the study area was designated as a "special study zone" for fault–related hazards. Relatively few persons interviewed (16%**) claimed that they were informed of any possible earthquake hazards by the previous owner, developer, or landlord. However, this percentage had doubled from the number who knew of these hazards in 1970 (8%*), which suggests that recent legislation and publicity may be having some small effect on public awareness of these hazards. An increasing percentage of people (22%*, 51%**) responded that they would inform future residents of potential earthquake hazards.

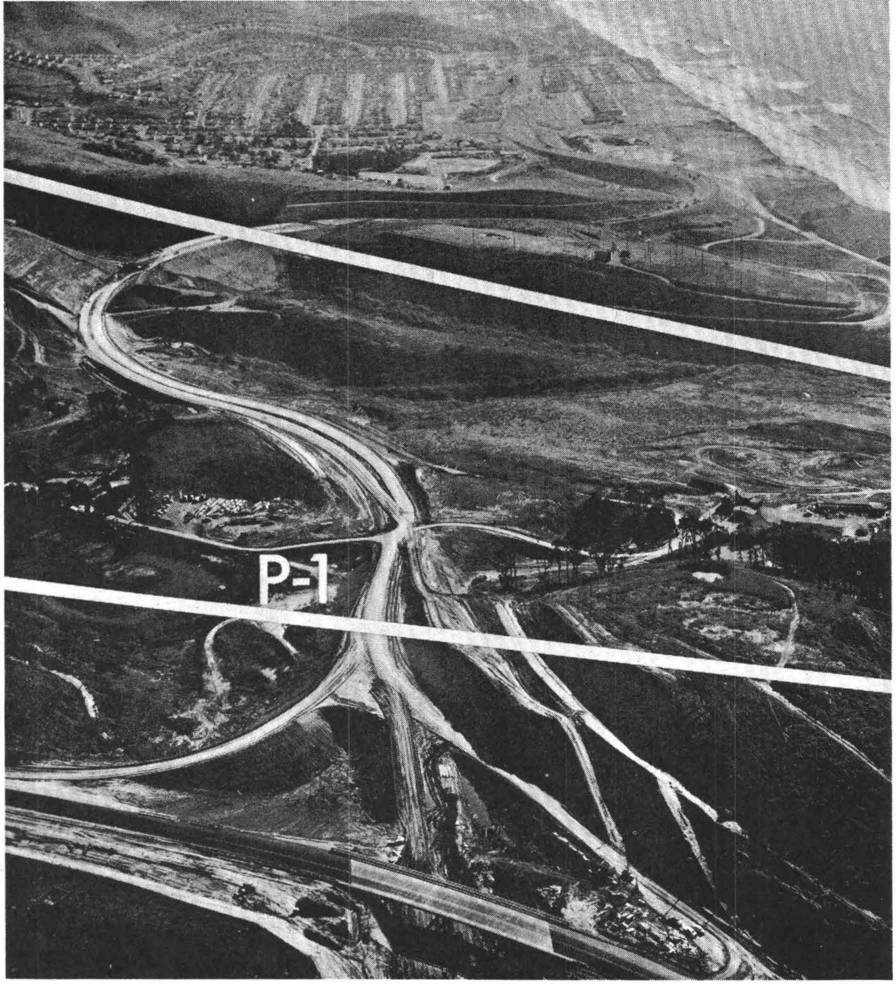


Figure 5. Aerial view taken in October 1957 looking south toward Pacifica across the northern end of the study area (outlined) before extensive residential development. Highway construction to realign Skyline Boulevard (Route 35) and the Cabrillo Freeway (Route 1) intersection is underway (lower center portion of the photo). Sag pond, P–1, is in the process of being drained and filled (left center). Franklin Delano Roosevelt Elementary School, located in the San Andreas fault zone, is under construction (right center). *Photo courtesy of the California Division of Highways (Caltrans).*

About half of those interviewed (52%*, 44%**) reported having felt small tremors while living in their current residence. In the event of a future earthquake, residents indicated a wide range of reactions. The most common response was to stand under a doorway (43%*, 43%**) whereas some would seek safety under a desk, table, or bed (8%*, 15%**) and others would stay away from windows, mirrors, and chimneys (5%*, 3%**). A lesser percentage indicated they would stay where they were and remain calm (20%*, 16%**) and some suggested they would run outside (12%*, 14%**). The remainder were unsure of their reaction (10%*, 5%**), or gave another response (2%*, 4%**).

One response which showed a strongly defined trend was the number of residents who carry special earthquake insurance on their homes. The cost of such insurance in the Bay area is independent of proximity to active faults, and, at the present time, the annual premium is typically about $2.00 per $1,000 of coverage. In 1970, very few of the families (5%*) in the area had coverage, but, by 1976, the percentage had more than quadrupled (22%**). The chief reasons given by those not covered by insurance were: (a) too expensive (59%*, 42%**), (b) not needed (29%*, 28%**), or (c) unaware of availability (9%*, 14%**).

Attitudes Toward Earthquake Prediction

Earthquake prediction once relegated to the realm of cultism, has in recent years become a respected scientific pursuit and has been given considerable attention in the news media. This is reflected by the large percentage of respondents (61%**) who think that earthquakes can be predicted. The vast majority (94%**) feel that earth scientists rather than astrologers or psychics will make the most reliable estimates.

Many people involved in prediction of earthquakes are concerned about the attitude of the public toward an announcement of an impending earthquake. In the questionnaire, residents were invited to give their initial reaction to a prediction of a major earthquake expected to occur in 20 years, 1 year, or 1 week. It was surprising to discover that a large number of persons would do nothing in the event of any such prediction, although the proportion of such responses has decreased somewhat over the 6–year study period. In the case of a prediction of a major earthquake occurring 20 years in the future, most persons would do nothing (94%*, 85%**), whereas a small percentage would move (2%*, 5%**). For an earthquake warning 1 year in advance, a smaller percentage of residents (77%*, 61%**) indicated they would take no action, whereas a growing percentage (11%*, 19%**) indicated they would move or leave the area temporarily. Some were unsure of what steps to take (9%*, 8%**) and the remainder had a varied response (table 1). Finally, with a warning of only one week, a surprisingly large percentage of residents (52%*, 38%**) continued to indicate that they would do nothing, while over a third (36%*, 40%**) would move or leave the area temporarily. The remaining responses were similar to those for the 1–year prediction (table 1).

Awareness of Public Agencies Information Policy

This area of questioning was a brief survey of the role played by government agencies in informing the residents of earthquake hazards and concerns about pursuing earthquake research. In general, it was found that a relatively low percentage of residents (22%*, 28%**) had received earthquake hazard information directly from their local government. The majority of those interviewed (81%*, 77%**) supported legislation which would make it a requirement that all prospective occupants be informed of the potential earthquake hazards at the site. Only a small percentage (16%**), however, was aware of the passage in 1972 of the Alquist–Priolo Act which was designed to encourage such disclosures and limit building of residential structures on seismically active faults. In light of the recent efforts of Senator Alan Cranston of California and others to increase significantly the funding of earthquake research, it is interesting that the vast majority of residents (75%*, 88%**) feel that such research should be sponsored by State and Federal governments.

USE OF SURVEY RESULTS

The presentation of these results of a 6-year survey is intended as a preliminary study of the public's knowledge and concerns about earthquake hazards in a narrow zone along the San Andreas fault. It is apparent from the study, that although those interviewed were well aware of their proximity to the fault, they were for the most part unconcerned about the potential destructiveness of a major or catastrophic earthquake. Such an attitude may be understandable in view of the fact that the area has been subjected to only minor earthquakes over the past 70 years, and also because of a lack of experience among residents with other natural disasters.

Further contributing factors to the lack of concern by residents may be the failure of many to understand the direct relationship between faults and earthquakes, and the lack of knowledge of the potential geologic hazards in the immediate vicinity of the fault zone. The evidence presented by Lawson (1908), Oakeshott (1959), Algermissen (1972), and Borcherdt and others (1975) has shown that maximum ground shaking and fault rupture will typically be greatest along the fault zone (front cover). It may be concluded, therefore, that although this area astride the San Andreas fault is predominately residential and does not have high–rise structures like those of the large cities of the San Francisco Bay area, widespread damage to structures will probably result if a major earthquake of the magnitude and location of the 1906 tremor occurs.

EARTHQUAKE EDUCATION

The need for greater community earthquake preparedness is receiving increasing attention, particularly since an accurate and dependable system of prediction may be developed in the near future. This increased likelihood of reliable earthquake prediction makes a continued assessment of public attitudes a necessary step in defining the role of government agencies in hazard reduction and disaster preparedness. Recent experiences in China indicate that a key to reducing life loss is an understanding of the hazard and willing cooperation of citizens (Press, and others 1975). It is apparent from the survey that at present citizens are generally uninformed as to the proper action to take in the event of such a warning. Even with a prediction that a major earthquake will occur in one week, more than one–third of those interviewed would take no action.

Figure 6. View similar to that in figure 5 taken in April 1968 showing the extent of residential development between 1957 and 1968 in the northernmost part of the study area. The sag pond P–1 is the site of newly constructed homes. The highway interchange and the Franklin Delano Roosevelt School have been completed. *Photo courtesy of the California Division of Highways (Caltrans).*

A program of public education should begin immediately, even though there may be concerns about continually alarming the public about earthquake hazards while sustaining their awareness over a period of time. It is recommended that an established California governmental agency undertake to organize and coordinate this program. Along with advice on disaster preparedness and hazard abatement, residents should also be familiar with the longer term social and economic disruptions which are inevitable as a result of a tremor of the magnitude of the 1906 earthquake. These and other topics can be discussed most logically at community meetings involving representatives of appropriate government agencies along with members of the news media, and specialists in scientific, financial, and business matters. A community–centered program should be effective and have optimum impact because many of the hazards will be unique to each region. Without a long–range campaign, the public may not accept the credibility of scientific predictions and the necessity for inconvenient and sometimes costly hazard reduction measures.

Public educational programs have not been highly successful in the past. Nevertheless, a well–planned and imaginatively–constructed campaign, designed to relate to situations of immediate and tangible concerns may have a considerable impact on the residents of a disaster–prone area. The possibility of a potentially destructive earthquake in California in the near future dictates that such a program be designed and implemented as soon as possible.

ACKNOWLEDGEMENTS

We wish to thank our colleagues, Raymond Pestrong and Richard Lambert, for help in administering the surveys and for continued discussions and advice, and Charles Bickel for computer assistance. We also thank Hugo Hawkins for drafting assistance and George Strauch of Caltrans for providing most of the photographs. Special thanks go to the many students who conducted the surveys and to the residents of the study area for their courtesy and cooperation.

	Respondents	Percentage of Respondents	
		*1970** (%)	*1976*** (%)
1.	Age and sex:		
	–female adults		52
	–male adults		42
	–female minors		4
	–male minors		2
2.	Residents:		
	–own residence	93	82
	–rent or lease	7	18
3.	Lived in the San Francisco Bay area:		
	–for more than 20 years	51	48
	–for more than 10 years	64	71
4.	Lived in their current residence for less than 4 years:	67	50
5.	Had heard of the San Andreas fault:	96	98
6.	Were unaware of the relationship between fault movement and earthquakes:	31	38
7.	Knew that the San Andreas fault was within 1 mile of their residence:	77	77
8.	Knew of the proximity of the San Andreas fault before taking up residence:	72	63
9.	Would feel no safer from fault–related hazards if they lived 5 miles further from the San Andreas fault:	82	74
10.	Think the building industry is doing all it can to make residences safe in earthquakes:	20	26
11.	Were informed of potential earthquake hazards by the previous owner, developer, or landlord:	8	16
12.	Would inform future residents of potential earthquake hazards:	22	51
13.	Have felt earthquakes while living in their present residence:	52	44
14.	Would react to an earthquake occurring now by:		
	–standing under a doorway	43	43
	–getting under a desk, table, or bed	8	15
	–staying away from windows, mirrors, and chimneys	5	3
	–remaining stationary and calm	20	16
	–running outside	12	14
	–unsure	10	5
	–other responses	2	4
15.	Have earthquake insurance:	5	22
16.	Reasons for not obtaining earthquake insurance:		
	–too expensive	59	42
	–not needed	29	28
	–unaware of availability	9	14
	–other responses	3	16
17.	Feel that earthquakes can be predicted:		61
18.	Feel that geologists and/or other earth scientists will make the most reliable earthquake predictions:		94
19.	Reaction to prediction of a major earthquake with 20 years:		
	–would do nothing	94	85
	–would move	2	5
	–other responses	4	10
20.	Reaction to prediction of a major earthquake within one year:		
	–do nothing	77	61
	–leave the area temporarily		3
	–move		16
	–move or leave the area temporarily	11	
	–unsure	9	8
	–reinforce the residence	1	4
	–purchase insurance	1	1
	–other responses	1	7
21.	Reaction to prediction of a major earthquake within one week:		
	–do nothing	52	38
	–leave the area temporarily		35
	–move		5
	–move or leave the area temporarily	36	
	–unsure	9	8
	–reinforce the residence	1	3
	–purchase insurance	1	1
	–other responses	1	10
22.	Had received earthquake hazard information directly from their local government:	22	28
23.	Support legislation requiring that all prospective occupants be informed of potential earthquake hazards before buying or signing a lease:	81	77
24.	Were aware that a law (Alquist–Priolo Special Studies Zones Act) dealing with fault related hazards was passed in 1972:		16
25.	Were in favor of federal and/or state government funding of earthquake research:	75	88
	*Results of 1970 survey. **Results of 1976 survey.		

Table 1. Summary of Earthquake hazards survey, 1970 and 1976.

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THE USE OF COMMUNITY COLLEGES IN VOLUNTEER RESEARCH PROGRAMS

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The U. S. Geological Survey might well consider seeking the assistance of California's Community Colleges in the tasks of collecting earthquake precursory information and of reducing earthquake hazards via public education programs. The community colleges have established their own unique identity as institutions of lifelong learning: separate on the one hand from public elementary and secondary school systems and unique on the other hand among post-secondary institutions for their community-based sense of mission. Community colleges are autonomous institutions, by and large financed through local property taxes and governed by locally elected boards. For a volunteer effort like the collection of earthquake precursory data to be successful, such a program must enjoy broadly based community support and be guided by competent local technical leadership. Because of their number, size, wide distribution, sensitivity to their supporting communities, and highly trained faculties, California's community colleges offer a flexible and responsive educational system that could easily be brought into the earthquake prediction business.

A brief history of the community college movement in California is in order.[1] In 1907 the legislature authorized public junior colleges to provide for "postgraduate" course work by high schools. The Fresno Board of Education

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1 Excerpted from "Community College Five-Year Plan, 1977-1982", published by the Board of Governors, California Community Colleges, Sacramento, January, 1977.

established a two-year postgraduate course which began instruction in 1910 with about twenty students. The present character of community colleges has gradually evolved from this humble beginning. Organization change, particularly separation from the primary and secondary school system, reached a peak in the late 1960's and a separate state-level Board for the Community Colleges was founded in 1968. Growth has continued until today there are nearly 1,300,000 students enrolled in 104 colleges and 2,700 off-campus locations managed by 70 locally autonomous districts. The average college now enrolls nearly 10,000 students on campus. One in every eight California adults is served in regular instruction programs. Estimates suggest that once community service programs are counted, the community colleges may serve as many as one out of every five California adults! The broad spectrum of people reached by the community college is reflected in the fact that Foothill's typical day student has an average age of 28.6 and our average night student is 32.0 years old. In addition, almost every community college offers courses in geology and/or earth science and has on its staff, consequently, at least one instructor with a minimum of a Master's degree in geology or a closely related field. Thus, the community colleges are large, well established and well organized educational institutions with some geo-technical expertise that reach into every corner of California. These colleges offer the Geological Survey an existing organization that could be readily adapted to assist with both data gathering (and reduction) for earthquake prediction research and for dissemination of earthquake hazard information.

