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EARTHQUAKE HAZARDS PROGRAM

The Wasatch Front Forum is published quarterly by the Utah Geological Survey. Information, contributions, questions, and suggestions concerning future issues may be sent to the Editor at the address listed below:

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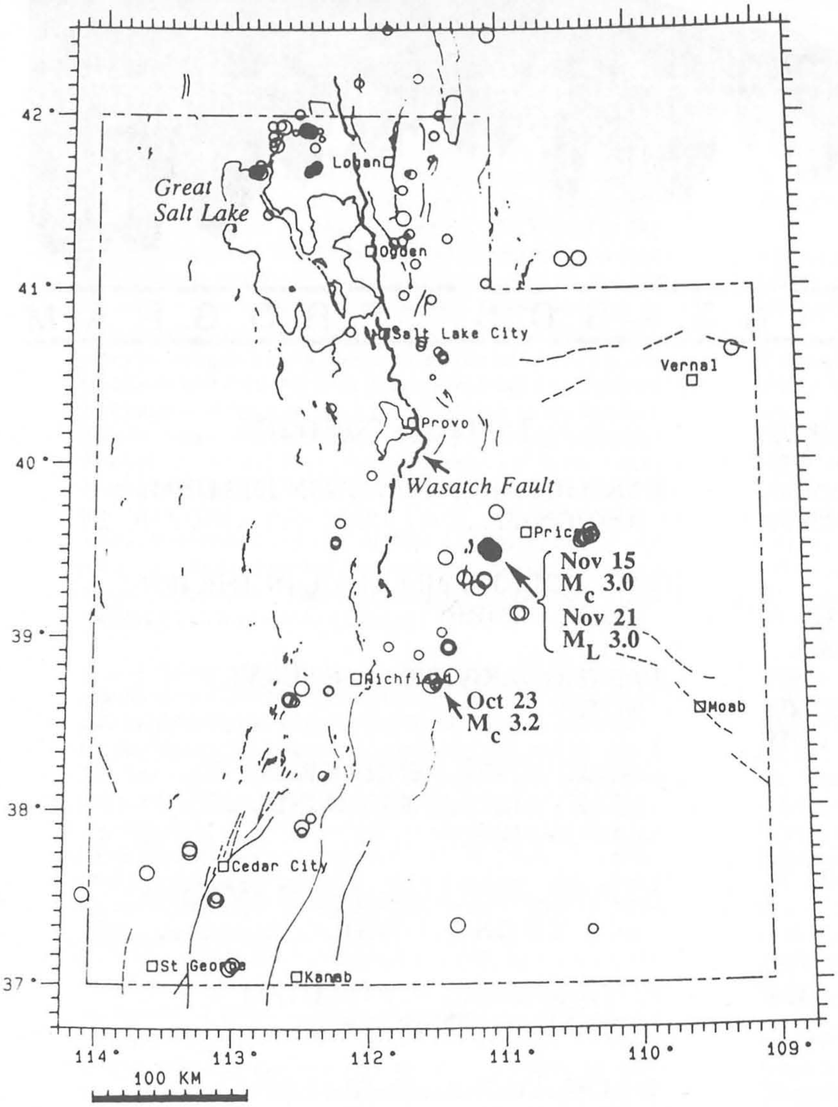

October 1 — December 31, 1990

by Susan J. Nava
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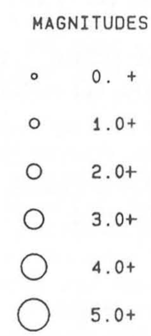

During the three-month period October 1 through December 31, 1990, the University of Utah Seismograph Stations located 168 earthquakes within the Utah region (see accompanying epicenter map). The total includes three earthquakes in the magnitude 3 range, specifically labeled on the epicenter map, and 66 in the magnitude 2.0 range. (Note: Magnitude indicated here is either local magnitude, M_L, or coda magnitude, M_C. All times indicated here are local time, which was Mountain Daylight Time from October 1 through 27, and Mountain Standard Time from October 28 through December 31.)

Larger and/or Felt Earthquakes:

- M_C 3.2 October 23, 2:49 a.m. 32 km west of Emery
- M_C 3.0 November 15, 7:08 a.m. 9 km west of Hiawatha
- M_L 2.6 November 20, 1:19 a.m. 13 km southeast of Castle Dale
  (Only felt earthquake during report period: felt locally in the towns of Clawson, Ferron, and Castle Dale.)
- M_L 3.0 November 21, 5:16 a.m. 5 km west of Hiawatha

Significant Clusters of Earthquakes:

- Near Price (coal-mining related): Two clusters located to the east and to the southwest of Price contain 8 and 23 shocks, respectively, ranging in magnitude from 1.5 to 3.0.
- North of the Great Salt Lake: Three clusters of earthquakes make up 35% of the shocks that occurred in the Utah region during the report period.

