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EARTHQUAKE HAZARDS PROGRAM

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DEADLINES FOR FUTURE ISSUES

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EARTHQUAKE BILLS IN THE 1990 UTAH LEGISLATURE

By Gary E. Christenson
Utah Geological and Mineral Survey

Six bills and one resolution concerning earthquake hazards and earthquake safety were introduced into the 1990 Utah Legislature. Some were the result of detailed planning and interim study prior to the legislative session, while others were written shortly before or early in the session and were probably at least in part inspired by the October 17, 1989, Loma Prieta earthquake near San Francisco. Unfortunately, none of the earthquake-related bills were successful, and the State has missed an opportunity to take positive action and demonstrate a commitment to earthquake safety and preparedness. A listing and brief summary of the bills and resolution considered by the legislature follow (SB=Senate bill, HJR=House Joint Resolution, HB=House bill):

SB 83 Seismic Instrumentation Board
(HB 342) (Sponsors: Craig Peterson, Senate; Donald LeBaron, House)
Establish a Seismic Instrumentation Board to administer funds to modernize seismic-network instrumentation, establish a strong-motion instrument program, acquire additional portable seismographs, improve communication systems for information transfer, and monitor earthquake deformation from global-positioning satellite measurements.

HJR 20 Earthquake Hazards in Public Schools Study
(Sponsors: Afton Bradshaw, Kim Burningham)
Resolve that the legislature strongly urge an interim study of the safety level of all state school buildings in the event of an earthquake.

HB 347 Fire Fighters Training
(Sponsor: John Valentine)
[Bill dealt chiefly with fire hazards, but included a section requiring instruction and training of fire fighters in heavy rescue and earthquake rescue]

HB 371 State Earthquake Building Code
(Sponsors: Gene Davis, Ray Nielsen)
Require that the seismic zone map of Utah in the 1988 Uniform Building Code (adopted statewide in 1988) be amended based on the best available technical information provided by the UGMS.

HB 385 Earthquake Insurance
(Sponsors: Gene Davis, Ray Nielsen, Mike Dmitrich)
Require the State Commissioner of Insurance to prepare and make available publications describing available insurance coverage for earthquake damage and losses.

HB 392 Natural Hazards Notice and Instruction
(Sponsor: Ray Nielsen)
Require geologic hazards site investigations for public-owned essential facilities and special-occupancy structures, geologic hazards ordinances in cities and counties for which geologic hazards maps are available (chiefly Wasatch Front), and earthquake education in elementary and secondary school.

HB 408 Mitigation of Earthquake Hazards in the Public Schools
(Sponsor: Kim Burningham)
Require assessments of seismic safety of Wasatch Front schools, including an estimate of retrofit costs, and establish a fund in the State Office of Education to match funds provided by districts to retrofit buildings.

Much was learned by sponsors and supporters during the 1990 session with regard to the steps needed to get legislation passed, and these steps are being taken in the interim. Sponsors and legislators need vocal support from constituents, local governments, and professional organizations to get legislation passed. Forum readers represent a diverse group which includes professionals involved in all aspects of earthquakes. You are encouraged to take an active role in supporting earthquake-related legislation introduced in the 1991 Legislature.

STATE AND LOCAL AFFAIRS COMMITTEE OF THE UTAH LEGISLATURE STUDIES UTAH'S NEEDS FOR EARTHQUAKE LEGISLATION

by Gary E. Christenson
Utah Geological and Mineral Survey

The State and Local Affairs Committee of the Utah Legislature has taken over interim study of the earthquake bills introduced and defeated in the 1990 legislative session and is taking a comprehensive look at all earthquake-related issues to develop legislation for the 1991 session. The committee devoted its May and June meetings to earthquake issues, and heard from a variety of speakers covering the broad range of earthquake issues from earthquake response and recovery to instrumentation. Following these meetings, the committee and Legislative General Counsel will prioritize issues and develop actual legislation. It is hoped that a package with broad-based support which addresses the state's critical needs will be ready for introduction into the 1991 Legislature.

UTAH ADVISORY COUNCIL FOR INTERGOVERNMENTAL RELATIONS ASKED BY GOVERNOR BANGERTER TO PROVIDE LEADERSHIP FOR GEOLOGIC HAZARDS ISSUES

Gary E. Christenson
Utah Geological and Mineral Survey

In a letter to Representative Ray Nielsen, Chairman of the Utah Advisory Council for Intergovernmental Relations (ACIR), Utah Governor Norman H. Bangerter requested that ACIR continue its role in providing leadership for geologic hazards issues. The ACIR began playing an important role in these issues in May, 1989 when the UGMS, Utah CEM, and the University of Utah Seismograph Stations were invited to make a presentation regarding earthquake hazard reduction (see v. 5, no. 4, Wasatch Front Forum). Presentations and updates continued in subsequent meetings, culminating in ACIR support of HB 392, the Natural Hazards Notice and Instruction bill. Members of ACIR were instrumental in sponsorship and support of this and other earthquake-related bills in the 1990 Utah Legislature and participated actively in the Sixth Annual Wasatch Front Earthquake Conference June 11-12, 1990 (see summary, p. 4, this issue). In recognition of this activity, Governor Bangerter wrote the following letter to the ACIR:

"I would like to take this opportunity to express my appreciation for the leadership the council has shown regarding geologic hazards issues. At this point I believe it would be appropriate for the council to continue in this important effort and work intensively through the summer to prioritize geologic hazards issues for both state legislation, and state and local policy attention.

It is also important that ACIR reach out to all interested parties and conduct appropriate discussions so that all critical issues in this area are analyzed and prepared for a final prioritizing process to take place at the council's annual Summit Conference on August 16, 1990. This area of important public safety policy not only provides a focus for the conference, but should greatly aid the State and Local Affairs Interim Committee in considering a balanced package of legislation with a high degree of consensus."

In response to the Governor's request, ACIR has formed an Earthquake Task Force consisting of members representing various local governments, state agencies, and professions. This task force will be working with the State and Local Affairs Interim Legislative Study Committee (see p. 3, this issue), which is working to draft legislation for the 1991 legislative session. The task force will also be developing a long-term, comprehensive plan for the state to deal with all aspects of the earthquake hazard in Utah beyond the 1991 session.

SUMMARY OF THE SIXTH ANNUAL WASATCH FRONT EARTHQUAKE CONFERENCE - JUNE 11-12, 1990

The Sixth Annual Wasatch Front Earthquake Conference was held in Salt Lake City on June 11-12, 1990. One of the purposes of the conference was to solicit perspectives and recommendations for 1991 legislation from invited speakers representing the state, both the legislative and executive branches. In addition, comments from attendees were solicited in working groups to gain a perspective from local governments, state agencies, and professionals. The following is a summary of comments presented at the conference relating to Utah's needs for earthquake hazard reduction.

<u>Governor's Perspective</u> (from Michael Christensen)

- Governor's office supports addressing Utah's earthquake problems.
- Actions are a shared responsibility and must involve cooperative programs between state and local governments, school districts, and the private sector.
- All costs must be weighed against benefits and other competing needs.
- Legislation should address broad needs of the state in a balanced way, yet be practical and realistic.

<u>Legislative Perspective</u> (Panelists: Senator Craig Peterson; Representatives Afton Bradshaw, Kim Burningham, Gene Davis, Don LeBaron, Ray Nielsen, and John Valentine)

- Strong state leadership of the earthquake program is needed.
- Commissions tend to be expensive and difficult to fund, and a new commission to provide such leadership is unlikely (may need to rely on ad hoc coordination).
- The legislative package should consist of several individual bills, not a single bill.
- Need a comprehensive, unified approach addressing needs for both short-term emergency response and longer-term mitigation (many of these concerns were addressed in the 1990 bills).
- The cost to make Utah prepared for and protected from earthquakes will be unavoidably high (multi-millions of dollars), but a necessary and good investment; a step-wise, multi-year approach has to be taken.
- Legislators react more to their constituents than to state agencies, and an educated constituency with lobbying and letter writing would help passage of legislation (favorable public opinion is insufficient).
- People assume and expect that work is being done to make Utah earthquake safe; this public perception that the problem is under control is not true.
- The earthquake threat in Utah isn't just a Wasatch Front problem.

<u>Working Group Recommendations</u>

Working Group 1 - Earthquake instrumentation and seismic vulnerability of buildings and other structures

- Building codes and new buildings
  - a) Utah's building codes are good, but not perfect.
  - b) Building code enforcement is weak; particularly need to ensure reliable plan checks and uniformity between public and private buildings.
  - c) Seismic zones--a mechanism already exists to evaluate and revise seismic zones, and no further legislation is needed at this time.
- Existing buildings
  - a) An inventory of buildings is needed.
  - b) Disclosure of unsafe buildings should be pursued.
  - c) Retrofit ordinances/incentives should be pursued.
- Instrumentation--Moderninstrumentation is needed badly in order to meet the state's needs, and the engineering community strongly supports the strong-motion program.