Foothill College has already gathered some experience in educational programs for the community in the area of earthquake awareness and earthquake hazards reduction. The following examples, which do not begin to exhaust the possibilities, might serve as useful models for the kinds of services that community colleges can easily provide. Via a special projects class in geology (slave labor), an Earthquake Trail on the 1906 trace of the San Andreas fault was designed, constructed and dedicated in 1974 at Point Reyes National Seashore in Marin County, California. Subsequently, Foothill has sought to broaden its role in public earthquake education on three fronts. First, despite many cases of poison oak, another self-guiding interpretive trail was built in 1977 along the San Andreas fault near Palo Alto, California, on public land belonging to the Midpeninsula Regional Open Space District. A sample trail brochure, written in part by geology students, is included at the end of this article. Second, to help the general public really "see" the San Andreas fault system and the potential impact it can have on their lives, the college has incorporated into its curriculum a docent training course that encompasses both local geology and natural history. This course trains community volunteers in environmental education who subsequently lead guided tours along the San Andreas Fault Trail and on other Open Space parcels as well as assist teachers in the local public elementary and secondary schools in environmental study programs. Both to assist the environmental docents and to provide a public clearing house for earthquake information, Foothill has established an exhibit in its Community Services Science Center entitled "Vibrations". Via this exhibit we hope to keep the public informed as to the "state-of-the-art" in earthquake research, as well as help our community members learn how to protect themselves, their property, and their families against the hazards posed by future earthquakes. We are also planning a mobile exhibit on earthquakes that can be taken to local schools and shopping centers.

The museum exhibit was made possible at Foothill because of a unique state-mandated function of the community colleges known as Community Services by which programs of general community enrichment are funded through a permissive override tax of .05¢/$100 of assessed valuation. These programs are not part of the college's formal instructional programs, but have greater diversity, offering both cultural and informational programs related to the interests of the citizens within the supporting district. For example, the Foothill-De Anza District established a Science Center as a part of this community outreach which is unparalleled by any other community college district. The Science Center was charged with providing programs for the general public of the district of a science or science-related nature. Its facilities include two planetariums, an observatory, and a museum which houses the earthquake display as one of its several exhibits.

Foothill College has explored some of the ways a community college can be responsive to community needs in the area of earthquake education. Foothill is also eager to participate in some aspect of the earthquake prediction effort such as training volunteers to gather premonitory data, for example. The unique structure of this type of educational institution and its well-financed provision for community services might enable the community college system to play a vital role in any U. S. Geological Survey efforts involving volunteer citizen participation in earthquake prediction research in California. It is to the scientific community pursuing earthquake prediction research, however, that we in the community colleges must look for leadership and direction.

Foothill College

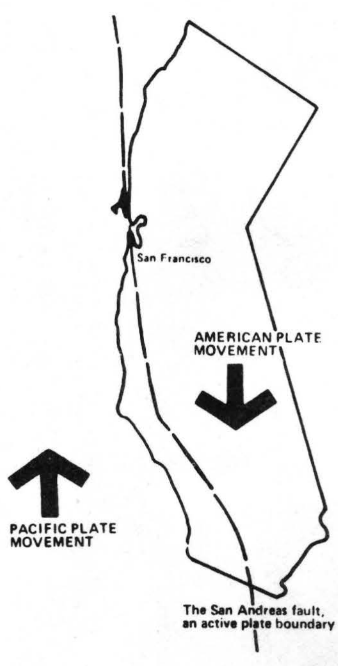
Los Trancos Open Space Preserve

SAN ANDREAS FAULT TRAIL

Designed and built by Tim Hall, Nick Hall and the students of Foothill College Geology classes.

WELCOME TO LOS TRANCOS OPEN SPACE PRESERVE. These 274 acres of undeveloped natural land were acquired by the Midpeninsula Regional Open Space District in 1977 for hiking, picnicking and environmental study. Part of the beauty of this preserve - especially the eye-pleasing shapes of some of its hillsides - were created by a famous geological phenomenon, the San Andreas fault. The San Andreas, one of the world's longest and most active faults, runs directly through the preserve.

Geologically speaking, California has a split personality, for it straddles two of the major 100-kilometer-thick "plates" that make up the earth's outer skin. The boundary between these two great moving plates is a complex zone of fractures known as the San Andreas fault system. The western margin of California, including the Santa Cruz Mountains, is attached to the Pacific Plate which is grinding slowly northwestward by the American Plate on its way toward Alaska. Millions of years of movement along the San Andreas have juxtaposed two very different kinds of bedrock here in northern California - granite on the west, and on the east a combination of oceanic volcanic and sedimentary rocks called the Franciscan Formation.

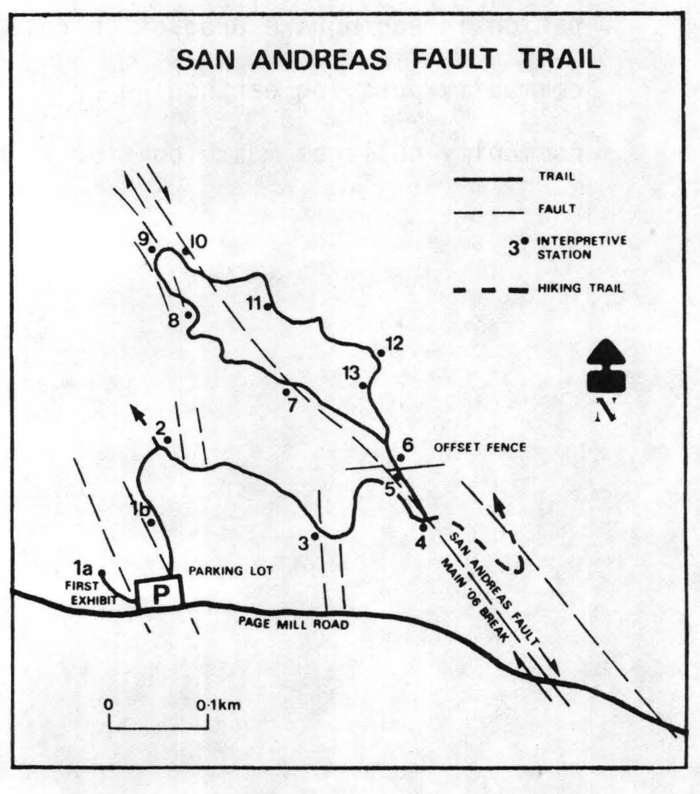


Since friction is preventing the two plates from sliding smoothly past each other in the Bay Area, the rocks next to the San Andreas fault are being bent by plate motion and are storing tremendous amounts of energy. Ultimately, the stored energy will overcome the friction "gluing" the edges of the plates together. They will snap into new positions, and the accumulated energy will be released in the form of destructive earthquake waves.

This happened early in the morning of April 18, 1906. Fences, roads and buildings which crossed the San Andreas in northern California were suddenly torn apart as the Pacific Plate jumped as much as 4.8 meters closer to Alaska. The shock waves that were generated caused tremendous destruction here in California and were recorded by seismographs all over the world. Since the American and Pacific Plates will continue to move each year as they have for millions of years, future destructive earthquakes in the Bay Area are inevitable.

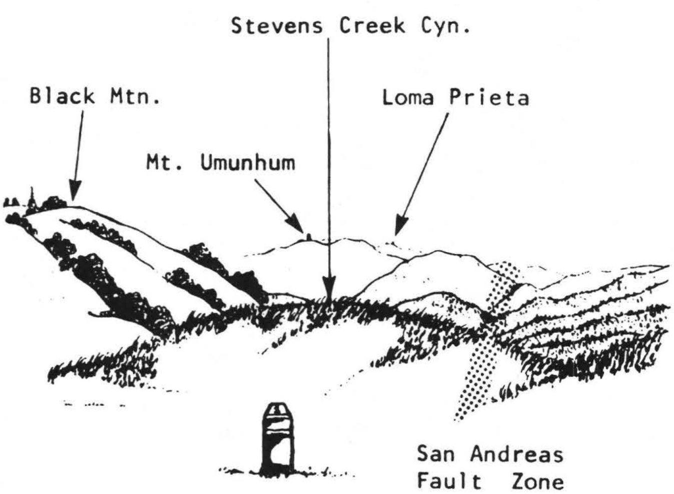
Geology students from Foothill College have constructed for you a kilometer-long self-guiding loop trail along this section of the San Andreas fault. The trail, marked by numbered posts with a yellow stripe, follows the main surface breaks accompanying the 1906 earthquake and interprets such fault-produced features as scarps, benches, linear ridges and valleys, sag ponds, landslides, springs and an offset fence. This trail is dedicated to the residents of the San Francisco Peninsula with the hope that the more they know about their geologic environment, the better they will be able to protect themselves against future earthquakes.

Take the trail to the left of the parking lot to STATION 1A



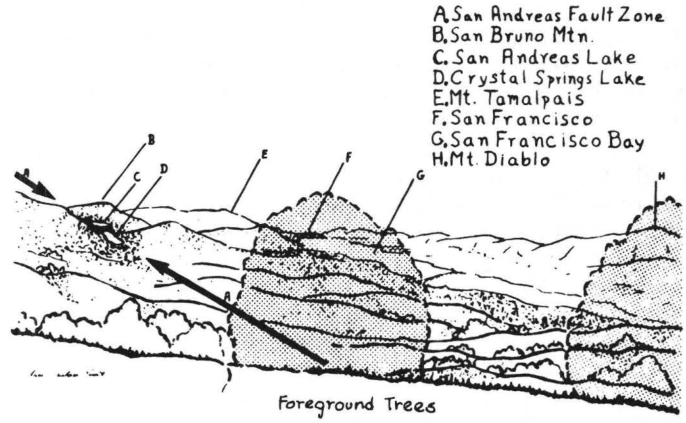
STATION 1A- Evidence of plate movement lies scattered all about you in the form of large boulders. These boulders consist of a distinctive type of conglomerate (a sedimentary rock made of rounded pebbles) that came from Loma Prieta, a mountain that sits on the American Plate 38 kilometers to the southeast. The sketch will show you where to find this mountain on a clear day. Between 1 and 2 million years ago streams carried these boulders from the flanks of Loma Prieta westward across the San Andreas fault and deposited them on the Pacific Plate. Recurrent movements along the San Andreas have shifted them into their present position.

From this vantage point you can see a number of landscape features that have been produced by faulting along the San Andreas, such as the linear ridge on which you are standing. The canyon of Upper Stevens Creek developed as running water easily eroded along the shattered rocks of the fault zone. Below you, the parking lot sits on the southern edge of a sag pond, a shallow depression that fills with water during the rainy season. The line of posts with yellow stripes on the far side of the sag pond marks a minor fault within the San Andreas zone that moved a small amount in 1906.



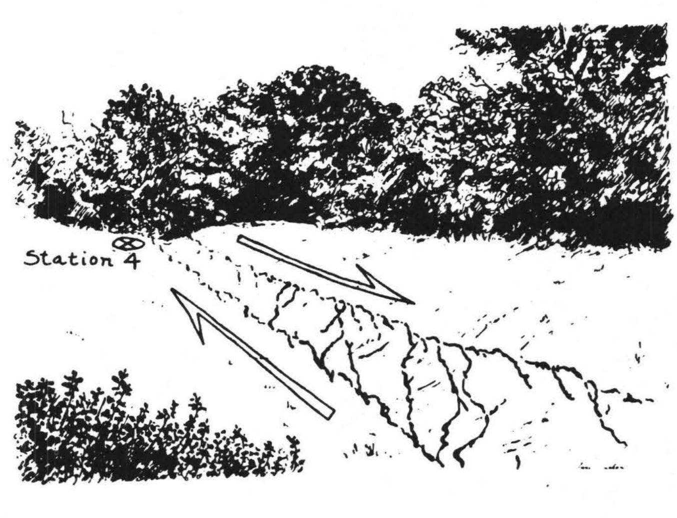
STATION 1B- From this vantage point on the main trail, you can see the long,straight, bouldery ridge opposite and how abruplty it rises above the parking lot and sag pond. No doubt it has been elevated by movement on a fault that runs along its base, marked by the line of chaparral. The sag pond in front of you is also bounded by faults, but the land in between has sunk or "sagged". Geologists call such a down-dropped block of land between two faults a "graben."

STATION 2- On a clear day you can easily follow the path of the San Andreas fault as it heads northwestward toward San Francisco. The sketch will help you locate some Bay Area landmarks. Crystal Springs Reservoir and San Andreas Lake, used for storing San Francisco's water supply, were made by damming the valley developed along the weakened rocks in the fault zone. Here at Los Trancos Open Space Preserve the San Andreas fault crosses a high,wide saddle between Skyline Ridge on your left (west) and Black Mountain on your right. As you head eastward down the trail toward the next station, look for more linear valleys and ridges that indicate the presence of other faults within the San Andreas zone.



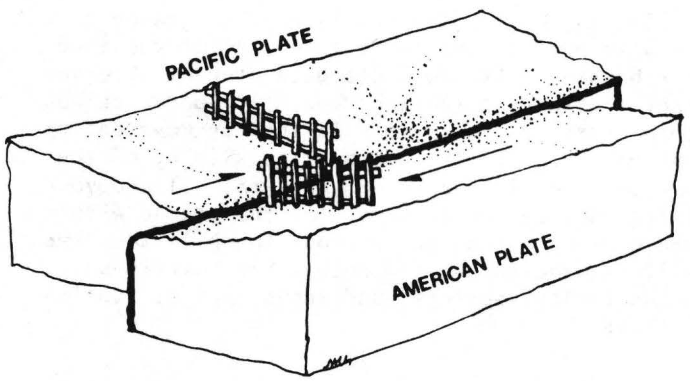
STATION 3- Before you is another graben that is also part of the fault zone. After the 1906 earthquake, a Stanford graduate student observed that the fence bordering Page Mill Road here was torn apart 10 centimeters, either by movement on one of the graben's faults or by sliding of the wet sediment in the graben down the hill to your left. Notice how much moister the ground within the graben is than the surrounding hillside. We will examine in greater detail the relationships among faults, springs, and landslides at Station 6 ahead.

STATION 4- Welcome to the main fault that caused the 1906 earthquake. The redwood posts with the yellow tops and stripes mark our best estimate of the line you ought not to be straddling in the event of another major shift along the San Andreas! It is along this line that we will find the best preserved and most spectacular fault-produced features like the linear ridge and valley in front of you. Historic photos show that here the fault consisted of two nearly parallel breaks which shifted a total of approximately 2 meters on that fateful morning of April 18th. The sketch shows what you would have seen had you been standing in the large patch of poison oak beyond the last post and looking northwesterly towards Station 4 (where you are standing now). Bear left and follow the loop trail along the main San Andreas fault.

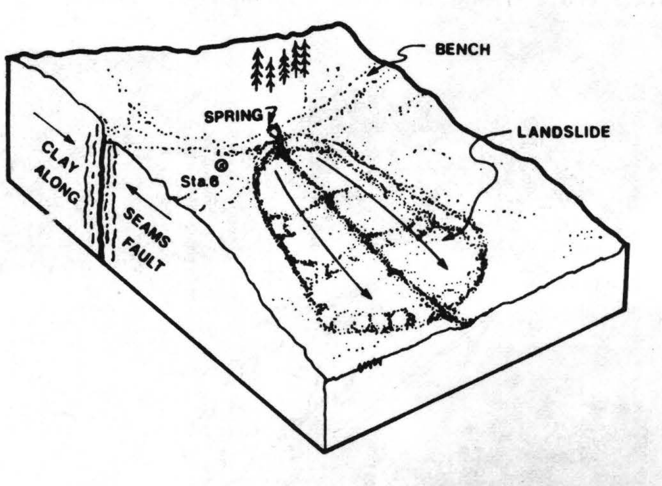


STATION 5- Here is how a fence that crossed the fault might have appeared immediately after the 1906 earthquake. This fence has been reconstructed from century old materials found on this property. An original section of this fence is still standing on the downhill side of the trail towards Los Trancos Creek. As a result of the 1906 faulting, the far left hand segment of this fence which sits on the Pacific Plate moved approximately 2 meters closer to Alaska.

At this point you might make two other significant geological observations: (1) Once across the main break there are no more conglomerate boulders. Here the bedrock close beneath your feet is greenstone - highly altered volcanic rock that is part of the Franciscan Formation. (2) The main trace of the San Andreas fault has created a flat bench along its path. It looks almost as if you are following an old overgrown road.