Working Group 2 - Earthquake response, recovery, education, and risk management. The principal problems that need to be addressed in legislation are:

- Resource availability

- Public awareness
- State agency preparedness
- Lack of uniform training for responders
- Getting a higher priority for earthquake preparedness
- Cross-state licensing problems for professionals
- Private industry participation
- Training of school personnel in disaster preparedness and response
- Defining response roles clearly
- State funding (not federal) for the state program

Working Group 3 - Earthquake hazards and land development (note: no realtors or elected local government officials were present to provide input)

- New development--State requirement for hazards ordinances
  - a) Difficult without first strengthening general requirements for land-use planning.
  - b) State should set general requirements, with input from local government, for ordinances.
  - c) Costs for reviews could be passed to developers through fees, but costs for preparation of ordinances may be a problem, particularly for small cities and rural counties.
  - d) Supplying expertise to local governments to enforce ordinances is a potential problem.
  - e) Associations of Governments should be involved.
- Existing development

  A state requirement of disclosure of hazards in real estate transactions was favored.
- Critical facility siting

  A state requirement for hazards investigations was favored, although no mechanism exists to ensure compliance.

Plenary Session - Where do we go from here? John Fellows (Legislative General Counsel) outlined the process as follows:

1) Need to generate list of policy issues
2) Interim study committee will prioritize list
3) Write legislation

The economic benefits (cost/benefit analysis), liability, and political ramifications of each issue should be outlined for presentation to ACIR, Interim Study Committee, etc. A working group should be picked to refine short and long-term goals and programs. A definitive plan is not necessary, but a beginning plan is needed for the consensus-building process.

Following the conference, the organizing agencies (UGMS, CEM, UUSS) compiled an overview of the current needs for earthquake hazard reduction in Utah, and presented it to the League of Cities and Towns, the State and Local Affairs Legislative Interim Committee, and the Utah Advisory Council for Intergovernmental Relations. The list will be used to direct writing of legislation for the 1991 session, and is given below.

OVERVIEW OF NEEDS FOR EARTHQUAKE HAZARD REDUCTION IN UTAH

- Develop a long-term state plan for hazard mitigation and emergency preparedness--including identification of effective leadership and involvement of local government, affected state agencies, and professional groups.

Earthquake Hazards Assessment for Planning

- Ensure proper planning for new construction, particularly essential facilities, in areas of earthquake and other geologic hazards (HB 392)*.

- Prepare and disseminate information about available insurance coverage for earthquake damage and losses (HB 385)*.

- Require disclosure of geological hazards in real estate transactions

Earthquake Engineering/Design and Seismology

- Assess seismic vulnerability of buildings and other structures and develop a plan to address unsafe structures, both public and private (HJR 20, HB 408; state agency building block)*.

- Assess implementation and enforcement of Utah's building codes for earthquake safety (HB 371)*.

- Obtain appropriate modern instrumentation to meet state needs for earthquake engineering, hazard assessment, and emergency response (SB 83, HB 342)*.

Emergency Planning for Response and Recovery

- Plan for effective earthquake response and recovery, including agency preparedness, training, and assessment of available resources (HB 347; state agency building block)*.

- Promote education and public information aimed at earthquake safety and greater awareness of natural hazards (HB 392; state agency building block)*.

- Establish rules of succession to ensure continuity of government (state and local) following an earthquake.

*Relevant bills--and state agency "building block" requests--proposed during last year's 1990 legislative session, shown for reference (see p. 2, this issue). Items are not ranked.

SALT LAKE CITY SCHOOLS MOVE TOWARD REDUCING EARTHQUAKE RISKS

By Susan S. Olig
Utah Geological and Mineral Survey

The Salt Lake City Board of Education has come a long way in planning to make their schools safer during earthquakes, and their actions are serving as a model for other districts in the Salt Lake Valley. The results of a seismic vulnerability assessment of the District's buildings prompted the Board to form the Seismic Study Committee in August of 1989. The Committee was charged with advising the Board on earthquake hazard reduction strategies, and was comprised of 19 members, including planners, engineers, lawyers, geologists, PTA representatives, and other concerned private citizens.

The Committee's main focus was on responding to the findings of a seismic assessment conducted by Reaveley Engineers and Associates Inc. This study used a methodology developed by the Applied Technology Council to evaluate the strength and structural ability of the District's facilities to withstand earthquake ground shaking. Of the 42 facilities evaluated, 33 posed an "appreciable or high life hazard" due to seismic vulnerability. The facilities with the poorer ratings generally were the older buildings built prior to more stringent building codes.

After three months of deliberation, the Committee submitted its recommendations to the Board in December of 1989. The report estimates as many as 4000 students could die in an earthquake of Richter magnitude 7.4 or greater, primarily as a result of the collapse or failure of buildings with inadequate earthquake-resistance. As many as 2900 deaths were estimated to result from a magnitude 6.2 earthquake. Although earthquakes of this size are relatively infrequent in the vicinity of Salt Lake City, they have occurred in the past and could occur at any time in the future. Because of the high risk involved and the present uncertainty in forecasting earthquakes, the committee agreed that "Prudent public planning entails the assumption that earthquakes are imminent, and that critical facilities such as school buildings be designed and modified accordingly". An excerpt of the general recommendations from the executive summary of the Committee's report follows:

A. <u>Requires Immediate Action</u>
Immediate action is warranted by the Board of Education to correct problems with structures in the Salt Lake City School District to minimize loss of life and property.

B. <u>Eliminate the Danger of 3-Story High Life-Hazard Structures</u>
These structures should be the first priority to be corrected through modifications or elimination. They should be corrected by

January 1, 1995. These structures are located on Highland, East, and West High School campuses.

C. Eliminate Other High Life-Hazard Structures
Priorities should be based on projected deaths and injuries. In addition, 3-story appreciable life-hazard structures should be eliminated or modified. These buildings should be eliminated or modified by January 1, 2000.

D. Eliminate 2-Story Appreciable Life-Hazard Structures
Priorities should be based on projected deaths and injuries. These structures should be eliminated or modified by January 1, 2005.

E. Eliminate Remaining Structural Life Safety Hazards
Priorities should be based on projected deaths and injuries. These buildings should be eliminated or modified by January 1, 2010.

F. Eliminate Non-Structural Life Safety Hazards
These modifications would correct life threatening hazards common to all buildings by September 1, 1993, unless those buildings are scheduled for major modification or elimination.

G. Increase Standards and Codes
Construction standards should be increased to insure that all new construction or modified buildings are functional after a large earthquake.

H. Conduct Inspections by Qualified Professionals
All major building modifications, plans, and construction should be reviewed and inspected by appropriate qualified professionals.

I. Perform Geotechnical Studies
These studies should be performed at all sites where the district is considering major modifications or construction.

J. Formalize and Implement Emergency Preparedness Planning
The plan for each school should be enhanced and monitored with annual reviews and exercises.

K. Support Procurement of Earthquake Data
The district should support the state's efforts to obtain earthquake measurement data.

L. Seek State and Federal Funding
The district should seek state and federal funding for seismic construction since many of the buildings are designated as disaster centers in event of emergency.

M. Develop a Financing Program
Capital expenditures required to implement the actions recommended by this report should be paid for by a combination of current budget and general obligation bond financing.

So far the Board has begun action on the recommendations by:

- authorizing geotechnical investigations to evaluate the liquefaction potential at three high schools, five intermediate schools, and one elementary school. Trenches will also be excavated at East and West High Schools to investigate for evidence of faults at these sites;
- authorizing a study to assess the remaining service life of each of the three high schools;
- asking each school to review and update its emergency preparedness plan;
- requesting the administration to include funds for non-structural retrofit of some schools in next year's budget; and,
- requesting the administration investigate possible alternative sites for high schools.

Other school districts are taking actions similar to Salt Lake City's. In January of 1990, the Jordan Board of Education commissioned a seismic vulnerability assessment of their facilities. Additionally, evaluation of selected buildings in the Granite and Davis School Districts have been conducted.

CATHOLIC DIOCESE OF SALT LAKE CITY COMMISSIONS SEISMIC STUDIES

By William R. Lund
Utah Geological and Mineral Survey

E.W. Allen and Associates of Salt Lake City has recently completed a seismic evaluation and feasibility study of the Cathedral of the Madeleine for the Catholic Diocese of Salt Lake City. The

Cathedral, which was built in the early 1900s, is presently in the first phase of a projected $5.3 millon renovation. The renovation was originally intended to upgrade the Cathedral's electrical and mechanical systems and to preserve and protect the highly ornate interior of the church. Recognizing the potential vulnerability of the nearly century old, multi-story, unreinforced brick and stone structure to earthquake damage, the decision was made to investigate the possibility of performing a seismic retrofit of the building in conjunction with the renovation. Both a conventional seismic retrofit (structural steel bracing, shotcreting, additional anchorage between walls and the roof) and base isolation are considered in the report. Bishop William K. Wiegan, chairman of the Cathedral Restoration Committee, announced in early August that the committee had reached its $6.3 million restoration fund goal (including a 1$ million endowment fund). They will continue their efforts to raise an additional $1.8 million for seismic reinforcement of the cathedral.