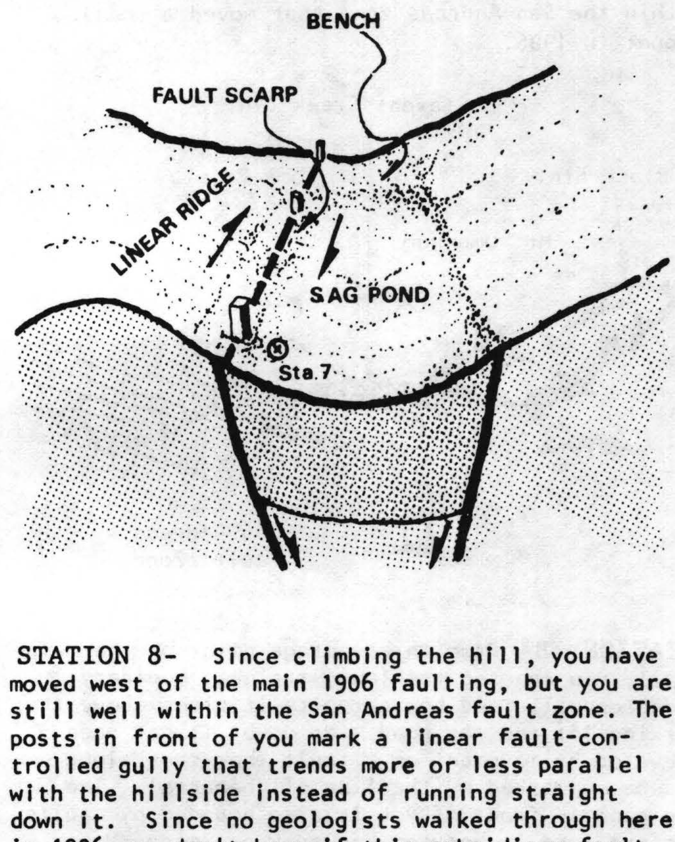


STATION 6- Here's a good example of how faults can have adverse affects on a hillside. The willow trees and culvert ahead mark the location of a spring that flows at least part of the year. Grinding action along a fault like the San Andreas reduces the bedrock to clay which then acts as a barrier to the downhill flow of undergound water. Commonly the water will bubble up to the surface at a low spot along a fault and form a spring. On this steep hillside water has saturated the fault-weakened rocks and caused a landslide. Much of this landslide material has subsequently been washed down the hill. Landslides are often triggered by big earthquakes. The 1906 earthquake caused



many landslides to form along the walls of the Stevens Creek Canyon southeast of you. Bear left at the next trail junction and watch for more striped posts that mark the major 1906 fault trace.

STATION 7- Before you are excellent examples of a sag pond and broad bench, features that often develop along major horizontally-moving faults like the San Andreas. The small cliff-like feature just in front of you which forms the left hand boundary of the sag pond was most likely produced or enhanced by the 1906 faulting. Sag ponds like this one indicate that here the earth's crust was stretched by the faulting which allowed parts of this hillside to sink a bit. Once this sag pond fills with sediment washed in from the surrounding slopes, it will evolve into a hillside bench. See the adjacent sketch. As you continue along the trail and go up the hill, notice the second sag pond and the linear ridge that forms its eastern boundary on your right. Also notice that several oak trees in this area were thrown down by violent ground shaking in 1906, but managed to survive and continue to grow.



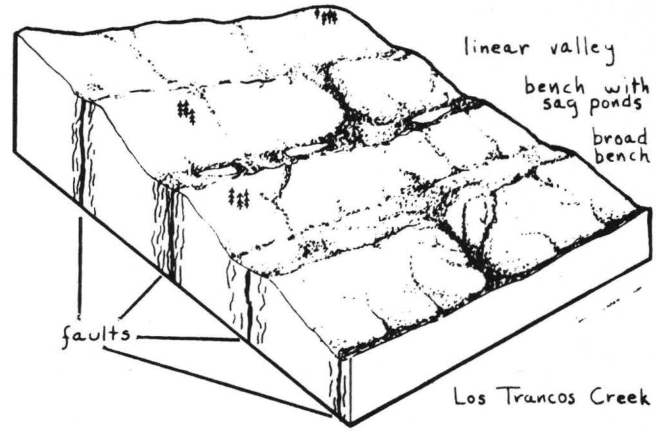
STATION 8- Since climbing the hill, you have moved west of the main 1906 faulting, but you are still well within the San Andreas fault zone. The posts in front of you mark a linear fault-controlled gully that trends more or less parallel with the hillside instead of running straight down it. Since no geologists walked through here in 1906, we don't know if this subsidiary fault moved then or not. As you proceed along the trail, there are more similar topographic features that have been created by faulting - sag ponds, linear ridges and valleys and benches.

STATION 9- By this point you have found a number of fault-produced features: the linear ridge you are standing on, the linear valley on your left and beyond it the higher linear ridge. Notice that the fault breaks here do not form a continuous and nearly straight line, as does the main break. As you continue down the trail, you will turn toward the east and approach the main 1906 fault again.

STATION 10- Welcome to the main break - again! Notice the beautifully developed road-like bench on your left. What sort of topographic feature do you think lies hidden beneath that tangle of poison oak on your right? (Don't go exploring - it's a sag pond!) As you look at this beautiful woodland scene, it is very difficult to imagine the awesome power that lies temporarily locked beneath you feet.

Once you cross the main trace of the San Andreas and begin to descend to a still lower fault-produced bench, look to your left for the huge old oak with the missing limbs. The arrows on the sketch point to the spots where the 1906 earthquake probably broke off large limbs. The missing vertical limb, in particular, could only have been torn off by such a violent motion.

STATION 11- The sketch shows the fault topography characteristic of this part of Los Trancos Open Space Preserve. You are now standing on the lowest broad bench. This bench, unlike the upper bench which the trail has followed, lacks the sag ponds and fault scarps that indicate recent fault activity. Notice, too, that here the central part of this lowest bench supports primarily grass and chaparral, not large trees. As yet we do not have a satisfactory explanation for this peculiar plant distribution.



STATION 12- Below you is Los Trancos Creek, which is following another line of sheared and broken rock within the San Andreas fault zone. At your feet you can see the familiar rounded boulders which came from Loma Prieta, while on the far eastern side of the creek are many outcrops of light gray limestone which form another part of the Franciscan Formation. You can examine outcrops of limestone up close by turning left when you return to the main trail. Here at the Preserve, the San Andreas fault zone is more than a half a kilometer wide, and consists of a complex array of slices of Franciscan bedrock intermixed in fault contact with slices of the conglomerate boulders. It is not until you go beyond the eastern boundary of the fault zone that the bedrock consists entirely of Franciscan rocks.

STATION 13- Reports of the 1906 earthquake document that numerous large trees along the fault were tilted, topped, or toppled by the violent ground motion. Although this canyon live oak and many other trees nearby broke under the weight of heavy wet snow a few years ago, the general effect is one that closely imitates the aftermath of a strong earthquake. A few meters further along the trail will bring you back to the spring and landslide. Turn left and return to the main trail loop.

For further information

Now that you have completed a walk on your neighborhood's active plate boundary, you probably ought to consider the future. Remember - it is not a question of "if" there will be another major quake, it is a question of "when" it will occur. Many geologists agree that a large earthquake is not very far off. Your best protection against the many dangers of a major earthquake are the plans and preparations you make BEFORE it happens.

To learn where the ground is safe in the Bay Area and how to protect yourself, your family and your property during the next earthquake, the Foothill College Geology Department invites you to study the earthquake and geology exhibits in the College's Science Center.

EARTHQUAKE PREDICTION

AND

HIGH SCHOOL STUDENT PARTICIPATION

by

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Program Administrator

Fremont Union High School District

and

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(Northern California Chapter)

December, 1977

EARTHQUAKE PREDICTION

Using high school students to make systematic observations of factors likely to portend earthquakes. Factors to be considered:

1. Recruiting
2. Education
3. Reliability
4. Continuity of program
5. Methods for conveying results
6. Analysis of results

1. Recruiting

High School volunteers could be recruited through their teachers. Already established vehicles of communication exist if the magazines of California Teachers Associations are used. The science associations being the most suitable, for example:

The California Science Teachers Journal
The American Association of Physics Teachers (Northern and Southern California sections) Newsletter.

2. Education

Programs should be developed for teachers so that they may act as consultants, advisers and educators to the students involved. Initially, students too should be involved in this course development.

3. Reliability

The meticulous recording of accurate information and the continuity of this process by individuals is a very necessary factor to be considered. It may best be accomplished by using teams of students rather than single individuals. The team could consist of ninth through twelfth grade students so that as the students progress through their high school science studies, their involvement in the program demands greater experimental expertise. The most mature student could be making the most precise and complex observations while teaching the younger ones how to eventually fill such roles.

4. Continuity of Program

As students rapidly move through a school system it is essential to involve members of the faculty in the program for the sake of continuity. This could be achieved in several ways:

1. One teacher and a class each year.
2. School Earthquake Club with a teacher as adviser - Involvement could be as part of a science club or as one of the activities of a service club.

5. Methods for Conveying Results

As some observations, such as strange animal behavior, may need reporting very quickly and others such as stress recordings over a period of time. Alternative channels for reporting information would need to be developed.

6. Analysis of Results

For sustained support from the students involved, it would be essential that they understand how their measurments and observations are to be used, analyzed and conclusions developed. Even better, they would participate in that process.

If they were able to use the information collected in a research paper it would be of great help to them in applying for scholarships and participating in science fairs and symposims, such as the County Science Fairs and the Junior Science and Humanities Symposium.

Recommendations

1. Advertise the proposed program in the California Science Teachers Journal, AAPT newsletter, CTA newspaper "Action" the ACSA magazine "Thrust", and the County Office of Education Newsletters.

2. Request responses by completing a form in form in the articles or advertisements in the magazines listed above.

3. Analyse the responses with respect to suitable geographic location. If response unsatisfactory, put on workshops at the appropriate (needed) County Offices of Education.

4. Involve some teachers and some students in developing suitable training programs.

5. Develop reward incentives such as certificates of participation , medals recognizing several years service and workshops for students to hear and meet important scientists.

A FRAMEWORK FOR A COMPREHENSIVE PUBLIC EDUCATION PROGRAM DEALING WITH EARTHQUAKES

--Preliminary Discussion Paper--

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14 December 1977

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Exhibits:

1. Partial list of meetings on earthquake education
2. 4-H Community Pride Program
3. San Francisco Bay Girl Scout Council
4. Generations Alliance Program
5. Internet materials

Provided with the paper:

Education Development Center, Inc. Annual Report

1. Introduction

Earthquakes, an old phenomenon, pose new problems for our society. A major earthquake could occur practically anywhere in the United States. The possibility of severe damage, injury, and loss of life is nationwide in scope. An earthquake prediction itself could have disrupting social and economic consequences; this adds complexity to the earthquake problem.

This paper discusses briefly our understanding of the nature of the earthquake problem with respect to the need for public education dealing with both earthquake events and earthquake predictions.

The paper calls for a strategic and comprehensive approach to planning, designing, implementing, and evaluating a program that will educate, inform, and sensitize all sectors of the public and private communities. While this approach should have nationwide applicability, implementation could be on a metropolitan or regional basis, focusing on the high risk damage areas initially, such as in California.

The approach involves three basic components:

(a) Strategic educational planning and research:

What are the various types of groups in the target population; what are their current perceptions of the earthquake problem; what are the most appropriate channels of communication with these groups; what are the different strategies that would be most effective in reaching these groups; what are the best processes for feedback and evaluation that can be tested prior to the event; how can we involve members of the target group in taking part in the planning, implementation, and evaluation process based, to the greatest extent, on their needs, interests, and resources?

These are some of the questions that should be dealt with in formulating a long-range plan for public education on the earthquake problem.

(b) Education now:

What kinds of educational efforts can we undertake now, without requiring major new research efforts and major new needs assessments; which are the existing groups in the target population that easily could undertake involvement in an earthquake education program; what services and materials are already in place that could be utilized in an educational effort?

These are some of the questions for which we have at least tentative answers based on our discussions with various groups in the San Francisco area, where a pilot project could be undertaken.

(c) Education following a prediction:

What kinds of new or reinforcing information should people be given following a USGS announcement of intensive study of an area; following the first prediction; and following the various revisions of the initial prediction? What are the different educational strategies that should be employed during these various phases?

In this component we present a phased time frame and a listing of the various elements for educational strategies that might be appropriate corresponding to each phase.

Important features of an earthquake education program should include information on:

- The nature of earthquakes as geophysical events, which take place with high frequency on a worldwide basis.

- Earthquake preparedness and mitigative measures that can be taken by individuals and groups in the target population.

- Desirable human response to statements made by various authoritative and non-authoritative sources with respect to earthquake activity, including predictions.

- Desirable behavior during and following an earthquake event, including information on what types of services to seek and where to find them.

The following section of this paper sets forth some reasons for our interest at Education Development Center, Inc. to be involved in earthquake education efforts, and some of the assumptions we are making regarding the nature of the task.

2. Assumptions

Education Development Center, Inc., a publicly supported, non-profit organization, has initiated and developed a wide variety of innovative educational programs on a local, regional, national, and international basis for nearly two decades (please see the EDC Annual Report for details).

The staff has developed a base of experience and training through involvement in different types of projects. In many cases, the experience gained on one type of project has invaluable application to another. EDC staff experience in areas such as public health care, burns prevention and response, secondary school science and social studies education, work with minorities and non-English speaking groups, and organization of large-scale network approaches to education offers rich possibilities for bringing proven effectiveness in and new perspectives to the educational aspects of the earthquake problem.

We are concerned with earthquakes as an international problem; however, the passage of the Earthquake Hazards Reduction Act of 1977 provides a strong foundation on which to begin to build a rational and comprehensive approach to earthquake education in the U.S. This Act calls for a national approach to earthquake education, and our approach offers elements that could be implemented on a nationwide basis, while developing a pilot approach to local or regional planning in a selected area: San Francisco Bay. The pilot is designed to be replicable in other areas around the country. We already have met with numerous officials and others in the Bay area and elsewhere in California.

Discussions with these people have led to a number of assumptions about the nature of earthquake education. Some of these are listed below:

- If a problem, such as earthquakes, involves large numbers of people, it may be a good idea to involve as many of them as possible in studying the problem. This serves as a means by which to sensitize the public to the problem.
- Involving members of the target population in planning, designing, implementing, and evaluating a public education program ensures the likelihood of its effectiveness.

- Since most Americans are involved in formal or informal relationships in groups, such as school, work, membership associations, or local community efforts, a public education program should build, to the greatest extent possible, on networks and resources that already exist and are in place.

- That the use of media can be an effective means by which to reach people who are not members of groups.

- That the use of media can serve to add credibility to educational and information dissemination efforts.

- That, although much attention has been paid to the Chinese model of public involvement and education with respect to earthquakes, the United States has a long history of public involvement in scientific and educational efforts, on which our public education program should build. However, the foreign experience, in China and elsewhere, deserves close study and our program may benefit from some involvement by experts from abroad.

- That it may be difficult to maintain a sustained public interest in a low probability event, regardless of the initial level of expressed interest, and an earthquake education program may best be couched in the context of a broader program on risk, safety, natural hazards, or environmental change, and may combine a local with a global scope in dealing with the issue.

- That while much will be learned from disaster education in other areas, such as floods, hurricanes, and tornadoes, the unique character of the earthquake problem requires a novel approach, not merely the transfer of techniques and strategies from other disaster education efforts.

- That the long-range nature of the earthquake problem requires a long-range, strategic planning process and an integrated approach to designing and developing programs undertaken by NSF, USGS, and other federal, state, and local organizations.

- That due to the fact that the ultimate test of the effectiveness of an educational effort will be during and following the earthquake event or prediction itself, great emphasis should be placed on the design of effective evaluation strategies and feedback mechanisms that will measure preparedness, knowledge, and attitudes with respect to the earthquake problem prior to an earthquake or prediction.

- That although earthquakes are a national problem, we should concentrate developing the local planning and preparedness process in a pilot area in California, where most earthquake activity takes place in the country, and where we can have close proximity to the USGS prediction effort.

The following section sets forth our perception of the nature of the earthquake problem and some policy issues that have implications for education.