A seismic evaluation is also being made of all Diocesan schools. The Salt Lake City Diocese operates two high schools and nine grade through middle schools in Utah extending from Price to Ogden, although the majority are in the Salt Lake Valley. The study is being performed by Reaveley Engineers and Associates, employing the same rapid structural evaluation techniques developed by that firm for their evaluation of the schools in the Salt Lake City School District. It is anticipated that the Reaveley study will be completed soon.

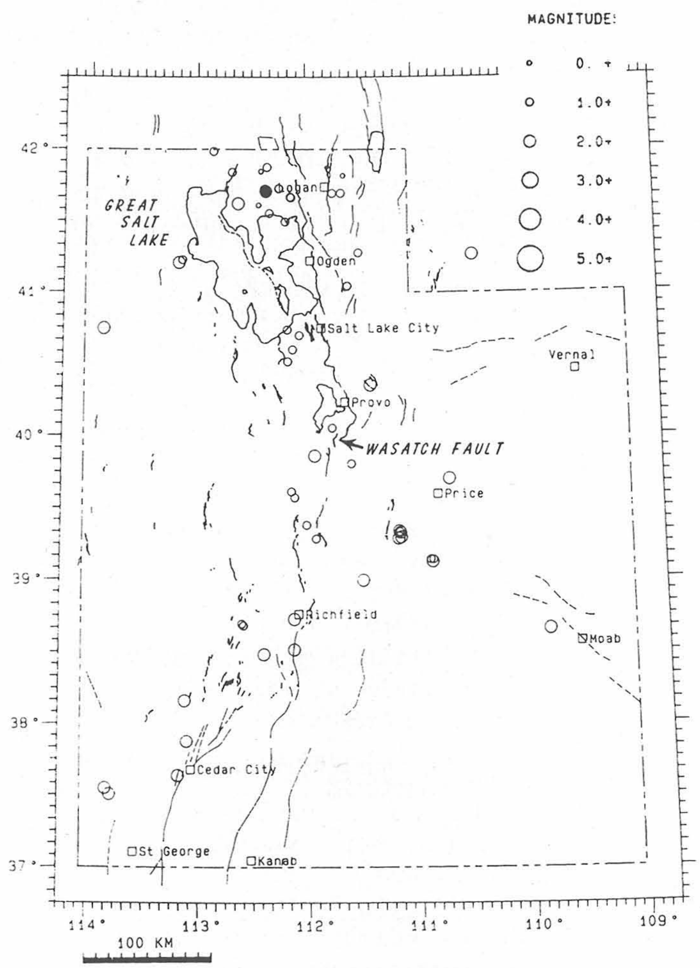
EARTHQUAKE ACTIVITY IN UTAH

by Susan J. Nava
University of Utah Seismograph Stations

October 1 - December 31, 1989

During the three-month period October 1 through December 31, 1989, the University of Utah Seismograph Stations located 76 earthquakes within the Utah region (see following epicenter map). Of these earthquakes, 22 had a magnitude (either local magnitudes, M_L, or coda magnitude, M_C) of 2.0 or greater, and tow were reported felt. There were no earthquakes which had a magnitude of 3.0 or greater during this report period.

Twenty-four aftershocks associated with the July 3, 1989, Blue Springs Hills earthquake (M_L 4.8) were located during the period from October 1-December 31, 1989. Two earthquakes were reported felt in the Utah region during the report period: an M_C 2.2 event on November 13 at 12:39 AM MST, which was felt by several employees at the Thiokol Corporation plant, about 20 km west of Tremonton, and an M_C 2.0 event on November 30 at 05:33 AM MST, felt in the vicinity of Montpelier, Idaho.



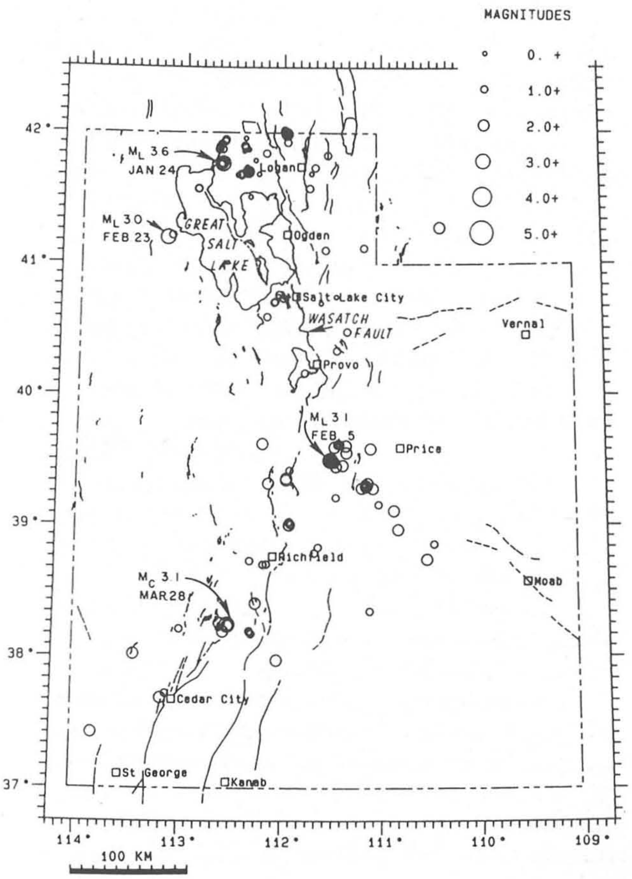
During the three-month period January 1 through March 1990, the University of Utah Seismograph Stations located 170 earthquakes within the Utah region (see following epicenter map). Of these earthquakes, 49 had a magnitude (either local Magnitude, M_L, or coda magnitude, M_C) of 2.0 or greater, and one was reported felt. There were four earthquakes of magnitude 3.0 or greater during this report period. (There epicenters are specifically labeled on the epicenter map.)

The largest earthquake during the report period was a shock of M_L 3.6 on January 24 at 2:03 AM MST, located 26 km south-southeast of Snowville. This earthquake occurred in the same general area as the 1934 magnitude 6.6 Hansel Valley earthquake, one of the largest earthquakes that has occurred in Utah since settlement. During the report period, ten additional shocks occurred in the same general vicinity.

A cluster of 30 earthquakes occurred in the Sanpete Valley of central Utah from January 1-March 31. The largest event of the sequence was an M_L 3.1 earthquake that occurred on February 5 at 3:23 AM MST. This earthquake was reported felt in the towns of Moroni, Wales, and Mt. Pleasant. Two other earthquakes of magnitude 3.0 and greater occurred in the Utah region during the report period: an M_L 3.0 event on February 23 at 3:40 PM MST, located 20 km west of Lakeside; and an M_C 3.1 event on March 28 at 3:47 AM MST, located 14 km east-southeast of Beaver.

Seismic activity continued to occur in the Blue Springs Hills area of north-central Utah (see clustered epicenters 45 km west of Logan), the location of an M_L 4.8 earthquake on July 3, 1989. Eighteen earthquakes were located from January 1-March 31, in the area of the July 1989 Blue Springs Hills main shock. North-central Utah was also the site of an earthquake swarm located just south of the Utah-Idaho border, near the town on Cornish (see clustered epicenters 40 km northwest of Logan). During the report period, there were 32 located shocks associated with the Cornish swarm, ranging in magnitude from M_C 0.9 to M_L 2.3.

Additional information on earthquakes within the Utah region is available from the University of Utah Seismograph Stations (810) 581-6274.



EXPECTED PROPERTY LOSS DUE TO GROUND SHAKING: SALT LAKE COUNTY, UTAH

by Philip E. Emmi
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INTRODUCTION

The assessment of risk to property and life from seismic hazards are of interest to a variety of publics. The purpose of this note is to report recent research results on expected losses to private residential and commercial buildings due to seismically induced ground shaking within the contiguously urbanizable area of Salt Lake County, Utah. Losses due to the possible additional factors of fire, liquefaction, rock falls, mud slides, directivity effects, tectonic subsidence or dam failure and subsequent flooding are not considered. This note details preliminary results prior to the publication of an article more thoroughly documenting our research methods. at issue is the magnitudes of loss related to ground shaking that can be expected over short, intermediate and longer time horizons, as well as the spatial variation in loss among different parts of Salt Lake County. Mitigation policy implications are also addressed.

The probabilistic assessment of risk requires the simultaneous treatment of various time frames, exceedence probabilities and loss magnitudes. In this study, we define risk in terms of the magnitudes of loss which have a 10 percent chance of being exceeded (a ninety percent chance of not being exceeded) over short (10-year), intermediate (50-year) and longer (250-year) periods. Each loss estimate, in fact, represents a distinct point on a unique risk curve belonging to a family of curves. For example, the magnitude of loss for which there is a 10 percent chance of being exceeded over a 10-year period also has a 50 percent chance of being exceeded over a 70-year period as well as a 90 percent chance of being exceeded over a 235-year period. Similar statements can be made about the higher magnitudes of expected loss with 10 percent exceedence probabilities over 50-year and 250-year exposure periods. The 10 percent exceedence probability is a standard value in the presentation of risk assessments: it is held constant while the duration of the exposure period is allowed to vary. The short (10-year) exposure period is generally useful when thinking about personal and private responses to earthquake hazards. The intermediate (50-year) period is useful when thinking about community and public responses, while the longer (250-year) exposure period is useful when thinking about the design of high occupancy structures, critical facilities, hazardous facilities and lifelines. All three exposure periods are useful when thinking about issues of liability and earthquake hazard insurance.

Data and Methods

Findings are based on three research initiatives. A probabilistic assessment of the ground motion hazard in Salt Lake County for the three exposure periods is derived from Emmi (1989). An inventory of residential and commercial buildings comes from data files maintained by the Salt Lake County Office of Tax Assessment. The engineering relationships (called damage functions) that define the rates of failure for each structure type given an intensity of ground shaking, come from studies by the Applied Technology Council (Rojahn, 1985).

The assessment of the ground shaking hazard for Salt Lake County is based on studies of seismic faults in the region, a probabilistic assessment of the ground acceleration that seismic events on these faults could impart to valley bedrock, and the degree to which different soils throughout the valley modulate or amplify seismic energy moving up through the bedrock. Ground shaking intensities (measured on the Modified Mercalli Intensity Scale) with a 10 percent chance of being exceed over a 10-year period range from VI near the Bonneville benches to VIII+ on fine silts and clays of the Quaternary flood plain and delta complex at the valley center. At intensity VI, damage is mostly limited to the internal contents of buildings. At intensity VIII+, only specially designed buildings will escape some damage.

Ground shaking intensities with a 10 percent chance of being exceeded over a 50-year period rang from VIII above the benches to X at the valley center. At intensity X, damage is great to masonry structures, and some well-build wood structures will be destroyed.

Ground shaking intensities with a 10 percent chance of being exceeded over a 250-year period range from VIII+ above the benches to XI at the valley center. At intensity XI, damage is great to wooden structures, while few masonry structures remain standing.

The category of "residential" refers to buildings with one to four residential units. Residential buildings with more than four units are classified as "commercial" structures. Data on all residential dwellings in the County is maintained on tape in digital, machine-readable format. Data on the quarter-section location, age, and value (measured as the reconstruction cost new) for each residential dwelling in the study area is extracted from the master tape. Data on the larger-class and smaller-class exterior wall types as well as the number of wall sections is also noted. This data is used to classify each dwelling into one of four structural frame types for later use with damage functions relating ground shaking intensity to expected loss by frame type. The four frame types include wood frame, reinforced masonry, unreinforced masonry with a load-bearing frame and unreinforced masonry.

Data on the location, value and frame type of each dwelling is entered into a computer-based geographic information system where digital maps of the ground shaking hazard already reside. For each exposure period, data on the expected intensity of ground shaking is attached to each quarter-section location code. Then, for each of the four frame types, data on the replacement value and the ground shaking intensity of each dwelling is read and related algebraically through an appropriate damage function to generate data and maps on expected loss for each frame type within that exposure period. The results from the analyses for each frame type are added together to yield data and maps on the total magnitude and spatial variation in expected loss to residential dwellings from seismically related ground shaking.

Data on commercial structures is not maintained in machine-readable format. Instead, it is kept on paper records. Thus, only a sample of the commercial structure records is used. The sample size is in excess of 2,000 records. A stratified random sample design with 100 percent sampling of major commercial centers is used. Data is extracted from sampled records on the quarter-section location, frame type, age, replacement value and use of the structure. This data is used to classify each structure into one of eighteen frame types for later reduction to six frame types and use with damage functions relating ground shaking to loss. These six include wood, light metal, reinforced masonry, braced steel, ductile concrete and unreinforced masonry. Data on location, value and frame type is entered into a computer-based geographic information system and processed as above. This yields maps and data on the total magnitude and spatial variation in expected loss to commercial structures.

<u>Results - Residential Dwellings</u>

The replacement value of the residential buildings in the study area equals $6.17 billion. The percentage loss to the residential stock which has a 10 percent chance of being exceeded in a 10-year period is 7.8 percent of replacement value (i.e., $481 million or $3,014 per residential building). However, spatial variation in expected loss is considerable. Loss to favorably located wood frame and reinforced masonry units is expected to be minimal, while loss to unreinforced masonry units at the valley center has a 10 percent chance of exceeding 33 percent of replacement cost.

The percentage loss having a 10 percent chance of being exceeded in a 50-year period is 20.0 percent of the replacement value of the stock (i.e., $1.23 billion or $7,728 per residential building). Again, spatial variation in expected loss is considerable. Over a 50-year exposure period, loss to favorably located wood frame units has a 90 percent chance of remaining at or below 5 percent of replacement cost. Loss to unreinforced masonry units at the valley center has a 10 percent chance of exceeding 64 percent of replacement value.

The loss having a 10 percent chance of being exceeded in a 250-year period is 31.3 percent of the stock's replacement value (i.e., $1.93 billion or $12,095 per residential building). Loss to favorably located wood frame units has a 90 percent chance of remaining at or below 8 percent of replacement value. Loss to unreinforced masonry units at the valley center has a 10 percent of exceeding 79 percent.

Patterns of spatial variation in per-unit loss to residential dwellings are quite complex, and generalization is difficult. Spatial variation in per-unit loss is a function of spatial variation in the ground shaking hazard, in the replacement value of construction, and in the spatial distribution of different frame types. Per-unit losses are generally low in the southwest quadrant of the county west of Redwood Road and south of 2100 South including parts of West Valley City, Kearns, West Jordan and Riverton. Also, per-unit losses are generally low in parts of Sandy, Union and Butterville, however the pattern of loss in this area in intermixed with small zones of high per-unit loss.

Per-unit loss is generally high in the areas within Midvale, West Jordan, South Jordan and Sandy near the Jordan River between Interstate Route 15 and 1800 West Street. The largest zone of high per-unit loss to residential dwellings is defined by an swath two miles on either side of an arc starting at the State Capitol and running through the Avenues, the Harvard-Yale district, the Country Club, East Millcreek and ending in Holladay. (Evidently the higher replacement value of residential units in these neighborhoods and their more vulnerable construction overshadows the lower intensities of ground shaking to which these units are subject and results in losses per-unit that are higher than would be expected when one simply considers spatial variation in the ground shaking hazard. Computer-generated maps showing the spatial distribution of per-unit loss to residential commercial structures are available for examination in the Department of Geography.)

Results - Commercial Structures

The total replacement value of the commercial buildings in the study area equals $4.51 billion. The percentage loss to the commercial stock which has a 10 percent chance of being exceeded in a 10 year period is 6.5 percent (i.e., $295 million or $24,872 per commercial building). Spatial variation in expected loss is considerable. Percentage loss to favorably located wood frame, reinforced masonry, light metal and braced steel structures has a 90 percent chance of remaining at or below 1 percent, while loss to non-ductile concrete and unreinforced masonry structures at the valley center has a 10 percent chance of exceeding 17 and 33 percent respectively.

Loss to the commercial stock having a 10 percent chance of being exceeded in a 50 year period is 16.4 percent (i.e., $740 million or $62,336 per commercial building). Loss to favorably located wood frame, light metal and braced steel structures has a 90 percent chance of remaining at or below 2 to 5 percent, while loss to non-ductile concrete and unreinforced masonry structures at the valley center has a 10 percent chance of exceeding 32 and 64 percent respectively.

Loss to the commercial stock having a 10 percent chance of being exceeded in a 250 year period is 24.5 percent (i.e., $1.10 billion or $92,997 per commercial building). Loss to favorably located wood frame, light metal and braced steel structures has a 90 percent chance of remaining at or below 7 to 8 percent, while loss to non-ductile concrete and unreinforced masonry structures at the valley center has a 10 percent chance of exceeding 48 and 79 percent respectively.

Patterns of spatial variation in loss per commercial structure are even more complex than patterns of loss for residential dwellings. Losses per structure are generally low along the Meadow Brook Expressway west of the golf course and then south along the Denver and Rio Grande Railroad. Low losses may also be found in Salt Lake City and South Salt Lake along 9th South both above and below Sugarhouse but not in Sugarhouse itself.

Losses per commercial structure are generally high in a circular area roughly two miles in radius centered on the County Fair Grounds in Murray. The largest area of generally high losses per structure is in Salt Lake City and parts of South Salt Lake and West Valley City in an area bounded on th north by North Temple on the south by 3300 South, on the West by I-15, and on the east by Foothill Boulevard. With the exception of the zone along 9th South, nearly all of this area is subject to higher than average loss per commercial structure.

Mitigation Policy Implications

Preliminary implications of research results for hazard mitigation policies can be outlined at this time. These include implications for the existing stock and implications for future additions to the stock. Implications regarding the existing stock are drawn from results on the magnitude of expected losses as well as from findings about their spatial variation.