3. The Earthquake Problem

The current and future prospects for loss of life, injury, and property damage caused by a major earthquake in the United States appear fairly great.[1,2,3,4*]

There are very few areas in the United States that are thought to be free of earthquake damage risk. The Panel on the Public Policy Implications of Earthquake Prediction of the National Research Council reports that, "Seventy million people throughout the United States live with a significant risk to their lives and property from earthquakes. Another 115 million are exposed to a less significant, but not negligible, seismic risk. Only 8 percent of Americans can safely ignore the earthquake hazard. But most Americans occupy, use, or are served by constructed facilities that were not designed to resist earthquakes and that could collapse in a quake with major losses of life and property."[2] Historically, large and damaging earthquakes have occurred in Alaska, California, Montana, Missouri, South Carolina, Massachusetts, and other states.[5] Indeed, earthquakes are a nationwide problem.

Earthquakes are a worldwide problem, as well. Large earthquakes occur around with world with remarkable regularity.[6] A long-term average of the frequency of earthquakes indicates that 18 events of 7 magnitude (Richter) or above take place every year.[4]

It is virtually certain that future damaging earthquakes will take place in the United States. This is due to the combination of two factors: (a) that the history of large quakes in the U.S. points to the probability of future large quakes; and (b) that the concentration of larger numbers of people and structures in high to moderate risk zones places an unprecedented number of people and amount of financial investment in the most vulnerable areas. According to Frank Press, "Because of the large increase in population density in the earthquake-prone sections of the U.S., the potential loss from an earthquake as strong as the San Francisco shocks of 1906 could be as high as tens of thousands injured, with property damage measured in the billions of dollars. A catastrophe on this scale would be unprecedented in the history of the country, yet it is an event that most seismologists expect to occur sooner or later."[7]

The likelihood of a devastating earthquake in the United States has resulted in legislation providing much greater financial support than in the past for efforts to achieve reliable earthquake prediction capabilities.[8] Seismologists believe that such a capability will be reached within the next 10-30 years;[2] however, a few successful predictions have already been made in this country and elsewhere, principally China,[3,7,9,10] and a credible prediction could be issued again in the U.S. at any moment.[3] Some recent studies assert that the prediction itself could precipitate significant financial and social disruption due to the social and business response in expectation of a possible disaster.[11,12] According to Haas and Mileti, "...if the prediction provides an extended lead time, the 'target' community will suffer significant social disruption and decline in the local economy, especially if this lead time is a year or longer."[11] (It appears that the larger the magnitude of an earthquake, the longer in advance precursory anomolies will appear;[3,11,13] so it seems likely that larger earthquakes may allow longer lead times for prediction.) The disruption from such predictions may be in the form of a sudden loss of property values in the area, emigration of residents and businesses, loss of businesses, loss of jobs, ceased construction, loss of tax revenues, lowered municipal services, and a corresponding rise in municipal problems, including looting, fire damage, and other events normally controlled by municipal services.[11]

The obvious aspects of the earthquake problem are, therefore, twofold:

(a) The damage that can result from an earthquake event, including secondary causes triggered by a quake, such as flooding from broken dams, fire, and tsunami damage.

(b) The potential disruption resulting from the issuance of an earthquake prediction.

Both of these aspects require carefully designed and evaluated educational programs tailored to ensure an effective response in the target population: correct, desirable, and rational behavior before, during, and following an earthquake prediction or event.

The entire social and economic justification for supporting and encouraging the work and research called for in the Newmark report[1] and the Earthquake Hazards Reduction Act of 1977 is to mitigate the consequences of the earthquake problem. However, as pointed out in the Newmark report, "The acceptance and effectiveness of any mitigative measures--many of which require an economic commitment--will depend critically on the public's perception of the necessity and utility of the measures, as well as on the reliability of the technological information upon which they are based,"[1] This asserts the vital importance of an effective public education program.

Unfortunately, there are manifold features involved in the complexity of the earthquake problem that will make it difficult to ensure an effective public education program. Some of these features are discussed briefly below.

Natural hazards are not unknown in the United States. The four chief hazards are floods, hurricanes, tornadoes, and earthquakes. However, the low-probability/high impact earthquake event is substantially different from the other chief hazards in a variety of ways. First, although we may say with confidence that a major earthquake will occur again in the United States, it is difficult to determine exactly where it will take place. Location is one of the key elements of an earthquake prediction (along with time and magnitude), and scientists are attempting to identify where predictable quakes will occur. In contrast, floods, hurricanes, and tornadoes all take place in fairly well known areas or paths. Second, the high impact earthquake is not a frequent event in the U.S., as are the other types of chief hazards, which occur seemingly in seasons, year after year. Third, unlike other hazards, earthquakes cannot be seen by people to be coming, thus making it difficult to reinforce the credibility of a prediction by personal observation.* Fourth, nearly none of the population alive today in the U.S. has experienced a major earthquake, thus the population does not have the kind of experiential learning that has been developed to some extent by people living in zones frequented by the other hazards. These differences point to some of the possible difficulties that may arise if traditional public education strategies developed in response to many other hazards are simply transferred to accomodate educational needs in dealing with earthquakes. Nevertheless, there is much to be learned from the experience of groups such as the Disaster Preparedness Staff of the National Weather Service and the Red Cross. Strategies developed in response to other hazards should be studied carefully.

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* The U.S. Geological Survey is, however, interested in identifying meaningful precursory phenomena that amateurs among the general public could take note of as part of the earthquake prediction effort. Public involvement in the monitoring process has valuable educational implications, and will be dealt with later in this proposal.

There is also the understandable feature of human nature that makes one tend to avoid thinking about a low probability/high impact event, such as being caught in a nuclear attack, getting burned or scalded, or experiencing a major earthquake. The experience of the Defense Civil Preparedness Agency (especially with their formal and informal public awareness campaigns dealing with protection from nuclear attack and their resulting studies of public attitude[14] and their in-school educational efforts dealing with natural as well as man-induced hazards[15]), the California State Department of Education,[16] and other agencies concerned with disaster education and response should prove extremely useful in formulating an effective approach to earthquake education. Also, the experience of the staffs of Education Development Center, Inc. and the Shriners Burns Institute, of the Massachusetts General Hospital, which are collaborating in developing and evaluating a public education effort dealing with burn injuries,* should prove very valuable, not only in identifying effective public education strategies, but also in dealing with the problem of unwillingness to consider the low probability/high impact event of getting burned or scalded.[17,18]

Another feature of complexity surrounding the earthquake problem is that of ensuring that the appropriate scientific bodies making predictions are to be regarded as the most credible sources for such predictions. Ensuring such credibility may prove difficult should a variety of groups or individuals outside of the scientific community purport to be able to predict quakes. A few such cases already have taken place in California: one involving the public in measuring tilt using modified carpenter's levels; another involving a religious group ceremoniously binding an earthquake fault to ensure against future earthquakes; and several apparently non-authoritative individuals claiming the personal ability to predict quakes, as reported in the news media.[19]

Perhaps of more serious consequence is the possibility of disagreement arising within the scientific community over a specific prediction. Such a case worth considering arose among French volcanologists involved in predicting the occurrence and magnitude of the 1976 eruption of La Soufriere volcano on Guadeloupe. The French government's policy of evacuating the population below

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* Funded by the U.S. Consumer Product Safety Commission, in progress.

the volcano critically depended on the scientific judgement of the timing and magnitude of the eruption. The French volcanologists became involved in a dispute, particularly against the view of one internationally known French volcanologist. As a result, the French government had to convene a meeting of invited volcanologists from other countries to study the data and arrive at a consensus. Six foreign and only two French scientists made up this group.[20] Could such a case occur in the United States? Such an event could have unsettling implications with respect to public acceptance of the credibility of the scientific community.

There are other policy oriented features involved in the earthquake problem. Among these are the questions about the right of the government to issue predictions that may disrupt the society and that may not prove accurate; the philosophical role of the government as protector of the people; the extent to which the government should allow people to live in high risk areas; whether the government should reimburse victims for damage caused by disasters or wrong predictions; whether to require people to bear the financial losses resulting from their individual choice to live in high risk areas; and other questions for which there are few clearly correct answers or responses that represent a distinct consensus.

Finally in this list of features is the fact that earthquakes do not selectively affect portions of the population in an earthquake area. However, certain economic and social characteristics of the target population may make a few segments of the population more vulnerable to death, injury, and economic loss than others. These segments may include the poor, living in old structures; the elderly, who may be hard to reach;[12] and non-English speaking people, who may be hard to inform.[21] Nevertheless, a damaging earthquake probably will affect everyone in one way or another, including the business communities, families and individuals, the very young, school children, the unemployed, the retired, the skilled, the unskilled, the English speaking, and the non-English speaking.

The combination of these features surrounding the earthquake problem exacerbates the unprecedented complexity of mitigating earthquake hazards and calls for an unprecedented and comprehensive planning approach to educating, informing, and sensitizing all sectors of the public, business, and the government with regard to earthquakes, earthquake preparedness, response to warnings, and reaction to and recovery from the earthquake event.

The earthquake problem also provides opportunity: If people can be motivated to support and undertake appropriate preparedness efforts; recognize and accept credible predictions; act rationally in response to predictions and during and following earthquakes, perhaps we will be able to claim success for the Earthquake Hazards Reduction Act and the efforts for which it calls.

This paper responds to the challenge of this opportunity.

4. Earthquake Education Components

As stated in the introduction, our approach to earthquake education involves three components: Strategic educational planning and research; Education now; and Education following a prediction. The following descriptions of these components represent a beginning for discussion with NSF, USGS, and other federal, state, and local groups concerned with the problem.

4.1 Strategic Educational Planning and Research

In general, developing an educational program involves four major elements: planning, design, implementation, and evaluation. A comprehensive public education program may include a variety of related and independent activities, each requiring different educational and curriculum strategies. Some of these activities involve the mass media, in-school programs, out-of-school programs, corporate or business programs, and community outreach programs. The four elements in program development can be applied to each of the activities comprising a comprehensive education program.

All of these activities should be integrated in the context of a long-range, strategic plan with its own design, implementation, and feedback and evaluation process. This plan, if dynamic, will ensure that all the activities of the program are inter-related, kept up-to-date, and responsive to changes in needs, interests, attitudes, and resources that will vary over time.

To ensure the effectiveness of the program, the strategic planning process must involve members of the target population. Appropriate members of the target population should comprise a Strategic Planning Team, which should be a permanent body. The team may include representatives from federal, state, and local government agencies, citizen organizations, businesses, and other groups.

The team determines the long-range goals and objectives for a comprehensive educational program. It identifies specific tasks to be accomplished and develops a plan of action. It monitors the development of all elements and activities that comprise the program, assesses and evaluates progress and results, and provides guidance for changes that may need to be made.

Also, a National Earthquake Education Advisory Committee, consisting of senior experts in the appropriate fields related to the earthquake problem, should be established. This committee would provide guidance to the various Strategic Planning Teams that could be organized in each city or area of the country interested in developing local or regional earthquake education programs.

Education Development Center can provide the bridge between senior scholars and experts, on the one hand, and the Strategic Planning Teams, on the other. Also, EDC can undertake or facilitate development of the specific educational activities selected by the Strategic Planning Team for local implementation.

We envision developing a strategic planning process and a comprehensive public education program, beginning in the San Francisco Bay area, over a period of three years. The chart on the following page shows the relationship of the Strategic Educational Planning and Research component to the other two components over a three-year period.

RELATIONSHIP BETWEEN COMPONENTS

	Year 1	Year 2	Year 3
Strategic Educational Planning and Research	Form Strategic Planning Team and begin training of members.	Continue evaluation of program elements and make recommendations for changes.	Transfer full operational and developmental leadership to the team for continuing management.
Education Following a Prediction (see page 20 for time phases before and after a prediction)	Develop scenarios for the design and implementation of specific educational elements according to the relative certainty of an earthquake.	Implement, test, and evaluate the elements, making changes according to the recommendations of Strategic Planning Team.	Continue operation of elements appropriate for the no-prediction time phase. If a prediction is issued, implement the appropriate elements as part of the plan.
Education Now	Identify all groups in and out of school that could take part in the Internet* program, focusing on an earthquake education component. Invite them to participate in the Internet network and begin sending them materials. Evaluate results and make changes accordingly. Design and develop mass media and community outreach elements that could be based on existing materials and resources. Identify specific target groups requiring different educational strategies.	Continue the Internet program. Implement and evaluate educational elements designed to reach various out of school target groups.	Continue the Internet program. Continue out of school educational efforts, incorporating recommendations made by the Strategic Planning Team.

* Internet is an existing environmental education program managed by Education Development Center that has high potential for use in an earthquake education program. It is discussed in greater detail in the next section.

4.2 Education Now

Certain types of educational efforts may easily begin now, based on existing programs that are underway. Four such programs are worth mentioning because they involve relatively large numbers of people, they include both in- and out-of-school activities, or they involve community outreach efforts, involving the elderly.

First, the 4-H Community Pride Program is in operation in California, and offers a framework for various earthquake education and preparedness efforts.

Second, the San Francisco Bay Girl Scout Council, with thousands of members, has a Worlds to Explore Program that involves girls in studying and taking part in community activities, including reaching the elderly.

Third, the American Association of Retired Persons has a Generations Alliance Program that bridges the gap between a variety of youth-serving organizations and the elderly around the country.

Fourth, Education Development Center is managing and developing a large-scale environmental education program called Internet, which can include as many teachers and out-of-school groups as are interested, in California or throughout the United States. During its prototype development, undertaken in cooperation with Unesco and the United Nations Environment Program, Internet included 68 teachers reaching over 5,000 students in 20 states and four Canadian provinces. We are expecting a follow-on contract with the UN Environment Program to expand the network to include a core of 2,000 teachers, directors of youth organizations, libraries, other groups, and individuals around the country and in Canada. This network could prove very effective as part of an earthquake education program.

Internet engages participants in three key activities:

(a) Increasing environmental awareness

Teachers and students in the network receive weekly packets of Internet Reports, one or two page summaries of a wide variety of environmental events, issues, problems, and conditions around the world. The information is current and factual. Much of the Internet Report material developed last school year was concerned with natural hazards and their social and economic, as well as environmental, aspects. A series of Internet Reports could be developed specifically to deal with the earthquake problem; however, one important value of the variety in reports is that they deal with certain themes of risk and change that are common to a wide range of environmental problems.

(b) Encouraging local community projects

The Internet Teacher Guide offers teachers and students a basic, step-by-step approach to identifying a local community environmental problem, and working with and through the community to help solve it. Information on local projects is shared through the network. The guide also contains primary source materials, such as environmental legislation and reports from international organizations.

It would be straightforward to design specific community projects that focused on earthquake hazard mitigation. Groups could study their community in terms of building codes, the relationship between codes and zoning and safety; they could map areas of possible damage should an earthquake take place; an activity might be patterned after the Junior Fire Marshals program that would involve students in searching their own houses for safety hazards and then correcting them.

(c) Involving students and teachers in scientific research

Specially written Internet Field Project Handbooks are sent to participants interested in collecting data or samples for actual scientific research or monitoring efforts led by principal scientists needing amateur, unskilled, voluntary assistance over broad geographic areas. A current field project involves students in monitoring the spring flowering dates in their respective areas as part of a Smithsonian botanical research program. John Whitman, director of the Internet program and proposed director if the earthquake education program, has been invited to attend a workshop on public involvement in earthquake monitoring in February 1978. We will be attempting to identify ways to transfer the Internet experience in organizing amateurs for science to the earthquake prediction effort. Such activity offers rich opportunity for participants to learn about research problems, in this case, earthquakes.

It would be simple to concentrate one segment of the Internet network in the San Francisco Bay area, the entire state of California, or throughout the United States. Its current scope includes all of North America: the United States and Canada.

These four programs are a few of the existing types of activities that could easily accomodate earthquake education activities that would not require major new research, needs assessment, and development of materials.

By beginning now to disseminate earthquake related information to the target population through credible channels, we can set the groundwork for familiarity that will be required should an actual prediction be made.

In addition to the above types of programs, there are other activities that could begin at this time.

- Media materials could be developed, based on existing information, that could be implemented immediately following a prediction. Camera-ready copy of bulletins or handbooks could be prepared for short-order printing by newspaper companies.

- Simulation games and role-playing activities could be developed for various groups in the public.

- Posters could be prepared for display in BART and other public places, businesses, schools, etc.