Findings on the magnitudes of loss to residential and commercial buildings are helpful when defining whether and in what manner the risk of loss from ground shaking constitutes a public concern. Clearly, the magnitudes of loss to residential dwellings over intermediate and longer exposure periods are high enough to constitute a public concern, but what of the loss expected over the shorter exposure period? The loss to residential dwellings having a 10 percent chance of being exceeded over a 10-year period, when spread out over the large number of residential units, is low enough ($3,014 per unit) to be an essentially private concern. However, the variation in loss among units by location and frame type is large enough to call into question this general conclusion. A more carefully drawn interpretation would hold that the losses to well-built dwellings in favorable locations are low enough to be considered essentially private concerns but the losses to less well-built units in susceptible locations are of such magnitudes as to merit a public response even for the shorter 10-year exposure period. In brief, for selected dwelling types in selected locations, the risk from ground shaking constitutes a public concern even in the short run. Comparable implications hold for commercial structures as well.

The magnitudes of expected loss suggest that a program of risk identification is in order. Such a program would serve the dual, short-run purposes of helping to identify potentially hazardous buildings and helping to clarify the responsibility for risk and remedial action.

The magnitudes of expected loss are sufficiently high as to limit the extent to which self-insurance represents a viable response to the ground shaking hazard. Yet the need for insurance is sufficiently general as to warrant a program of public education about risk insurance options. Concerns about the complex issues of tort liability are also sufficiently general as to warrant a program of public education. These could complement ongoing programs of earthquake safety conducted by the Utah State Division of Comprehensive Emergency Management.

The large magnitudes of expected loss also imply the possibility of substantially reduced loss through policies promoting the structural retrofitting of seismically vulnerable buildings. Such policies are already in effect in Salt Lake City. Similar regulations responding to variation in both risk and the seismic performance of existing structures are needed in other local jurisdictions.

The risk, the burden of response and the possibilities for implementation are shared between the public and private sectors. Public-private cooperation is essential for clarifying the extent of risk, for sharing in the cost of mitigation response and for developing the tools for mitigation policy implementation. Public policies governing taxes, infrastructure location, land use planning and building regulation can be utilized in ways that incrementally reduce exposure to seismic risks. Private-sector insurance and lending policies can also respond to the magnitude and spatial variation in seismically related risks. The evolution of tort liability can define with increasing clarity the distribution of responsibilities in the event of a damaging earthquake. Advances on each of these fronts are needed to develop an effective response to the hazards detailed above.

County population is projected to increase by 42 percent between 1985 and 2005. The number of dwelling units is projected to increase by 56 percent over the same period. The opportunity exists to significantly reduce exposure of the local population to risk through seismic hazard mitigation policies applied to new construction. Salt Lake County's recent Natural Hazard Ordinance is a step in the right direction. It embodies three principles which need to be used in the design or similar ordinances for all municipal jurisdictions in the county. It defines hazard areas by their relative degree of intensity. It exacts a deferring degree of scrutiny depending upon the risk to property and life implicit within the category of proposed land use. It exacts mitigation measures commensurate with the severity of the hazard and the proposed class of land use. Adopting in each municipality natural hazard ordinances promoting these three principles, perfecting the policy instruments through which these principles are implemented and establishing consistent and reasonable guidelines for their implementation constitutes an important part of the challenge to local public policy making in the decade to come. Coordinating such land use policies with tax policies, infrastructure location decisions, building regulations and private-sector insurance and lending policies constitutes the remainder of the hazard mitigation challenge.

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Rojahn, R.L., 1985, Earthquake Damage Evaluation Data for California, ATC-13: Applied Technology Council, Redwood City, Calif., 492.

PROPOSED HIGH SCHOOL NATURAL HAZARDS CURRICULUM TO INCLUDE EARTHQUAKE HAZARDS

by Gary E.Christenson
Utah Geological and Mineral Survey

On September 21, 1989, representatives from Utah CEM, UGMS, the Utah Museum of Natural History (UMNH), and others met with the Utah School District Earth Science Coordinators to propose Natural Hazards lectures for high school science core curricula. The lectures would be designed to inform students of natural hazards (for example, earthquakes, landslides, wildfires, and floods) and where they occur so that students can be better informed when choosing where to live and work. As presently envisioned, they would consist of several elements, each addressing a particular hazard, with one element devoted to earthquake hazards. The earthquake hazards element would be prepared by UGMS, Utah CEM, and UMNH, with Utah CEM coordinating preparation of all elements. A Steering and Review Committee of educators to advise those preparing lectures and to review lecture sets has been established, and includes a College Professor of Earth Science, a High School Earth Science Instructor, and a High School Administrator with an Earth Science background.

At the September 21 meeting, the District Earth Science Coordinators indicated that they were interested in the curriculum proposal, and gave approval to develop the lecture set. The lecture set has now been developed, and will be used during the 1990-1991 school year by several teachers in a pilot project. Teacher in-service training was held August 1-3, 1990. Comments will be taken from teachers participating in the pilot project, and the curriculum revised accordingly. The complete package will then be finalized and available to all districts for the 1991-1992 school year.

NEWS FROM UTAH COMPREHENSIVE EMERGENCY MANAGEMENT

By James L. Tingey

VIDEO PUBLIC SERVICE ANNOUNCEMENTS ON EARTHQUAKE PREPAREDNESS

The Utah Division of Comprehensive Emergency Management (CEM) through a grant from the Federal Emergency Management Agency (FEMA) has contracted the production of four television public service announcements on earthquake preparedness. Scene Scene, an Orem video production company created the 30 second announcements which began showing in October of 1989.

Public response to the short messages has been excellent and CEM continues to send out preparedness pamphlets to interested parties. FEMA has sent the videos to several other states because they are fairly generic and would not be difficult to adapt to another location.

A radio spot was also produced on the same grant by Scene Scene and is being played routinely.

CEM LOMA PRIETA EARTHQUAKE VIDEO

CEM has produced a 12 minute video on the recent Loma Prieta earthquake. The video was shown to Utah Governor Norman Bangerter after a team from CEM made a reconnaissance trip to the bay area in October. The team consisted of CEM staff members Jim Tingey, Tony Popish, and Fred May, and the Utah Department of Transportation Bridge Engineer David Christensen. The video shows problems encountered and draws some parallels to Utah. The tape entitled "Lessons Learned" is available from CEM's training and education section.

FEMA STUDIES BUILDING OWNERS ATTITUDES

FEMA investigators Mel Green and David

Hattis have recently collected information through personal interviews in Utah, Puget Sound, and the Central United States about building owners attitudes toward earthquake mitigation.

The study is intended to give the federal government an idea of present regulations and procedures concerning new and existing buildings in seismically active areas.

In Utah the two private consultant/investigators interviewed government officials with the state, counties, and cities. Private building owners were also interviewed about any earthquake mitigation of "in house" rules on building construction.

Results of the study will be published by FEMA this fall. In addition, Hattis and Green plan on a CEM workshop in Utah on September 26, 1990, at the Olympus Hotel (formerly the Tri-Arc Hotel) in Salt Lake City, Utah. The purpose of the workshop will be to educate building owners about possible incentives in implementing earthquake resistant design and retrofitting programs. Invitations to the workshop are currently being sent out. For more information contact Jim Tingey at CEM.

REPORT ON THE WESTERN STATES SEISMIC POLICY COUNCIL CONFERENCE

The Idaho Bureau of Disaster Services and the Idaho Geological Survey co-hosted the annual conference of the Western States Seismic Policy Council (WSSPC) in Boise during November 6-9, 1989. Nearly 100 earth scientists and emergency response planners attended the meeting to exchange information on earthquake hazards in the western United States. Utah was represented by Tony Popish (Comprehensive Emergency Management) and Susan Olig (Utah Geological and Mineral Survey). Many of the talks and discussions focused on the recent Loma Prieta earthquake in California, but talks also covered efforts to characterize and mitigate earthquake hazards in Idaho, Washington, Oregon, and Hawaii.

A list of speakers and topics follows. A proceedings volume is now available, prepared by Clark D. Meek, WSSPC Executive Assistant, entitled "Proceedings of the XII Annual Meeting of the Western States Seismic Policy Council, November 6-9, 1989, Boise, Idaho," 300 p. For more specific information contact the former WSSPC chairman, Roy M. Breckenridge (Idaho Geological Survey, 208-885-7991). The WSSPC conference is sponsored by the Federal Emergency Management Agency and hosted by a different state each year. Next year's conference will be hosted by Alaska and chaired by Gary M. "Mike" Webb (Alaska Division of Emergency Services, 907-376-3061).