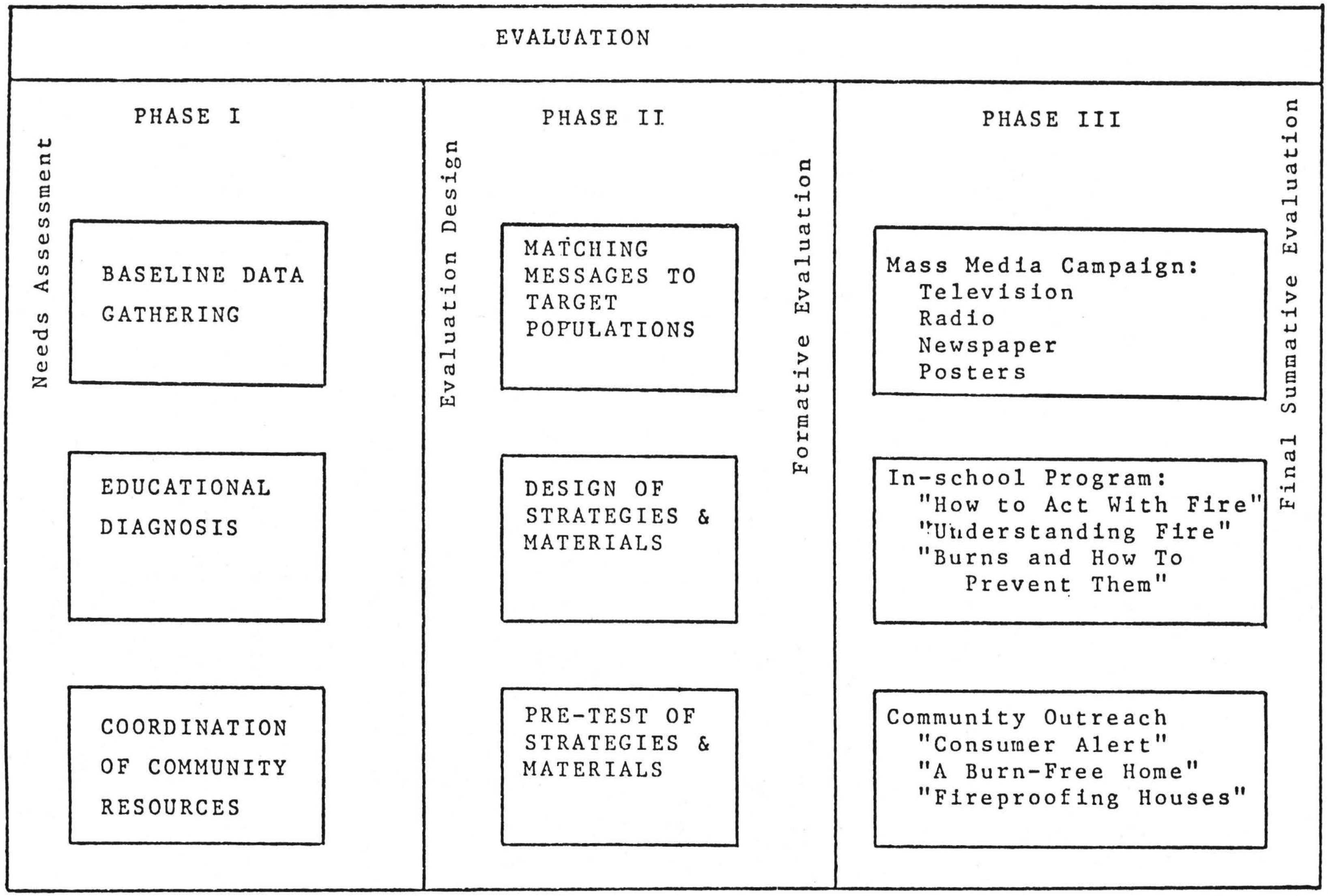
- A telephone number could be established, similar to the weather and time numbers, that the public could call to find out about the latest earthquake activity or expected events.

- Periodic spots for radio and television could prime the public for earthquake preparedness ("You're in earthquake country. Are you prepared for one? Write to . . . for a list of things you can do to protect your family, and yourself, for the next earthquake.").

The Burn Prevention Education Program of Education Development Center offers an exemplary approach to using the mass media for public education in dealing with events that most people do not want to think about.

In any effort, the evaluation process will be critical. The following design for the Burn Prevention Education Program offers an overall, but somewhat out of date, framework for an evaluation effort in a public education program. It is worth pointing out that in an earthquake education program, the Strategic Planning Team will develop an on-going, permanent process of evaluation for the entire program.

A Design for a Burn Prevention Education Program



4.3 Education Following a Prediction

At this time, we know of no prediction for an earthquake in the United States. We may begin to undertake the proposed action set forth in the previous section, "Education Now."

However, the U.S. Geological Survey or other credible source could issue a prediction at any time. Should such an announcement be made, there is no organized, pre-planned educational program that could be launched to help ensure that the public and businesses will react favorably. It behooves us to begin to plan, design, and develop such an educational program now, so as to be prepared to implement it on short notice.

Depending on the amount of lead time offered following a USGS announcement, different educational strategies and media would be employed. A comprehensive educational program for the public includes the following categories, and different strategies could be designed and employed in each category:

- Mass Media
  - Television
  - Radio
  - Newspapers
  - Posters in public areas
  - Announcements in public areas, such as before film shows in theaters

- In-school
  - Classroom activities
  - Out-of-school projects
  - School-wide activities, such as assemblies

- Community Outreach
  - Existing community groups, such as voluntary youth-serving organizations (Boy and Girl Scouts; 4-H Clubs), religious groups, professional societies, and organized community programs, such as for the elderly, youth, home-makers, etc.
  - Work-related groups, such as firemen, police, taxi drivers, and business firms, government agencies, etc.
  - Non-related individuals, such as the elderly, live-alones, and the unemployed
  - Non-related groups or individuals, such as non-English speaking people living alone or in relatively isolated ethnic groups that may be hard to inform, the poor or disadvantaged, who might be hard to reach

A comprehensive educational program should be concerned with:

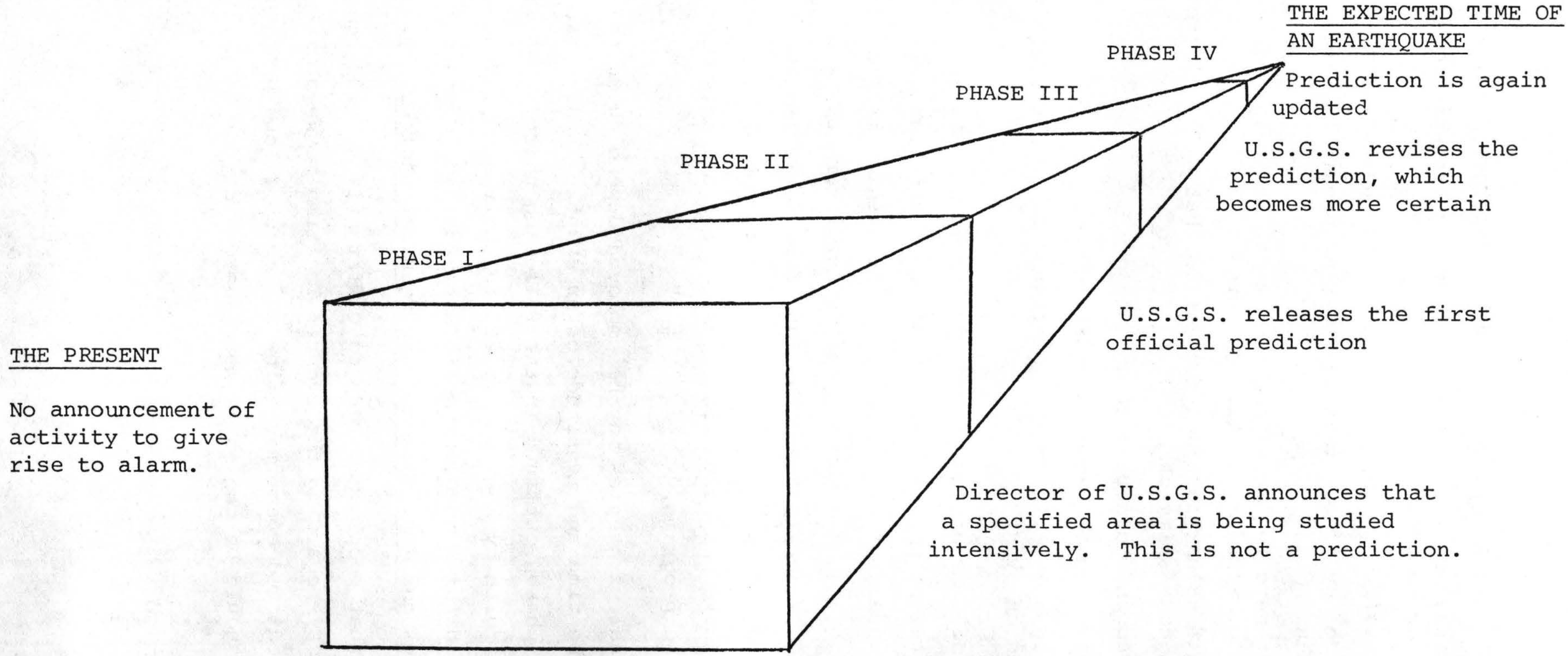
- the physical, social, and economic characteristics of the earthquake problem
- the scientific and policy aspects of earthquake predictions
- the psychology of reaction to disaster predictions and events themselves
- how to prepare for an earthquake event, including taking and supporting hazard mitigation measures
- where to find services and facilities that will help reduce an earthquake's impact
- how to respond to a prediction
- how to react during an earthquake
- how to organize, find help, and engage in recovery efforts following an event

The actual design of an educational program should be determined with representatives of the target population. These representatives will be identified during the process of establishing the Strategic Planning Team. Once local needs, interests, and resources are determined, we may proceed to plan, design, implement, and evaluate the component educational elements in our comprehensive educational program. Meanwhile, we have set forth above some of the elements that should characterize these programs.

Different educational strategies may be employed depending on the state of certainty of the time and magnitude of an event. These strategies could correspond to the phases outlined in the following chart. The phases correspond to those set forth by Haas and Mileti in their study, Socioeconomic Impact of Earthquake Prediction on Government, Business, and Community: Research Findings, Issues and Implications for Organizational Policy.

The point here is that people may respond differently to different announcements of certainty regarding the event. The time between an announcement and the predicted event may allow for more or less preparedness. Educational strategies should be chosen as most appropriate and effective within this constraint.

TIME FRAME FOR PUBLIC EDUCATION*



<u>Different educational strategies should be designed for optimum effectiveness to correspond to the different time phases relative to the certainty of an earthquake event.</u>

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* These time elements correspond to the time phases set forth by Haas and Mileti (Socioeconomic Impact of Earthquake Prediction on Government, Business, and Community: Research Findings, Issues and Implications for Organizational Policy)

5. Conclusion

This paper has presented our current perspective of the earthquake problem with particular respect to public education.

Because of the novelty and complexity of the problem and the number of groups involved at the federal, state, and local levels, we would not feel comfortable presenting a specific proposal for a project without having first had the opportunity to discuss the topics raised in this paper. Once we have a better idea of what will be desirable, we will be in a better position to see how we might play a role.

As a first step, we propose meeting with members of NSF and local groups in the San Francisco Bay area to discuss a strategy for a comprehensive public education program. This meeting might be similar to the one that USGS has planned for the first week in February 1978, to discuss how the public might be involved in their earthquake prediction effort. We feel that there is a certain degree of overlap between public education and public involvement in monitoring. It would be appropriate to coordinate the educational aspects of both efforts.

We are prepared to discuss such a meeting with NSF and other groups (in fact, many of those we already have contacted would like to see such a meeting take place), and to prepare a proposal to coordinate such a meeting, should NSF not be in a position to do so.

Meanwhile, we would like to discuss any aspect of this paper with NSF in order to sharpen our perspective of how EDC might best participate in developing a public education program on earthquakes.

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Internet:
International Environmental Resources Network

Post Office Box 417, Concord, Massachusetts 01742 (617) 369-8480/369-8481

Program Description

Internet is an international environmental education program being developed under contract with the United Nations Educational, Scientific and Cultural Organization and the United Nations Environment Program.

Internet links together interested teachers from any discipline at the 7th through 12th grade levels in a communications network designed to:

1. Increase student awareness of the wide range and complexity of environmental issues, problems, conditions, and events taking place around the world,

2. Offer students the opportunity to communicate with each other through Internet in order to exchange information on local environmental issues, experiences, and ideas,

3. Offer students the opportunity to participate in actual field research projects for principal scientists who need help in collecting observational data and samples from broad geographic areas, and

4. Offer students an approach to identifying and helping solve a local environmental problem, working constructively with the community, elected and appointed officials, business people, and other citizens and resources.

During its first year of development, 1976-1977, Internet will mail materials to participating teachers that may be used in or out of the classroom, however the particular teacher sees fit.

Internet will attempt to develop the following materials for teachers:

To offer Guidance	An initial, updatable teacher guide that presents an evolving approach to utilizing Internet materials. Participating teachers are expected to offer comments and suggestions on the guide as it evolves, so that the guide will develop to meet actual teaching and learning needs.
To increase Awareness	Periodic reports, called Internet Reports, of worldwide environmental issues and news--ranging from social, economic, political, and legal conditions to sudden, naturally occurring events, such as volcanic eruptions, floods, earthquakes, and even events and conditions on other bodies in space, such as the moon and Mars.

To promote Participation	Occasional scientific field research projects that involve students in assisting principal scientists conduct field research.
To guide Management	A basic, step-by-step approach to identifying, documenting, and helping manage a local, community environmental problem or issue--whether in an urban, suburban, or rural setting.

Internet is not an advocacy program, for or against conservation or industry; rather, the Internet approach encourages a fair and reasoned consideration of issues from a variety of viewpoints, promoting discussion between students and conservation, business, government, and citizen groups.

Internet offers an approach building upon existing resources and developing a working relationship between students and other groups sharing a common goal: To help improve the quality of life and the quality of the environment.

Internet is part of a worldwide approach to environmental education developed by Unesco as an outgrowth of recommendations made at the United Nations Conference on the Human Environment, held in Stockholm in 1972, and at the non-governmental International Environmental Education Workshop, held in Belgrade in 1975. Background information and documents on these conferences are provided to teachers participating in Internet.

Internet invites interested, enthusiastic, action-oriented teachers from any discipline--whether social studies, science, humanities, or media--in public and private schools to join in this international educational effort.

Individuals and organizations not participating in Internet but interested in receiving the Internet materials are invited to contact us for information on subscription rates.

Internet Reports:

No. 6

DISASTER WARNINGS: IS ANYBODY LISTENING?

The following article is written by Dr. Gilbert F. White, Director of the Natural Hazards Research and Applications Information Center at the University of Colorado. The article appears in the Natural Hazards Observer (March 1977).

The prospect of being able to predict the time, magnitude and place of an earthquake, or to designate a tornado path 30 minutes in advance, or to forecast a flash flood as much as an hour ahead of its peak underlines two troublesome questions for government scientists. They have statutory obligations to issue warnings of what they can predict, but their responsibility cannot stop there. The issuance of a warning cannot be dismissed as a strictly seismological, hydrological or meteorological exercise. Either by default or by design they are involved in the content of the warning and its means of communication. Proper public response often is assumed rather than assured. Unless the message is intelligible and helpful and reaches the right persons at the right time it falls short of serving its purpose. Scientists should know 1) whether anybody is listening and 2) what people in fact do when they get the message.

So long as severe earthquakes, hurricanes or tornadoes could not be predicted and were regarded as Acts of God, the scientist who observed them could be content with recording their characteristics. With the advance of knowledge and technology it became practicable to forecast flood peaks on larger streams with considerable accuracy; predictions of velocity and landfall of a tropical cyclone have been made with moderate confidence, and a tsunami warning service is in operation. The populations of relatively small areas can be alerted to possible tornadoes. Avalanche alerts are common.

A new and fruitful linkage is being forged between the operating forecaster, the disaster preparedness expert, the communications manager, and the social scientist. Those who generate the forecast need to be supplemented by more than curbstone judgment as to how people respond. In turn, investigators of human response need to understand the limitations of the forecaster, and find ways to protect his credibility and scientific objectivity.

Warning systems for many natural events are becoming more sophisticated. The likely social response to the infant art of earthquake prediction attracts the most public attention, but capabilities to predict volcanic activity and landslides are increasing. In terms of lives and property affected flood. hurricane, and tornado warning networks have largest immediate significance. In all cases the challenge is to speed up communication between the physical and social scientist so that advances in prediction technology can be translated into reduced human suffering and property losses.

--GFW

The following article appears in the same issue of the Natural Hazards Observer:

DON'T BLAME ME

California Governor Brown signed a bill in Sept. of 1976 which absolves public officials from liability for damage resulting from actions taken or not taken in response to a scientifically-valid earthquake prediction. The bill declared the intent to "insure that appropriate actions are taken in the public interest by government agencies without fear of consequent financial liabilities when acting in a responsible manner under such circumstances to assure public safety."

Questions and Projects:

1. Study your town's plans for responding to disaster warnings. Find out what the roles of the police, fire department, civil defense office, hospitals, and citizen groups are in times of disaster alert, impact, and response. What roles can students play?

2. Does your school have periodic drills to prepare students for the appropriate action in times of a disaster warning?

Internet Reports: No. 9

HAZARDS OF PREDICTING DISASTER

Predicting natural events was a dubious power once reserved only to those close to a deity. What power one could have in earlier times if able to predict eclipses, or, more portentous, disasters, such as earthquakes, floods and volcanic eruptions!

Even today, there are rewards and risks associated with the powers of prediction. In particular, four recent predictions of volcanic activity have proved wrought with both potentially high benefits and high risks.

In 1975, based on a statistical assessment of the likelihood of major mud flows occurring due to increased thermal activity on Mt. Baker volcano ($48^{0}47$'N, $121^{0}49$'W) in Washington state, the National Park Service closed large recreational areas that lay in the path of the possible mud flows. The town of Concrete, Washington exists principally on the basis of the inflow of tourist money spent each summer. To close the parks meant a certain economic impact on the town and its inhabitants. The mud flows have not yet occurred, the town is still there, and the University of Washington has a $45,000 grant from the National Science Foundation to estimate and assess the social and economic impact of the prediction of a disaster that never took place.

In February 1976, the US Geological Survey issued a prediction of an eruption to take place on Mauna Loa volcano ($19^{0}29$'N, $155^{0}37$'W), on the island of Hawaii some time before July 1978 (see Internet Report 50).

In late August 1976, scientists monitoring volcanic activity on Taal Volcano ($14^{0}01$'N, $121^{0}00$'E), Taal Island, Luzon, Philippines became concerned about the likelihood of an eruption, and recommended the evacuation of several thousand persons from Taal Island and some lakeshore towns.

In late October, also of this year, a noted international authority on volcanoes was dismissed from his post as director of an important volcanological institute following a dispute over the magnitude of a predicted eruption of La Soufriere de Guadeloupe volcano ($16^{0}03$'N, $61^{0}40$'W), in the West Indies. As reported in the New York Times (29 October 1976), several French scientists predicted a major eruption to take place with the force of "several atomic bombs." Seventy thousand people were evacuated after the scientists warned of an inevitable eruption. The now-dismissed scientist had argued that the eruption would not be as severe as predicted. The outcome? The evacuation caused substantial economic losses on the one hand, and on the other, one scientist's disagreement over the danger of the eruption cost him his job. The actual eruptive activity that did occur was not of the catastrophic proportions predicted.

Questions and Projects:

1. What is the difference between predicting a disaster that people can see coming, such as a tornado, and one that is less evident, such as an earthquake? Will people react the same way to a prediction?

2. If you predict a disaster that may not take place for several months or years (if at all), what might happen to the property values in that area?

3. Who should be responsible for making a prediction that might have a severe economic impact, whether or not a disaster actually takes place?

   Should the scientists make the prediction, and then take the blame? Should the government announce the prediction and pay for the costs of its impact?

4. Is a disaster warning system any good if no one pays any attention to it?

5. Would it make sense for you to live in a disaster prone area, even if a disaster may not happen very often?

6. If you owned an insurance company and provided insurance against damage caused by, say earthquakes, would you advertise to increase sales of the policy after an earthquake prediction, or would you try to cancel existing policy accounts?

Internet Reports: No. 47

URBAN GROWTH AND THE THREAT TO AGRICULTURAL LAND

Agricultural land is now recognized to be a finite resource in competition with urban and industrial growth. In the past, agricultural land was considered an inexhaustible resource waiting to be transformed into urban centers, industrial parks, and housing in general.

The problem, according to the Committee for Agriculture of the Organization for Economic Cooperation and Development (OECD), is twofold: the land itself is being physically used for other purposes, such as roads and buildings; and agricultural conditions are deteriorating through, for instance, pollution and land price increases, caused by the proximity of agricultural land to urban areas.

Loss of agricultural land, through land consumption, has somewhat been concealed by an increase in productivity for a given area of land. For instance, as an extreme example, in the United States, the average amount of agricultural land has decreased by two percent over the last 20 years; however, yields of principal products have increased by about 50% during the same period. Here is a table of losses of agricultural land to urban uses (approximate estimates, yearly average 1960-70, % of total agricultural area):

Austria	- 0.18
Belgium	- 1.23
Denmark	- 0.30
Finland	- 0.28
France	- 0.18
Germany	- 0.25
Japan	- 0.73
Netherlands	- 0.43
New Zealand	- 0.05
Norway	- 0.15
Sweden	- 0.33
Turkey	- 0.04
United Kingdom	- 0.18
United States	- 0.08

The figures do not appear particularly drastic; however, in the case of Belgium, the agricultural/urban balance would be severely upset if the reduction exceeded one percent for several consecutive years. Nevertheless, the problem is considered to be significant, and is exacerbated by the fact that the most fertile land is also the most threatened because historically settlements began in agriculturally rich areas.

One example of the deteriorating conditions caused by the proximity of agricultural land to urban areas is the dramatic increase in the price of land, which encourages farmers to sell out, and discourages farm expansion. Also, the nearness to towns raises the cost of manpower because of competition with urban jobs. Although the area actually affected by building (land consumption) in the next 50 years may only be a small percentage of farmland, such urbanization causes prices of land to rise over areas 10 to 20 times the acreage actually consumed.

Land-use management is being undertaken largely through zoning, dividing up a land area into different zones designated for different uses. Zoning is implemented either through regulations, which must be enforced, or by incentives, or both. Zoning has problems, however, not only in the substantial resources required to introduce and enforce it, but also due to the resistance posed by vested interests.

Traditionally, land use has been a matter of local interest within any particular country. Now, however, the problems of land use can be of international concern, as well. For instance, many countries became concerned over plans to clear the Amazon forest, because of the potential effects on the world's climate threatened by such clearing. Also, countries that depend on importing their food are concerned about how the exporting countries are managing their agricultural land. Furthermore, foreign demand for recreational area, say in the Mediterranean countries, exacerbates the land-use problem in the affected country which must make a tradeoff between the residential needs of its citizens and the leisure requirements of visitors from other countries.

This report is based on an article titled, "Should Agricultural Land be Protected?" appearing in the OECD OBSERVER (September/October 1976). The article is based on a report by the OECD Committee for Agriculture, titled "Land Use Policies and Agriculture," (Paris, 1976).

Questions and Projects:

1. Where does your food come from? Is any of it imported from other countries?

2. Is there any agricultural land near you? If so, find out how the prices for the land have changed in the past 20 years. If not, has your area ever been agricultural?

3. Find out what kind of zoning laws exist in your area. To what extent does the public in your community take part in the zoning process? What can and can't you do on your property because of the zoning laws?

4. Do you want to find out more about agriculture and the environment? If so, contact Internet teacher Dan A. Webster, who teaches Agriculture at the F. Madill High School, Wingham, Ontario NOG 2WO, Canada. Dan edits the Bulletin of the Environmental Science Teachers Association of Ontario. The bulletin is filled with interesting and informative articles, which sometimes include action-oriented projects. The address of the ESTAO itself is Box 430, Teeswater, Ontario, NOG 2SO, Canada.

Internet Reports: No. 50

VOLCANO ERUPTION PREDICTED

The U. S. Geological Survey has predicted a possible major eruption of Mauna Loa volcano on the island of Hawaii for some time before July 1978. Aside from precautions taken at Mount Baker (in Washington state) in 1975, based on a substantial change in thermal activity there, this is the first time an eruption has been officially predicted.

The prediction is based upon Mauna Loa's historical record. Since 1852, small summit eruptions, similar to the July 1975 eruption, have always preceded a major flank eruption. Scientists believe that the July 1975 eruption seems to indicate that the NE rift of Mauna Loa will be the location of a flank eruption. This constitutes a possible threat to the city of Hilo.

The implications of the prediction are complex. Hilo has been spared by all previous major eruptions, and many residents have developed folklore about Mauna Loa. There are questions as to how the community would react to various methods, (i.e. bombing the volcano), employed by technicians to divert the lava flow and thereby mitigate the hazard. The USGS has contracted for technical expertise on monitoring and determining the location and construction of barriers. How the prediction is affecting the community, what adjustments the residents are aware of, and which they are choosing to implement are difficult to assess.

Further information on the situation is available from the Hawaiian Volcano Observatory, U. S. Geological Survey, Hawaii National Park, Hawaii 96718.

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Questions and Projects:

I. In your area, are there natural hazards, such as volcanos, earthquakes, floods, tornados, hurricanes, forest fires, or other threats to man and his environmental neighbors?

2. When did the last hazardous event occur there?

3. How severe were these occurrences in terms of effects in the environment of man?

4. Do insurance companies insure houses in your area against any or all of the types of hazards that might occur in your area?

DUNE MIGRATION ON EARTH AND MARS

The following report was prepared for Internet by Dr. Farouk El-Baz, Research Director of the Center for Earth and Planetary Studies at the National Air and Space Museum, Smithsonian Institution, Washington, D.C.:

Images recently transmitted by Viking spacecraft indicate that the surface of Mars displays numerous dunes and other windblown features. These images generated new interest in studying Earth's deserts for a better understanding of where and how dunes form. The studies will allow comparisons of the environments of both planets.

Deserts are regions that remain dry most of the time and therefore, cannot support much vegetation or any population. This definition includes the polar ice of the frozen tundra. On Earth these "cold deserts" constitute nearly one-sixth of the land masses or nine million square miles. There are similar deserts on the Martian poles, where numerous dunes form. In fact, the largest known dune field in the solar system is that surrounding the north polar ice of Mars. The term desert, however, is more usually applied to hot and dry tracts of land near 30° north and south latitude close to the Tropic of Cancer and Tropic of Capricorn. These "hot deserts" constitute nearly one-fifth of the land masses of Earth, or over eleven million square miles.

The largest of the world deserts is the Great Sahara of North Africa. It is 3,500,000 square miles; nearly as large an area as the entire United States including Hawaii and Alaska. Contrary to widespread belief, not all of it is covered by sand; only 500,000 square miles. It's largest dune field is the Great Sand Sea in the Western (Libyan) Desert of Egypt. The desert was photographed on the Apollo-Soyuz mission of July 1975 with color film for the purpose of studying its forms to compare with features of other dunes on Earth and Mars.

Dr. Farouk El-Baz is conducting a study of the Apollo-Soyuz photographs. He recently went to the Western Desert of Egypt to check some of the findings in the field. It was found that sand migrates there in two different ways: as dunes and as sheets. Sand dunes in the Western Desert of Egypt form long lines along the prevailing winds from north to south. The dunes shift as the eternal winds carry the grains one by one, moving them downwind. These shifting sands create a real danger to arable soil farther south. Dr. El-Baz observed dunes encroaching on farmland near the banks of the Nile. The danger is magnified by the fact that only five percent of the land area of Egypt is fertile soil. The rest is barren desert that should not be allowed to grow. On the contrary, it should be tamed and parts of it reclaimed.

Another feature evident in the Apollo-Soyuz photographs is the spread of sand in relatively thin sheets. These sand sheets appear to form not along the prevailing north to south winds, but the seasonal subsidiary winds moving from west to east. These winds create sandstorms that result in the spread of sand more thinly on the soil in its way. Sand deposits in this case are also similar to light and dark colored streaks on Mars. In both cases the windblown particles appear to deposit on the lee side of topographic irregularities in the terrain. These and similar studies will result in a better understanding of the desert environment and where it is best to reclaim arable land from the desert. The studies will also allow analog correlation between the windblown features of Earth and Mars.

Questions and Projects:

1. In 1974, the United Nations General Assembly passed a resolution calling for "International Cooperation to combat Desertification."

   The United Nations Environment Program was charged with the responsibility of convening a world conference on desertification. This conference is scheduled to take place from 29 August - 9 September 1977 in Nairobi, Kenya.

   The purpose of the conference is to increase understanding of the processes of desertification and to adopt a plan to stop, and when possible, reverse the processes.

   The conference will review four aspects of the subject:

   a) climate and desertification
   b) ecological change and desertification
   c) society and desertification
   d) technology and desertification

   Divide the class into four small research groups to prepare reports on these aspects. Then convene a meeting of the groups to discuss the problem of desertification and make specific recommendations on how to stop or reverse the process. Or, choose a local land-use issue, study it, write a report, and submit it to the agency or office that should be concerned with the problem. Refer to the Internet Teacher Guide for suggestions.

2. Earth's deserts are compared with those of Mars. One difference between the two is that Earth's deserts may be managed by man. Discuss man's land-use practices that may promote or prevent desertification. Also, consider changes in climate that may have caused desertification.

3. Locate Earth's deserts. Have these areas always been deserts?

THE FUEL CRISIS OF 1917-1918

The United States is suffering a fuel crisis that is not its first. In mid-December 1917, a massive cold wave struck the U.S. east of the Pacific coast and froze parts of the country through the following January.

Temperatures plunged to 4 below zero in Philadelphia and 14 below in Boston. In one week, 263 people died of pneumonia in New York City and others froze to death.

In those days the country ran on coal, not oil, and coal was cheap: $1 a ton in 1915. Bituminous coal production grew from 17 million tons to 423 million tons between 1870 and 1914. Energy was abundant and inexpensive, and energy-consuming businessmen like James J. Hill, Andrew Carnegie, and J. P. Morgan were creating industrial empires during the era.

The price of coal was kept down because there were too many coal producers to organize, and no single operator owned large enough holdings to control the market. The coal industry was plagued by low prices, low wages, waste, inefficiency, and disorganization up to the war in 1914.

When war broke out in Europe, the U.S. market suddenly was swamped with orders for supplies of iron, steel, munitions, and other war needs. The demand for war goods exceeded the supplies in the U.S. Production was spurred, and the demand for coal ignited a skyrocketing price, from $1 a ton in 1915 to, in exceptional cases, $5 a ton on the Pittsburg open market in 1917. Mostly, however, prices rose to around $2 a ton. Shortages created panic. Coal producers wanted to stabilize prices at $3 a ton. President Wilson felt they would be gouging the public.

In August 1917, Congress allowed Wilson to fix the price of coal, which he did, arbitrarily, at $2 a ton. This weakened the market, cut production, and abetted the crisis.

Transportation shortages compounded the problem. Food and coal competed for space on the railroads, and food was considered more important. As winter arrived in 1917, coal miners were unable to ship all the coal they dug. Coal that moved through Ohio towards the Great Lakes was hijacked and hoarded. Meanwhile, goods awaiting shipment in eastern ports were piling up, delivery trains became congested, empty cars for coal transportation were scarce, pipes were bursting, people dying, panic rising, and ships needing fuel were unable to leave port to deliver goods for the war effort.

Wilson's fuel administrator, Harry Garfield, became the most unpopular person in the U.S. in January 1918, when he shut down industry for five days to stop the flow of manufactured goods. His plan was to decongest the transportation system and free up the railroads to transport coal to the ships bound for Europe. Also, to save fuel, he declared Mondays a holiday. The business community was outraged. Losses in wages and production exceeded $1 billion. Finally, on February 13th, the Monday holidays were ended, people returned to work, and the fuel management crisis was over.