Update - National Earthquake Hazard Reduction Program, Robert Wesson (Chief of the Office of Earthquakes, Volcanoes, & Engineering, U. S. Geological Survey)

Case History - Uniform Building Code Zoning, Spencer Wood (Boise State University) and Robert Smith (Idaho Department of Transportation)

Similarities between UBC and NEHRP - Seismic Design Provisions, Edwin Zacher (HJ Bruner Associates)

Risk Evaluation of Existing Buildings - Applied Technology Council Methodology, Christopher Rojahn (Executive Director of the Applied Technology Council)

Methodology of Loss Estimation Studies, Robert Reitherman (Reitherman Company)

Washington State Schools Project, Carol Martens (Washington Sate Division of Emergency Management)

Update - National Earthquake Hazard Reduction Program and the Federal Emergency Management Agency, Jay Scruggs (Federal Emergency Management Agency)

Anticipating Earthquakes: Risk Reduction Policy and Practices, Peter May (University of Washington)

Potential Subduction, Probable Intraplate, and Known Crustal Earthquake Source Areas in the Cascadia Subduction zone, Craig Weaver (U. S. Geological Survey)

Evaluating Earthquake Hazards in Oregon, Ian Madin (Oregon Department of Geology and Minerals Industries)

Earthquake Hazard Studies By Washington Division of Geology and Earth Resources, Tim Walsh and Steve Palmer (Washington Division of Geology and Earth Resources)

Loma Prieta, California Earthquake October 17, 1989, Robert Wesson (Chief of the Office of Earthquakes, Volcanoes, & Engineering, U. S. Geological Survey)

Uniform Building Code (UBC) Hazard Zone Map, Dennis McCreary (International Conference of Building Officials)

Idaho School Seismic Safety Standards Study, Roy Breckenridge (Idaho Geological Survey), Kenneth Sprenke, Richard Nielsen, and Dwaine Martin (University of Idaho), Eldon Nelson (Idaho Department of Education), and Jack Rayne (Idaho Department of Labor and Industrial Services)

Earthquake Idaho Exercise - Case History, James Jackson (Idaho Bureau of Disaster Services)

Observations By Bay Area earthquake Preparedness & Others in the Loma Prieta, California Earthquake, Paula Schulz (Bay Area Regional Earthquake Preparedness)

6.1 Magnitude South Hawaii Earthquake June 25, 1989 Seismicity & Volcanism, Robert Koyanagi (U. S. Geological Survey)

Rapid Visual Screening for Potential Seismic Hazards: Applied Technology Council-21, Boise Downtown Tour, Christopher Rojahn (Executive Director of the Applied Technology Council) and Brent Ballif (Ballif L. H. Associates)

Private Sector Involvement in the Community Recovery Process, David Harris (First Interstate Bank)

Business Disaster Contingency Planning, Robert Lanning (Hewlett Packard)

Unfunded National Earthquake Hazard Response Workshop, Mike Hopkinson (Federal Emergency Management Agency)

[The following article is the first excerpt in a series of seven, to be reprinted in subsequent issues of the Forum from the publication entitled, "Reducing Earthquake Hazards in Utah: The Crucial Connection Between Researchers and Practitioners". The full paper will be included in the USGS Professional Paper on the Wasatch Front but is now available as U.S. Geological Survey Open-File Report 90-217. The editors feel the information to be timely and relevant enough to reprint herein. Questions can be directed to Bill Kockelman at (415) 329-5158. Ed.]

REDUCING EARTHQUAKE HAZARDS IN UTAH: THE CRUCIAL CONNECTION BETWEEN RESEARCHERS AND PRACTITIONERS

By William J. Kockelman
U.S. Geological Survey

ABSTRACT

Translation and transfer of complex scientific and engineering studies to nontechnical users are necessary for their use in reducing earthquake hazards in Utah. Three elements are needed for effective translation: likelihood of occurrence, location, and severity of potential hazards. Examples of translated information for Utah include surface fault rupture, ground shaking, and various ground failures. Three elements are needed for effective transfer to nontechnical users: deliver, assistance, and encouragement. Examples of transfer techniques in Utah include serial publications, outreach programs, guidelines, and guidebooks. The importance of evaluating and revising earthquake-hazard reduction programs and their components can not be overemphasized. Examples of evaluations include natural-hazard reduction programs and various translation and transfer techniques.

This report was prepared for research

managers, funding grantors, and evaluators of the Utah earthquake-hazard reduction program who are concerned about effectiveness. It provides an overview of the Utah program for those researchers, engineers, planners, and decisionmakers--public and private--who are committed to reducing human casualties, property damage, and interruptions of socioeconomic systems.

INTRODUCTION AND PURPOSE

Effective comprehensive programs having earthquake-hazard reduction as a goal need five components, each a prerequisite for its successor:

1. Conducting scientific and engineering studies of the physical processes of earthquake phenomena -- source, location, size, likelihood of occurrence, severity, triggering mechanism, path, ground response, structure response, and equipment response.
2. Translating the results of such studies into reports and onto maps at an appropriate scale so that the nature and extent of the hazards and their effects are understood by nontechnical users.
3. Transferring this translated information to those who will or are required to use it, and assisting and encouraging them in its use through educational, advisory, and review services.
4. Selecting and using appropriate hazard reduction techniques -- legislation, regulation, design criteria, education, incentives, public plans, and corporate policies.
5. Evaluating the effectiveness of the hazard reduction techniques after they have been in use for a period of time and revising them, if necessary. Evaluation and revision of the entire program as well as the other components -- studies, translation, and transfer -- may also be undertaken.

These five components (fig. 1) encompass a broad range of activities which are often described or divided differently. Examples include: 48 resolutions by the United Nations Educational, Scientific, and Cultural Organization (1976), six general topics and 37 issues by the U.S. Office of Science and Technology Policy (1978), 48 detailed initiatives recommended by the California Seismic Safety Commission (1986), and 171 action items at a state governor's conference on geologic hazards (Utah Geological and Mineral Survey, 1983).

5. EVALUATION/REVISION
    - Studies
    - Translation
    - Transfer
    - Reduction
    - Program

4. REDUCTION TECHNIQUES
    - Mitigation
    - Preparedness
    - Response
    - Recovery
    - Reconstruction

3. TRANSFER TECHNIQUES
    - Educational services
    - Advisory services
    - Review services
    - Other

2. TRANSLATION ELEMENTS
    - Likelihood
    - Location
    - Severity
    - Format
    - Other

1. EARTHQUAKE STUDIES
    - Geologic
    - Geophysical
    - Seismologic
    - Engineering
    - Other

FIGURE 1. -- Five components needed for an effective comprehensive earthquake-hazard reduction program depicted as steps or building blocks, each a prerequisite for its successor.

The purpose of this report is to emphasize the crucial connection between scientific and engineering studies and their ultimate use for hazard reduction by Utahans. The connection consists of two of the five components shown in figure 1 -- translation and transfer. Emphasis on this crucial connection is provided by a discussion of the problem -- failure to translate and transfer -- and efforts toward making the connection in Utah. Translation and transfer are defined, described, and then illustrated, first by the use of general examples and then by the use of specific examples in Utah.

Scientific and Engineering Studies

A prerequisite for a successful Utah earthquake-hazard reduction program is the production by researchers of adequate and reliable scientific and engineering information about potential earthquake hazards -- surface fault rupture, ground shaking, liquefaction, landsliding, seiches, tsunamis, subsidence, and their effects. Actual hazards occur when land uses, or structures, or equipment are located, constructed, or operated in such a way that people may be harmed, their property damaged, or their socioeconomic systems interrupted.

Numerous geologic, geophysical, seismologic, and engineering studies are necessary to assess potential earthquake hazards in Utah. These studies are concerned with the physical process of earthquakes -- source, location, size, likelihood of occurrence, triggering mechanism, path, and severity of effects on a site, structure, or socioeconomic activity. These studies can be divided in several ways. To give the nontechnical reader an overview, some of the studies and the knowledge derived are shown in list 1.

A description of many of these studies can be obtained from perusing various scientific and technical reports and texts, such as: Richter (1958), Wallace, (1974), Borcherdt (1975), Applied Technology Council (1978), Hays (1980), Ziony (1985), Power and others (1986), Evernden and Thomson (1988), and Schwartz (1988). Most of these studies are complex and interconnected, have limitations because of lack of data, and require special technical skills.

Many of these studies were envisioned and are described in the "Regional Earthquake Hazards Assessments" draft work plan for the Wasatch Front. This plan was reproduced in a workshop proceedings edited by Hays and Gori (1984, p. 17-44). The results of those studies may be seen in a two-volume report edited by Gori and Hays (1987) or in the first volume (ck) of this professional paper. Such studies are vital, because in the words of a former U.S. Geological Survey director, Walter C. Mendenhall: "There can be no applied science unless there is science to apply." It has been my experience that it is not prudent for planners to develop land-use regulations, engineers to design structures, and lenders and public works directors to adopt policies reducing earthquake hazards without reliable scientific and engineering assessments. Hands (1985, p. 3) observes that "implementation plans may not mean much if they are not based on the best scientific knowledge and data available."