Source: "The fuel crisis, largely forgotten, of World War 1" by James P. Johnson, Smithsonian (December 1976)

Internet interview with James Johnson, History Department, Brooklyn College, New York (4 February 1977)

Questions and Projects:

1. Was the fuel crisis of 1917-1918 due to a depletion of coal? How much coal is left in the U.S. today? Why is coal no longer used as a major source of energy?

2. Is the present fuel crisis one of resource-depletion or management?

3. List ways to save oil, gas, and electricity. Start a fuel-saving campaign in your area and calculate the amount of energy your campaign is saving. Send your results to the President.

4. How did the war play a role in spurring government action in managing the fuel crisis? Do you think that private industry and the coal producers would have managed the situation better? Who should manage the current fuel crisis, industry or the government?

5. Is the 1917-1918 fuel crisis mentioned in your textbooks?

NUCLEAR EXPLOSIONS and EARTHQUAKES

Underground nuclear explosions send out shock waves that are registered by seismometers around the world. Sometimes, depending on the size of the explosion, the seismic magnitude may be over 5.0 on the Richter scale. For example, seismic signals recorded by the United States early Tuesday morning, 7 December 1976, were presumed to be caused by a Soviet underground nuclear explosion. The signals originated at 11:57 pm EST, 6 December 1976 at the Semipalatinsk nuclear test site in western Siberia. The magnitude was recorded at 5.5 on the Richter scale.

Some people ask whether nuclear explosions trigger earthquakes. According to E. M. Fournier d'Albe, director of the Unesco program in geophysics, certain underground nuclear explosions have been followed by small quakes within 100-200 km of the explosion; however these quakes are of less magnitude than the explosion itself. There is no evidence so far indicating that distant or destructive quakes are caused by underground nuclear explosions.

Source: The UNESCO COURIER October 1976

Questions and Projects:

1. See Internet Report No. 70. Waverly Person, of the U.S. Geological Survey National Earthquake Information Service, reports that NEIS locates about 6,000 quakes each year. The largest quake ever recorded was 8.9, but it is possible to have yet a larger one. That is why the Richter scale is open-ended.

   How do you think the NEIS can determine which quakes are natural and which are caused by man?

2. What other types of man-made activity, in addition to nuclear explosions, do you think would be registered on a seismometer?

3. Is there a seismometer in your area? If so, arrange to visit it and study how it works.

<u>PROJECT BURN PREVENTION</u>

AN EXPERIMENTAL MODEL FOR A PUBLIC

EDUCATION PROGRAM DEALING WITH HAZARD

Cheryl Healer, Project Director
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December 20, 1977

INTRODUCTION

Public education on burn injuries may have much in common with public education on earthquakes. Knowledge of the correct behavioral response to a burn emergency, as to an earthquake, can mitigate the consequences of the hazard. Moreover, burn injuries may be a result of fires caused by earthquake damage.* Indeed, the most significant difference between burns and earthquakes may be that most burns are preventable, but it is not within the control of the individual to prevent an earthquake.

This paper presents a model educational program now underway to prevent and minimize harm from burns in the hope that there is application and transferability to help people deal more effectively with other hazards.

In describing the program in progress, the paper discusses the following critical issues:

- The problem
- Partnerships in the collaborative effort
- Needs assessment: deficiencies in knowledge and the patterns of injury
- Delivery systems for the educational information
- Development of the educational materials and strategies
- Evaluation of the program's impact on knowledge and burn injury rate

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*Don DeNevi, *Earthquakes*, Celestial Arts, 1977. In the Tokyo earthquake of 1923 (8.3 Richter), 99,331 people died, including 38,000 who were burned to death.

THE BURN INJURY PROBLEM

Burns are the most devastating and traumatic injury a human being can sustain and still survive, according to medical authorities. A burn is an injury to the skin caused by exposure to heat from a flame, hot liquid, electricity, a hot surface, and even the sun. Too much heat will destroy the skin, vital to our survival. Skin is the largest organ in the body, providing us with a protective covering that keeps muscle, bone and body fluid in, and the hazards of the environment out. Skin is our major barrier against infection; it regulates body temperature; it contains the senses that allow us to know things by feel. Finally it is a critical part of our appearance: the world looks at our skin and recognizes us. A major burn, defined as one that covers 20 percent or more of the body, affects every organ and requires difficult, prolonged and costly treatment.

Tragedy and suffering, however, are not subjects people discuss easily. They are horrifying to consider, and many people avoid them by thinking, "It will never happen to me." But this is not reality. The tragic facts speak for themselves.

Every year in the United States:

- Over two million Americans are burned by hot liquid, flame, electricity, and other burn sources;
- Twelve thousand die in fires;
- Three hundred thousand are injured;
- Fifty thousand are hospitalized for periods ranging from six weeks to two years;
- $11.4 billion is lost to fire damage.

One out of ten individuals in the United States will suffer a burn accident in his or her lifetime serious enough to require hospitalization.

Burns kill as many children as all forms of cancer and infectious diseases. Among the causes of accidental deaths, only motor vehicles and falls cause more deaths each year than burns.

People need to face the reality of burn injuries but they are reluctant to do so. The medical community, federal government, and educational research and development specialists recognized the need to combat this problem and collaborated in creating Project Burn Prevention in order to reduce human suffering, loss, and economic disaster. The important and challenging task is to make people willing to look in detail at a subject that touches basic fears of violent death, disfigurement, and disability.

PROJECT OVERVIEW

The burn injury is a medical, social, environmental, and financial problem of national proportions. One of the first needs to develop a serious and significant educational effort is a major commitment from agencies and institutions in a position to provide financial support. Project Burn Prevention is funded by the U.S. Consumer Product Safety Commission, a federal regulatory agency whose responsibility it is to:

- Protect the public against unreasonable risks of injury associated with consumer products;
- Promote research and investigation into the causes and prevention of product-related deaths, illnesses, and injuries;
- Develop uniform safety standards for consumer products and minimize conflicting state and local regulations;
- Assist consumers to evaluate the comparative safety of consumer products.

The project is designed to explore the feasibility of using educational strategies to increase knowledge and appropriate behaviors, change attitudes, and reduce the number and severity of burn injuries. CPSC's investment in the project is approximately $1 million over four years; this amount is equivalent to the cost it requires to rehabilitate one severely burned person over his/her lifetime. Thus should we prevent one severe burn, the project would by this criterion have been successful.

Another important goal of this project is to develop a model which is generalizable to other geographic locations, such that any major city or community can replicate the educational program to heighten people's awareness, add to their knowledge, and better equip them to enact appropriate behaviors to protect them and their families from the possible long-term, disastrous consequences of a burn injury.

A consortium of Boston institutions collaborate on the project. Massachusetts General Hospital administers the contract fiscally; Shriners Burns Institute provides project direction, medical expertise about the burn injury, and baseline injury data; and Education Development Center is responsible for the design and development of the educational materials and strategies. As well, EDC is providing technical support for program implementation and evaluating changes in knowledge and attitudes.

The project is being carried out in two sites. The Boston Standard Metropolitan Statistical Area (SMSA) is the experimental site, and the Springfield (Massachusetts) SMSA is the control site.

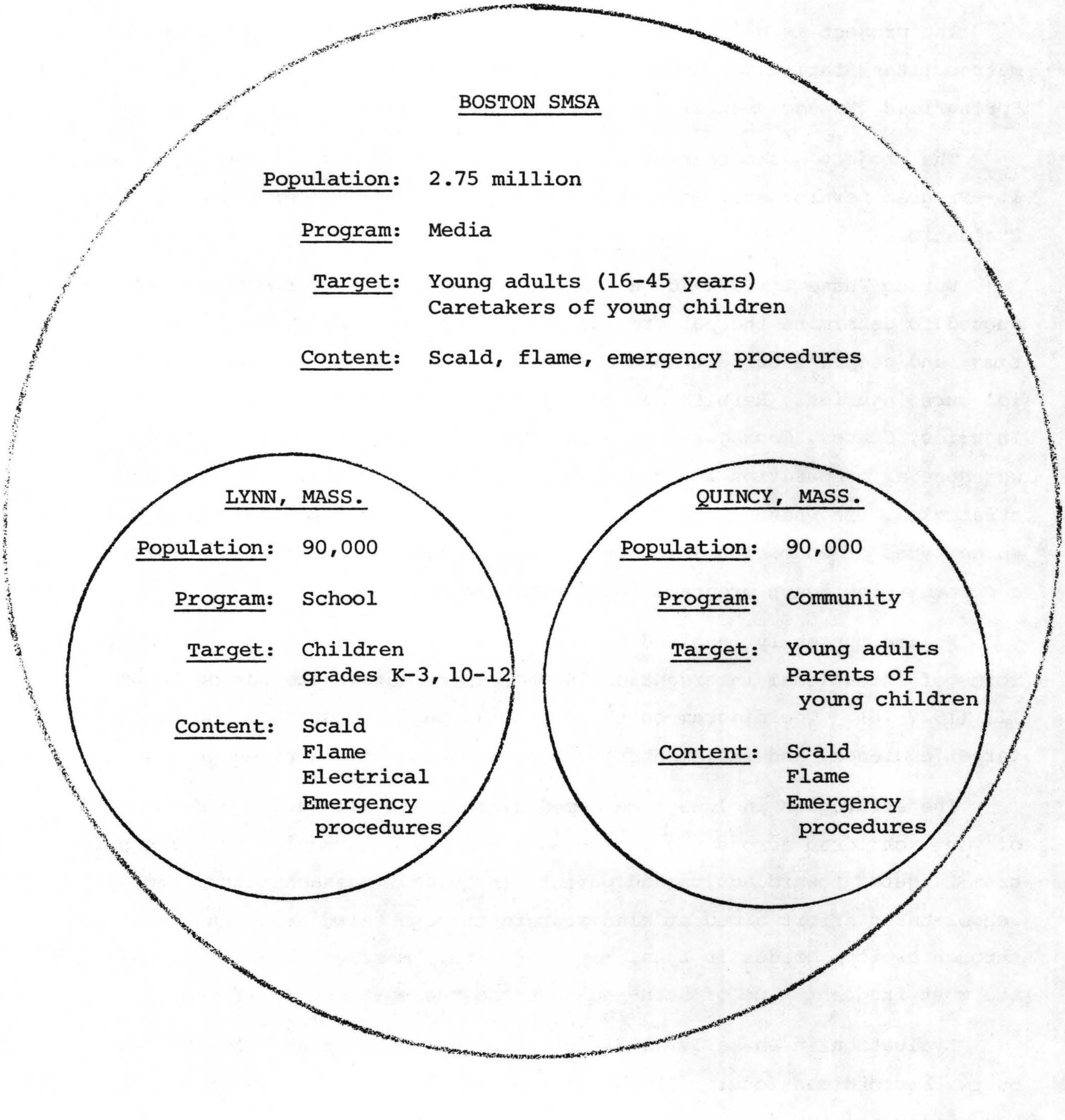
The project has a four-phase plan: Phase I--Needs Assessment; Phase II--Program Development; Phase III--Program Implementation; and Phase IV--Evaluation.

During Phase I (1975-76) a comprehensive needs assessment was conducted to determine the patterns of burn accidents; profiles of burn victims; and people's current knowledge of prevention and emergency treatment for burn injuries. Results can be found in the Year I report, *Burn Injuries, Causes, Consequences, Knowledge and Behavior*. This research was done as preparation for the development of preventive materials and strategies. In Phase II (1976-77) project staff developed materials for three types of educational intervention programs: a mass-media effort, a community outreach program, and a school-based one.

We are currently involved in full-scale implementation of all these forms of educational intervention in the experimental site during Phase III (1977-78). The diagram on the following page illustrates the content, target audience, and implementation site for each of the three programs.

The strategies include a mass-media effort to all adults and parents of young children across the entire Boston SMSA; a community outreach program targeted toward adults and parents in Quincy, Massachusetts; and a school-based effort aimed at kindergaretn through third grade and tenth through twelfth grades in Lynn, Massachusetts. Message content emphasizes the most frequent type of burn--scalds--and the most severe--flame.

Evaluation in Phase IV (1978-79) will measure program effectiveness on two basic dimensions: (1) changes in the incidence and severity of burn injuries; and (2) changes in knowledge, attitudes, and appropriate behaviors. A cost-benefit analysis will be made of the three different approaches. Phase IV will also explore the networks and lay the groundwork for national replication and dissemination of the educational program.


BOSTON SMSA
Population: 2.75 million
Program: Media
Target: Young adults (16-45 years)
Caretakers of young children
Content: Scald, flame, emergency procedures
LYNN, MASS.
Population: 90,000
Program: School
Target: Children
grades K-3, 10-12
Content: Scald
Flame
Electrical
Emergency
procedures
QUINCY, MASS.
Population: 90,000
Program: Community
Target: Young adults
Parents of
young children
Content: Scald
Flame
Emergency
procedures

ELEMENTS OF THE EDUCATIONAL PROGRAM

Before and while developing the many materials and activities for Project Burn Prevention, many issues were given thoughtful consideration. A discussion of the highlights will help in understanding the original purpose intended for the materials, the philosophy of approach, and the development process.

The project model from its inception was designed to have three different types of educational delivery systems: mass media, school-based, and community outreach. The purpose of the media campaign is to heighten awareness about burn prevention to instill the message that "burns aren't accidental" and to enhance public receptivity to the school and community-based programs. The school program is intended to reach a broad segment of the population: the children themselves as direct recipients and those other family and community members to whom it may filter back. It is hoped that children who become crusaders for the cause will tend to exert heavy pressure on families and communities.

The community outreach has access to high-risk segments of the population not directly influenced by the school-age program whose education cannot be left to the transitory impact of a mass-media campaign. These include groups such as mothers of toddlers, people living in deteriorating, overcrowded housing, etc. These educational materials and experiences must be based on a nonformal approach. Those groups are reached by various community agencies and services. In turn it is hoped that adults and parents who are direct receivers of this information will transmit it to their families and children.

Given those three educational delivery systems, we set out to address the following issues:

- Who will be the target audience?
- What delivery system shall be used for each audience?
- What are the characteristics of the target audience?
- What shall the priority messages be?

- What will be the educational philosophy of the materials development team?

- How will the development team involve the greater community in the process?

- What will be the general characteristics of the materials?

- How will we evaluate the program?

A discussion of each follows.

<u>Who Will Be the Target Audience?</u>
<u>What Delivery System Shall Be Used for Each Audience?</u>

As was mentioned earlier, Year I of the project was spent gathering data about how people are burned and what they don't know to prevent them or do in an emergency. To select the target audience it was necessary to consider the following combination of factors: Which age groups are at highest risk; that is suffer the greatest number and severity of burn injuries? Which age groups know the least and appear to have the greatest need for information? What delivery systems could most effectively reach those groups in greatest need?

Phase I findings revealed that the very young (0 to 2) are at greatest risk; specifically they suffer burn injuries at three times the rate of any other age group. Adolescents and young adults are the other two groups whose members are burned more frequently than would be indicated by their normal representation in the total population in Massachusetts. Males are usually more at risk than females, most marked during the preadolescent age group. Children three to eight are the next most vulnerable age group. The elderly tend to be at lower risk in terms of numbers but their burns are often more severe.

Knowledge scores about prevention and how to behave in an emergency were rather low for most age groups, suggesting perhaps that knowledge about the topic is not extensive.

Given that one of our delivery systems was to be through the schools, from Phase I data it made sense to target that program to adolescents and young school-aged children. It was believed that the mass media would be the most effective approach with the young adult population 20 to 44, with particular focus on homebound parents of very young children. Heightened awareness of the risks to infants and toddlers might best be accomplished through media with more in-depth personalized follow-up to the same target audience through community networks.

Because of the relationship of the selected target groups to one another--that is, parents of children, adolescents who take care of children, children who take things home from school to parents--it was decided that the risk groups should not be approached in isolation from one another but as interacting members of the families. Messages addressed to each age group can be carried by different family members across generations. For example, to help assure that families of children in the school site would be aware of what their children are learning and to know themselves, a booklet was developed to take home to coordinate the educational effort.

<u>What Are the Characteristics of the Target Audience?</u>

The source of data to determine the patterns of burn injuries in Phase I was the Massachusetts State Reporting Form (a Massachusetts law requires that all burns greater than 5 percent body surface must be reported). The census tracts in which the victims lived were analyzed. Income, average years of schooling, average age of housing were considered. The reporting form as a data source is not that reliable; therefore interpretation should be done cautiously. Generally there was wide variation among census tracts on all characteristics examined. Burn victims were reported from census tracts of very low socioeconomic status and of very high socioeconomic status. Similarly, from the samples of people selected to determine how much people knew about burn prevention, few statistically significant differences according to race, income, school district, and socioeconomic factors emerged. Given both of these sets of data it seems that burns do happen to both high- and low-income groups, though there is a greater tendency for more burns among the lower. It also seems that most segments of the population have information gaps with respect to the topic. As a result it was decided that the materials for the educational campaign should appeal to the broadest possible range of socioeconomic groups bearing in mind that the direction toward lower income groups in older housing should receive greater emphasis.

What Shall the Priority Messages Be?

Again based on Phase I's findings, project staff concluded that a burn prevention campaign must address the problem of scalds because of the high incidence rate, and the problem of flame burns because of the severity of injury. Scalds account for 42 percent of the state burn reports, while flame burns, the second most frequent burn (26 percent), tend to be the most severe. Other types of burns are addressed for specific age groups, depending on considerations of consumer interest and age-related risk and severity factors.

In the educational diagnosis, all respondents tended to score higher on scald items than on flame items, suggesting perhaps that factors other than knowledge (haste, stress, distraction) contribute to the scald injury. Knowledge about flammable liquids, clothing, and emergency treatment was low. The educational diagnosis also revealed widespread ignorance across all age groups about electricity and electrical burns.

The remaining state burn reports (32 percent) were distributed among other types of burns: contact, chemical, radiation, and electrical burns. Contact, radiation, and chemical burns are given much less attention in our materials because their results tend to be minor when compared to scald and flame. Key parts of our materials focus on electrical burns. Though they are fewer in number, they have devastating results. They are considered in age-specific campaigns.

While different age groups are at highest risk from different sources of burn injury, the educational diagnosis revealed that the knowledge deficiencies are very much the same across age groups. These findings suggest that many of the same messages are pertinent to all age groups, although the format and strategy should be adapted appropriately to age differences.

What Will Be the Educational Philosophy of the Materials Development Team?

Since burn injuries are so closely connected to physical hazards in the environment (e.g., free matchbooks, flammable fabrics, variation in design of appliances, etc.), a point of discussion is: Do you provide people with the information to make competent decisions or do you legislate to change the environment assuming you cannot count on people to protect themselves? In some cases both legislation and education are necessary and complementary. In others the enactment of legislation becomes an issue of removing individual freedom.

Although in some instances our funder, the U.S. Consumer Product Safety Commission, has enacted legislation, John Byington, chairman of the commission, stated that "about two-thirds of all injuries related to consumer products relate not to the performance of the design of the products themselves, but to the involvement of the consumer with the product through misuse, abuse, not following proper procedures whatever they may be." Our place of beginning in Project Burn Prevention was the philosophy that an informed and educated citizenry will act on their own behalf to prevent harm to themselves or someone they love. On this belief rest all our efforts.

We approached the materials development phase with another overriding premise. Primarily we wanted to create materials through which learners would assume an active, participatory role in the learning process, experiencing situations directly, whenever possible. Our review of existing materials indicated that most were based on a "Do-Don't" approach, often including a teacher's guide (for all grades K-12) containing suggestions for many activities around topics or themes throughout the year, but few or no materials for learners themselves.

Given the different ages of our target audiences, the challenge we faced was to create materials through which the learner could experience and realize the problem as directly as possible and leave the activity equipped with the knowledge and attitude to make an informed choice about the way he/she behaves in relation to his/her environment. One facet of the problem is that even though people sometimes know the correct thing to do, it is difficult to actively change their behavior. For example, interviews with burn victims told us that they had known to drop and roll prior to their accident, but when on fire panicked and either screamed or ran. In many cases it was the action of the bystander which saved them. Through providing individuals opportunities to practice preventive and emergency behaviors and expose them to others' experiences, it is our goal to increase people's sense of competency and reduce the burn injury rate.

To motivate people to translate the knowing into doing, to incorporate the knowledge and information into their daily lives was a major challenge to our work. Our overall approach to create a sense of identification with the problem was a developmental one; with each age group we began with their interests, characteristics, and abilities. Often this involved the use of case studies so that we constructed activities based on the real life stories of people with whom we wanted the user to identify. For example, our introduction of the problem to adolescents was through the audio tape of two local boys telling the actual story of how they received electrical burns from climbing high tension installations. Our entry point was to hinge the burn injury problem on a more generic issue: that of risk taking, a common phenomenon for adolescents. Activities were developed so that students could consider how feelings, such as boredom, anger, etc., can affect what they do.

For parents we applied a model from Exploring Childhood, another EDC course, to typical case studies of injuries to children. An activity was constructed to enable adults to think about the interrelationship of factors in their own lives as caretakers, factors in the developmental stage of the child, and physical hazards in the environment.

Because of the nature of heat, fire, electricity, and the resulting burn injuries to human skin, there are many issues which stand between an enactive, participatory approach and the topic. On the one hand, there is a need to convince people that burn injuries are a real and significant problem and to motivate them to act in ways to prevent them. On the other hand, the topic itself can raise people's fear and anxiety to the level where they "block" on the topic altogether and remove it from their minds and conscious actions. How, then, in a highly visual world in which many sponsors compete for our attention in areas which are deemed important to our health and well-being--e.g., the effects of cigarette smoking, wearing seat belts when driving, self-examination to detect breast cancer, the relationship between alcohol and driving, good habits for dental hygiene--can Project Burn Prevention effectively impact people's knowledge and ultimately their behavior to prevent burns without scaring them away from the topic altogether?

Our decisions of how to proceed with respect to the use of fear and realism differed depending on the age of the audience and medium of delivery. A deliberate decision was made *not* to use fear as a major component of any public service announcement because of the particular nature of the television medium; most people turn to TV for escape and in this brief fleeting 30-second exposure, fear would not be a positive tool in capturing people's attention.

In our development of school and community materials we pilot-tested pieces with their intended target audiences before embarking on an idea. Through this process we specifically tried out different levels of fear with different audiences and solicited their reactions to develop materials that introduced an appropriate degree of realism without inhibiting learning.

DEVELOPMENT PROCESS

A core staff team of five people at Education Development Center was responsible for the entire materials development task. Interacting with the core team, the Media Department at EDC produced the television spots and other key audio-visual pieces. In addition, many different free-lance artists and photographers contributed to the materials. EDC's design studio coordinated production of all print pieces.

The core development team at EDC involved many other specialists in the process. They were interviewed before and during development. As well project staff solidicted their feedback to pilot drafts of the materials. Representatives who contributed input to the concept, format, design, etc. included school administrators, parents, teachers, students, physicians, health educators, school audio-visual coordinators, psychologists in the burns field, television and radio producers, and community leaders.

WHAT ARE THE GENERAL CHARACTERISTICS OF THE MATERIALS?

Mass Media Campaign

Television

Four public service annountements: The spots are 30 seconds in length because they are easier for stations to place than longer ones. Each contains elements designed to:

- Attract attention;
- Create a sense of identification;
- Readily identify the burn problem;
- Appeal strongly to caring for others;
- Identify appropriate preventive behaviors;
- Identify a place where people can write for additional information.

As well, the project has held "prime-time" appearances on radio and television. Some have coincided with the period of peak media and public interest in the burn problem which follows naturally after news coverage of a fatal house fire, flaming car crash, electrical injury, or serious scald. Appearances have also included programs of consumer reports, medical forums, noon and evening news, etc.

Media Booklet

This material combines text, illustrations and activities to alert families to major burn risks, prevention behaviors, and treatment. It was developed in close coordination with the public service announcements and the school and community materials in order to reinforce and build up on the messages of those materials. Children in school can also take this booklet home to extend the message to their families. The booklet has been distributed through the following channels:

- Write-in responses to the PSAs.
- Write-in responses to the posters.

- The Massachusetts Bay Transit Authority has made a public service commitment to the project to place posters in all cars and buses. An address for the booklet appeared on the bottom of these.

- Handed out in school test sites for students to take home.

- Handed out in community meetings for participants to take home.

Posters

The purpose is to grab passers-by's interest in a few seconds. Therefore, the messages are brief, bold, and visually dramatic. On each poster is a place to write for the booklet. Throughout the implementation period the posters were located in:

- MBTA subway cars;

- Supermarkets, stores, shopping malls, etc.;

- Community organizations and buildings, e.g., Lions, community action councils, YMCA;

- Newspapers;

- Schools, hospitals, clinics, etc.

School Materials

Before development began we collected and reviewed existing materials. As well we conducted a structured telephone interview with school superintendents locally and nationally, as well as local teachers. Based on this input we made the following decisions about school materials:

- One way we envision our program being distinctively different from others is that we produced kits containing materials for students to handle, as well as instructional materials for teachers and/or community leaders.

- Cost for a kit will be affordable, probably in the range of $35 to $75 per kit.

- The design is flexible to allow the teacher to fit the program into her day/week and year easily, and within a variety of departments.

- The materials provide interesting activities through which teachers can promote basic skills, as well as knowledge about burn prevention.

- The adolescent materials appeal to a broad set of issues important in any area of study--stress, anger, quality of environment, child development, and basic scientific concepts important for survival.

- Materials confront some underlying emotional reactions.

- A variety of materials are included in the kit, such as audio tapes, story cards, filmstrips, print, etc.

- A variety of activities are suggested, including problem solving, role playing, games, listening, discussion, sharing experiences, small-group work, sorting and classifying, reading, and writing.

- Ways to relate and share learning to the home and community are included.

Community Materials

Our challenge in developing a plan for the community-based strategy was to find channels through which we could effectively penetrate a community and saturate its residents with information.

The project was widely publicized in the community through the use of local community radio, television, and newspapers. The kits for adults and children, as well as the projection equipment, were made available to any interested party on a loan basis from the town library and its branches. Some examples of groups who have used the materials include:

- Community action neighborhood centers;

- Parent-teacher organizations;

- Churches;

- Boy Scouts, Explorers;

- Hospitals;

- Social welfare organizations (children's protective services, Council for Children);

- Housing Authority;

- Pediatric clinics.

EVALUATION OF PROJECT BURN PREVENTION

Project Burn Prevention is being evaluated along three basic dimensions. Data is being collected to determine:

- Reactions to the materials from deliverers and participants (formative evaluation);
- Changes in the target groups' knowledge and attitudes (summative evaluation, pre/post vs. control site);
- Changes in the actual rate of burn injuries (hospital record data).

A discussion of each follows.

Formative Evaluation

The basic purpose of formative evaluation is to collect data from program participants about the program and its materials. This information will provide a context for interpreting quantitative pre/post gains. It will help the project decide which components of the program should be highlighted for national replication, and will also allow us to identify strengths and weaknesses in the materials and their presentation.

Changes in knowledge, attitudes, and reported behaviors before and after the program can best be understood within the context of how materials were used and how people reacted to them. The formative evaluation will attempt to answer a set of generic questions about the program materials. The basic questions we are asking are:

Planning

- How did people hear about the project? How did they respond?
- How did we prepare people to receive the materials?

Implementation

- Who delivered the materials? What networks evolved for use of the materials?
- How many people were reached? Who were they?
- What recommendations can we make for replicating the program in other cities?

Reactions to the Materials

- What were the strengths and weaknesses of the materials? Why?

- What are the recommended changes?

The basic approach to answering these questions will be that of a case study. Each major materials will be evaluated through a combination of approaches:

- Brief questionnaires for program deliverers (teachers, community leaders, media representatives) and recipients (students and community groups) will inquire about such features of the materials as appeal, clarity, quality of content, and usefulness.

- In-depth interviews with a selected range of users will probe reactions further.

- On-site observations of classroom and community use of the materials will balance self-reports against observed behavior.

Summative Evaluation

Criterion-referenced testing was selected as the technique to establish a baseline of the general public's knowledge and understanding of concepts, general awareness, and behaviors related to fire and burn prevention. Since it was not feasible to use measures that always correspond to the ultimate criterion (what one does when confronted with a burn situation), the best alternative was to find an indirect or intermediate criterion related to, or predictive of, performance in the crisis situation. The relevance of criterion-referencing to educational program evaluation relates directly to how we will interpret the criterion-referenced test scores later. The learning objectives inherent in the educational program are one set of standards (criteria) against which the program's success can be measured. The issue to be answered will be: Did persons A and B learn what the program intended? Each learning objective is translated into a set of questions or performance tasks that represent a sample of knowledge or behavior keyed to the objective.

Early in the fall of 1975 an afternoon conference was held at EDC for the purpose of obtaining experts' advice as to the important educational messages for the general population and for the high-risk groups identified in earlier study, i.e., parents of toddlers, children (including adolescents) of varying ages, and the elderly.

Based on this input, project staff developed objectives for the program and test items to measure them. These instruments were used in Phase I to provide information about what people don't know about preventing burns and have since been refined to accurately measure all the objectives of the educational program which has since been developed.

In order to determine whether Project Burn Prevention has had any impact, the basic plan for this evaluation follows a Solomon-four group design, which is presented below.

Premeasures (Before educational campaign)	Treatment (Educational campaign)	Postmeasures (After educational campaign)
Random Sample 1 (Experimental Site)	X	Random Sample 1 (Experimental Site)
Random Sample 2 (Control Site)		Random Sample 2 (Control Site)
No Premeasures Random Sample 3 (Experimental Site)	X	Random Sample 3 (Experimental Site)
No Premeasures Random Sample 4 (Control Site)		Random Sample 4 (Control Site)

In order to implement this experimental design, specific instruments are being administered to the groups outlined below.

Educational Intervention	Audience	Target Site	Control Site	Instrument
Mass media	Young adults (16- to 45-year-olds	Boston SMSA	Springfield SMSA	Telephone survey
		Sample size:		
	Caretakers of young children	600	400	

Educational Intervention	Audience	Target Site	Control Site	Instrument
Community	Young adults (16- to 45-year-olds)	Quincy	South Hadley	Telephone survey
		Sample size: 300	300	
	Caretakers of young children			
		Sample size:		
	K-3	800 (200 at each grade level)		Criterion-referenced tests
	10-12	600 (200 at each grade level)		
School		Lynn	Holyoke	
		Sample size:		
	K-3	800 (200 at each grade level)		Criterion-referenced tests
	10-12	600 (200 at each grade level)		
	Young adults (16- to 45-year-olds)	Sample size: 300	0	Telephone survey
	Caretakers of young children			

Burn Injury Data

The burn epidemiology component of Project Burn Prevention is designed to measure changes in burn incidence and severity rates for hospital-treated nonoccupational burns which might be attributed in part to the educational intervention. The medical records (both in-patient and emergency room) of 20 hospitals used by the study populations were reviewed, as were burn-related death certificates. Demographic, etiologic, and medical information was collected for all burn patients. Population-based four-year baseline incidence rates were established for the residents of the project's six target and control cities.

These rates will serve as the expected rates in the data analysis. Comparable observed rates will be computed for the eight-month program implementation period, and for the twelve-month follow-up period. Data will be analyzed by type of burn, age group at risk, and burn severity.

A burn severity rating system was devised to assess changes in burn severity which might result from a population better informed about burns and emergency procedures. Measures of severity (extent, depth and location of injury, age and disposition of patient, number of days hospitalized) were incorporated into a mathematical function which weighs these variables and computes a severity score for each burn patient. This score, which approximates clinical judgment, provides an internally consistent scale for evaluating changes in burn severity.

SUMMARY

We suspect that one reason people find it so hard to think about fire and burns as hazards that affect them personally is that they believe they would be powerless in the event of a burn accident, and hence unable to prevent tragedy. They believe, in effect, that accidental burns are a matter of bad luck. Could this also be true with respect to earthquakes?

Most serious burn injuries, however, can be prevented if people know what to do. Proper response to the emergency--for example, knowing what to do in a house fire or how to immediately treat a burn--can significantly minimize the consequences. Preparedness is also a key factor in mitigating the effects of other hazards. *Perhaps the most important thing is to convince people that what happens is not up to chance, that they will have control over their lives if they know what to do in an emergency and if they take a few simple precautions to prevent burns from happening.* Through the use of many different educational strategies it is the goal of Project Burn Prevention to bring this critical lifesaving information to people.