Hazard Reduction Techniques

Numerous earthquake-hazard reduction techniques are available in Utah to engineers, planners, and decisionmakers, both public and private. These techniques have the following specific objectives: awareness of, avoidance of, accommodation to, or response to, the effect of the earthquake phenomena on people and their land uses, structures, and socioeconomic systems. The general goal of these objectives is to reduce human casualties, property damages, and socioeconomic interruptions.

Many of the reduction techniques are also complex, interconnected, and require special skills -- legal, financial, legislative, design, economic, communicative, educational, political, and engineering. To give the reader an overview, examples of specific reduction techniques are shown in list 2. These techniques can be divided in other ways, for example:

- o Prevent mitigation techniques, which may take 1 to 20 years.
- o Preparedness measures, which may take 1 to 20 weeks.
- o Response during and immediately after an event.
- o Recovery operations after an event, which may take 1 to 20 weeks.
- o Post-event reconstruction activities, which may take 1 to 20 years.

These estimated time periods vary depending upon the postulated or actual size of the earthquake, its damage, the reduction techniques in place, and the resources available to the State of Utah, its communities, its corporations, and its families.

Many of the hazard reduction techniques identified in this report have been discussed and illustrated by Blair and Spangle (1979), Kockelman and Brabb (1979), Brown and Kockelman (1983), Kockelman (1985, 1986), Jochim and others (1988), Mader and Blair-Tyler (1988), Blair-Tyler and Gregory (1988), and the

United Nations Office of the Disaster Relief Coordinator (Lohman and others, 1988).

List 1

<u>Examples of scientific and engineering studies necessary to assess earthquake hazards 1/</u>

Types of Studies 2/	**Knowledge Derived**
Geologic Detailed geologic mapping Lithologic investigations Stratigraphy Borehole sampling Trenching Paleontology Scarp analysis Stream offsets Geomorphologic studies Structural geology	Fault slip rates, physical properties, fault length, fault age, fault geometry, bedrock strength, zones of deformation, amplification of ground motion, lateral and vertical offsets, earthquake recurrence intervals, earthquake sources, depth to ground water, fault location, bedrock types, deformation patterns, plate tectonics context, driving forces, and other knowledge concerning surface rupture, ground shaking, landsliding, liquefaction, seiches, tsunamis, and subsidence.

Geophysical/Geochemical
 	
Geodetic leveling and trilateration
Field monitoring:
    Stress and strain
    Tilt and creep
    Electrical changes
    Radon/helium emissions
    Water chemistry changes
    Water-well levels
Electromagnetic soundings
Gravity, electrical, and magnetic studies
Seismic refraction and reflection profiling
Radiometric dating
	Precursor detection, ongoing deformation, fault zone properties, recurrence intervals, shear wave velocity, stress accumulation, crustal anatomy, crustal properties, wave attenuation, crustal velocity mode, ground-motion characteristics, deformation patterns, buried faults or structure locations, and three-demensional crustal geometry.

Seismologic Historical seismicity Earthquake monitoring Strong ground-motion monitoring networks Ground response Seismic wave propagation Segmentation analyses Wave propagation Rupture process	Asperity locations, velocity, severity of shaking, acceleration, displacement, seismic gaps, source zones, fault mechanism, rupture direction, seismic direction, recurrence interval, epicenters, epicentral intensity, fault type, fault length, fault width, maximum probable magnitude, seismic hazard zones, rupture characteristics, seismic moment, stress drop, local amplification, duration of shaking, focal mechanism and depth, and response spectrum.

List 1 (continued)

Examples of scientific and engineering studies necessary to assess earthquake hazards 1/

Types of Studies 2/	Knowledge Derived
Engineering	
Structural mechanics Engineering characteristics Risk analysis Monitoring of structures Damage inventories Soil-structure interaction Structural vulnerability Soil mechanics Rock mechanics Soil/rock acoustic impedance Standard penetration tests	Seismic risk maps, structural performance, hysteretic behavior, strength of materials, stiffness degradation, structural strength, structural reliability, design criteria, material properties, response spectra, seismic intensities, nonlinear behavior, inelasticity, ductility, damping, energy absorption, bearing capacity, soil properties, amplification levels, shear wave velocity, shear modulus, failure limits, load limits, ultimate load limits, and foundation design.

1/ These studies are just some of the ones necessary to assess earthquake "hazards:" many other types of studies are necessary to evaluate "vulnerable" structures, "secondary" hazards (fires, floods, and toxin spills), people "exposed," and socioeconomic activities "at risk."

2/ The term "studies" is loosely used here to include experiments, measurments, investigations, observations, models, techniques, analyses, mapping, monitoring, or testing. Many of the seismologic studies are a special type of geophysical research.

Note: Robert Brown, geologist, Robert Simpson, geophysicist, Allan Lindh, seismologist, and Mehmet Celebi, structural engineer, U.S. Geological Survey, provided critical comments and valuable suggestions that have refined and improved this list. However, because of its abbreviated form, the author remaisn responsible for its omissions and any errors.

List 2

Examples of techniques for reducing earthquake hazards in Utah

Incorporating hazard information into plans and programs
- Community-facilities inventories and plans
- Economic-development evaluations and plans
- Land-subdivision layouts
- Land-use and transportation inventories and plans
- Public-safety plans
- Redevelopment plans pre-disaster and post-disaster
- Utility inventories and plans

Regulating development
- Placing moratoriums on building
- Reviewing annexation, project, and rezoning applications
- Enacting building and grading ordinances
- Adopting design and construction regulations
- Requiring engineering, geologic, and seismologic reports
- Requiring investigations in hazard zones
- Enacting subdivision ordinances
- Creating special hazard-reduction zones and regulations

Siting, designing, and constructing safe structures
- Reconstructing after a disaster
- Reconstructing or relocating community facilities
- Reconstructing or relocating utilities
- Securing building contents and nonstructural components
- Evaluating specific sites for hazards
- Siting and designing critical facilities
- Training design professionals

Discouraging new development in hazardous areas
- Disclosing potential hazards to real-estate buyers
- Adopting lending policies that reflect risk of loss
- Adopting utility and public-facility service-area policies
- Requiring nonsubsidized insurance related to level of hazard
- Posting public signs that warn of potential hazards
- Making a public record of potential hazard locations
- Clarifying the legal liability of builders and property owners

Strengthening, converting, or removing unsafe structures
- Condemning and demolishing unsafe structures
- Creating nonconforming land uses
- Repairing unsafe dams or lowering their water levels
- Retrofitting bridges and overpasses
- Strengthening or anchoring buildings
- Acquiring or exchanging hazardous properties
- Reducing land-use intensities or building occupancies

Preparing for and responding to emergencies and disasters
- Estimating damages and losses from an earthquake
- Preparing damage scenarios for critical facilities
- Providing for damage inspection, repair, and recovery
- Conducting emergency or disaster training exercises
- Operating monitoring, warning, and evacuation systems
- Initiating public and corporate education programs
- Preparing emergency response and recovery plans
- Creating community recovery information clearinghouses

Utah's Draft Work Plan

A collective partnership of Utahans and others in 1983 created a unique state earthquake-hazard reduction program. The formulators of the draft work plan for the Wasatch Front not only envisioned the use of scientific and engineering studies to reduce the hazard, but provided for an "implementation" component having three priorities: (1) determining the needs of users, (2) producing translated information that meets the need, and (3) fostering an environment for use of research results by local government. For the purpose of this report, users are defined as those who are interested in or who have responsibility for reducing earthquake hazards. Examples of specific techniques to reduce hazards (list 2) and potential users of earthquake-hazard information (list 3) were compiled. The reduction techniques most appropriate for Utah were to be selected by these users. These techniques and users were included in the draft work plan reproduced by Hays and Gori (1984, p. 37-44). The adopted work plan provides a bench mark for evaluating its accomplishments.

List 3

Examples of potential users of earthquake hazard information in Utah

City, county, and multicounty government users
- City building, engineering, zoning, and safety departments
- County building, engineering, zoning, and safety departments
- Mayors and city council members
- Multicounty planning, development, and preparedness agencies
- Municipal engineers, planners, and administrators
- City and county offices of emergency services
- Planning and zoning officials, commissions and departments

Police, fire, and sheriff's departments
Public works departments
County tax assessors
School districts

State government users
Department of Community and Economic Development (Community Services Office, Economic and Industrial Development)
Department of Business Regulation (Contracts and Real Estate divisions)
Department of Financial Institutions
Department of Health (Environmental, Health Care Financing)
Department of Insurance
Department of Natural Resources
Department of Public Safety
Department of Social Services
Department of Transportation
Division of Comprehensive Emergency Management
Division of Risk Management
Division of Water Resources
Division of Water Rights
Facilities Construction and Management
Geological and Mineral Survey
Legislative Fiscal Analyst
Legislative Research and General Counsel
Legislature and legislators
National Guard
Office of the Governor
Planning and Budget Office
Public Service Commission
Science Advisor
State Board of Regents
State Fire Marshall
State Tax Commission
State Office of Education
State Planning Coordinator

Private, corporate, and quasi-public uses
Civic, religious, and voluntary groups
Concerned citizens
Construction companies
Consulting planners, geologists, architects, and engineers
Extractive, manufacturing, and processing industries
Financial and insuring institutions
Landowners, developers, and real-estate salespersons
News Media
Professional and scientific societies (including geologic, engineering, architecture, and planning societies)
Utility companies
University departments (including geology, civil engineering, structural engineering, architecture, urban and regional planning, and environmental departments)

Implementation Underway

Descriptions and illustrations of the reduction techniques are beyond the scope of this report. However, many of them were selected, successfully used, or are pending in Utah. Descriptions of some of them may be seen in the previous volume (ck) or in the volumes edited by Gori and hays (1987, 1988). One of them -- a model natural-hazards reduction ordinance drafted by the Salt Lake County planning staff (Barnes, 1988a, b) -- has been adapted and adopted by the city of Washington Terrace.

In addition, geologists, engineers, and planners -- public and private -- are evaluating the location or design of developments in relation to earthquake hazards, for example: rezonings and annexations by Utah and Juab counties; geologist R.M. Robison (written commun., 1985, 1986); subdivision layouts, apartment project locations, fire station design, and aqueduct relocation by Salt Lake County geologist C.V. Nelson (1988, written commun., 1985, 1986); and long-range environmental plans, subdivision layouts, and critical facilities, including water tanks, fire stations, jails and waste disposal by Weber and DAvis counties' geologist Mike Lowe (written commun., 1989).

According to Utah Geological and Mineral Survey geologist W.F. Case (written commun., 1988), a residential development in Ogden was scrutinized because it was proposed to be located in a rockfall-hazard area shown on his map. The developer the hired an engineering firm to determine the extent of the hazard and to reduce it.

Previously adopted techniques to reduce losses from natural hazards can be revised to include the latest earthquake research information. Examples of regulations that can or have been revised include: the site development regulations of the Salt Lake City Council (1981), Emigration Canyon master plan adopted by the Salt Lake County Commission (1985), multihazard mitigation plan for Ogden City and Weber County prepared by the Utah Multi Hazards Mitigation Project Administrative Review Committee (1985), and the critical environmental zone created by the Mapleton City Council (1985).

Others include: seismic risk reduction recommendations for primary and secondary schools by Taylor and Ward (1979), hillside site development regulations by the Spanish Fork City Council (1980), regulations governing dam safety by Hansen and Morgan (1982), structural seismic resistance regulation by the Ogden City Council (1983), sensitive area overlay zone ordinance by the Ogden City Council (1985), hillside development standards and sensitive lands development ordinance by the Provo Municipal Council (1985), seismic-hazard area regulations by the Orem City Council (1986), structural directives of the Headquarters Structural Engineering Staff (1987), development overlay zone by the Washington Terrace City Council (1988), emergency training exercises by the Utah Division of Comprehensive Emergency Management (Tingey and May, 1988), and the emergency recovery plans proposed by the Financial Institution Emergency Preparedness Committee (James Tingey, written commun., 1988).

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MEETINGS AND CONFERENCES

September 11-16, 1990, Ninth European conference on earthquake engineering, held in Moscow, USSR. This conference will provide an opportunity for earthquake specialists to acquaint conference participants with recent work on seismic hazards and to take part in discussions on developing trends in research and design. Sessions are planned to examine seismic risk and the development of seismic codes and standards; design of seismic-resistant buildings; strong ground motion and soil/structure interaction; experimental methods for testing structures; earthquake response of structures; engineering analysis of structural damage after strong earthquakes; repair and strengthening of structures after earthquakes; low-cost housing in seismic regions; reliability of lifelines in earthquakes; prediction of building behavior in earthquakes; lessening seismic risk in populated areas; and social and economic aspects of earthquake engineering. For information, contact 9ECEE Organizing Committee, Gosstroy USSR, Pushkinskaya 26, IO3828, Moscow, USSR.

October 15-18, 1990, Putting the pieces together: a national conference about the Loma Prieta earthquake, presented by the Bay Area Regional Earthquake Preparedness Project, held at the Hyatt Regency at the San Francisco Airport.

Experts are currently involved in an intensive study of the earthquake and its aftermath. The conference will provide a forum for discussion of their insights on this disaster and implications for future preparedness, design and seismic retrofit. Policy makers from the public and private sector have met the challenge and are moving forward with economic recovery and community reconstruction programs. Find out directly from elected officials and managers how short and long-term recovery issues are being resolved. Find out for yourself about the new directions for improving state, local and corporate ability to respond to the next Bay area earthquake. For more information, call ABAG Conference Services at (415) 464-7960.

March 11-15, 1991, Second international conference on recent advances in geotechnical earthquake engineering and soil dynamics, held at the Sheraton Hotel Downtown in St. Louis, Missouri. In recognition of the International Decade for Natural Hazard Reduction and as part of a continuing effort to provide a forum for geotechnical, structural and civil engineers, seismologists, geologists, and teachers of engineering schools, the University of Missouri-Rolla presents this conference. The participants will have the opportunity to discuss recent advances in the thematic areas including: static and dynamic engineering soil parameters and constitutive relations of soils; model testing in cyclic loading; deformation and liquefaction of sands, silts, gravels, and clays; dynamic earth pressures and seismic design of earth retaining structures; soil structure interaction under dynamic loading; earthquake geotechnology in offshore structures; stability of slopes and earth dams under earthquakes; soil amplification during earthquakes and microzonation; seismology: predicting strong ground motion for design; wave propagation in soils; and dynamic characteristics of vibration sources other than earthquakes. For more information, contact Shamsher Prakash, Conference Chairman, Department of Civil Engineering, University of Missouri-Rolla, Rolla, MO, 65401, (314) 341-4489 or -4461.

April 10-12, 1991, 27th annual symposium on engineering geology and geotechnical engineering, sponsored by Utah State University, Idaho State University, University of Idaho, Boise State University, and University of Nevada-Reno, held in Logan, Utah. The Symposium invites presentations on all aspects of engineering geology and geotechnical engineering with emphasis on the western U.S. One page abstracts are due December 21, 1990, with camera-ready copy of manuscripts (20-page limit) due March 1, 1991. A short course "Techniques in paleoseismology" will be held April 9, and a field trip to the Jordanelle damsite is scheduled for April 13. For more information contact James McCalpin, Department of Geology, Utah State University, Logan, UT 84322-4505, (801) 750-1220.

June 12-14, 1991, Sixth Canadian conference on earthquake engineering, organized by the Department of Civil Engineering, University of Toronto, held in Toronto, Ontario, Canada. The purposes of this conference are to present new developments in earthquake engineering and earthquake hazard mitigation, focus attention on earthquake engineering problems in Canada, and bring together practicing engineers, researchers and scientists from Canada and other countries who are actively involved in earthquake engineering and related fields. Conference topics will include: ground motion and seismicity; seismic risk and hazard; lifelines; seismic analysis of structures; design of structures and components; experimental methods and testing; soil-structure interaction, soil stability, and foundations; observations of behavior during earthquakes; characteristics and impact of earthquakes in eastern North America; seismic code provisions; planning of emergency response; and repair and retrofitting of structures. For more information contact, the Organizing Secretary, 6CCEE, University of Toronto, Department of Civil Engineering, Toronto, Ontario, Canada, M5S 1A4, (416) 978-5960.

August 22-23, 1991, Third U.S. conference on lifeline earthquake engineering, sponsored by the American Society of Civil Engineers, Technical Council on Lifeline Earthquake Engineering and the Los Angeles Section, ASCE, held in Los Angeles, California. The conference is presented in cooperation with EERI's Fourth international conference on seismic zonation. The conference will present recent advances in lifeline earthquake engineering, address engineering practice and policy for mitigating earthquake effects on an infrastructure, and contribute to the development of new knowledge and improved performance of lifelines which may be subject to earthquakes. Subject areas include: seismic hazard; risk and reliability; dynamic analysis; experimental projects; design/strengthening/retrofit; vulnerability assessment; planning for mitigation; performance and behavior; socio-economic/insurance impacts; policies for loss reduction and mitigation; implementation strategies; and lifeline experience during earthquakes. Issues resulting from the Loma Prieta earthquake of 1989 will be included.

August 26-28, 1991, Fourth international conference on seismic zonation, sponsored by the Earthquake Engineering Research Institute, will be held at Stanford University in Palo Alto, California. The conference will provide a state-of-the-art assessment of the advances in seismic zonation integrating earth sciences, engineering, planning, social sciences, and public policy. It will emphasize results pertinent to disaster mitigation on local, regional and national scales at locations throughout the World. The recent tragic earthquakes in Mexico City (1985) and Armenia (1988) have emphasized the importance of using zonation techniques to reduce earthquake damage. These events raise numerous social science and public policy issues as well. Lessons learned from these events have led to multidisciplinary advances pertinent to reduction of life and property losses in future earthquakes. For further information, contact the Earthquake Engineering Research Institute, 6431 Fairmont Avenue, Suite 7, El Cerrito, CA 94530-3624, (415) 525-3668.

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