—60 km northwest of Logan: 29 earthquakes, magnitude 0.4 to 2.2, occurred primarily in late November and early December.

—50 km west of Logan: 9 earthquakes, magnitude 0.7 to 1.8, occurred in the same location of an M_L 4.8 shock in July 1989.

—85 km west of Logan (along the northern arm of the Great Salt Lake): 11 earthquakes, magnitude 1.0 to 2.6.

This is one of the most seismically active regions of Utah, and the observed activity is not unusual.

Additional information on earthquakes within the Utah region is available from the University of Utah Seismograph Stations.

EARTHQUAKE BILLS FAIL IN THE 1991 LEGISLATURE

After extensive work over the interim in preparation for the 1991 Legislature, particularly by the UACIR Earthquake Task Force and the Legislature's State and Local Affairs Interim Committee, four earthquake bills were introduced:

HB 11	Natural Disaster Commission (Sponsors: Donald LeBaron and Ray Nielsen; supported by the State and Local Affairs Interim Committee)
HB 44	Earthquake Insurance (Sponsor: Gene Davis)
HB 156 SB 169	Earthquake Instrumentation (Sponsors: Donald LeBaron, House; Craig Peterson, Senate)
HB 229	Seismic Vulnerability Assessment of Schools (Sponsor: Kim Burningham)

None of the bills passed. The Natural Disaster Commission Bill fell victim to last-minute amending and manuevering to remove the fiscal note. After amending, it passed the House unanimously, but time ran out before the Senate was able to vote on it. Fiscal notes were retained on both the Earthquake Instrumentation (reduced to $500,000) and Seismic Vulnerability Assessment of Schools ($250,000) bills, but neither was given a high enough priority for funding and both died in the last days of the session. The Earthquake Insurance bill, which would have tasked the State Insurance Commissioner to publish an information brochure on homeowner's earthquake insurance, was defeated in committee hearings earlier in the session because it was believed that legislation was not required to accomplish this.

Only one earthquake issue was placed on the Interim Study Resolution. The issue is to require that money collected by local governments for building structural plan checks be spent for that purpose. It was referred to interim study to look at its impact on local governments and to look at existing legislation that may already address the issue.

This is the second year that considerable time and effort has been spent by many to prepare legislation and develop support, only to be disappointed with no return from the Legislature. The base of support for earthquake hazard reduction measures has grown significantly through this process, however, and attempts to achieve the needed actions will continue, although efforts will perhaps be concentrated on other fronts.

EARTHQUAKE ISSUE OF SURVEY NOTES

The theme of the most recent issue of the Utah Geological Survey's quarterly publication, Survey Notes, is earthquakes in Utah. Individual articles within the issue summarize earthquake hazards, Quaternary tectonics, earthquake ground shaking, and earthquake legislation in Utah. Single copies of Survey Notes, 1991, v. 24, no. 3, 32 p., are available free of charge from the Publication Sales Office, Utah Geological Survey, 606 Black Hawk Way, Salt Lake City, UT 84108-1280, (801) 581-6831, FAX 801-581-4450. The introduction by Utah Geological Survey Director M. Lee Allison is excerpted below. Ed.

Utah has one of the most innovative and aggressive earthquake programs in the country. However, it is essentially an ad hoc program consisting of dozens of actions undertaken by government agencies, public groups, and industry, largely on a volunteer basis and often on their own initiative.

Tremendous advances have occurred in the past decade in better understanding and preparing for Utah's next big earthquake. The five-year-long federally funded National Earthquake Hazards Reduction Program (NEHRP) was the first time such an effort was implemented outside of California. The successes in locating fault and liquefaction hazards, determining recurrence intervals, and involving local governments in activities like the County Geologist Program, greatly improved our capabilities. As an outgrowth of the NEHRP program, the UGS now has a larger, better trained cadre of geoscientists with the skills and information *we need.*

The Utah Division of Comprehensive Emergency Management (CEM), with support from the Federal Emergency Management Agency, is getting in place all the response plans and procedures for state and local governments. They work with engineers, emergency responders and public officials to better prepare Utah for earthquakes as well as other disasters.

The University of Utah Seismograph Stations (UUSS) monitors and records seismic events across the state and interprets the results. A recent national review panel gave them high ratings for being well operated and excellently managed, as well as for their outstanding and impressive record of reports and publications.

Armed with this background, knowledge, and capability, we have entered the public arena to create and improve laws and regulations to better deal with the earthquake threat. In four counties along the Wasatch Front (Salt Lake, Utah, Weber, and Davis), detailed hazards maps are now in use by the planning departments and hazards ordinances are passed or being drafted. The International Conference of Building Officials (ICBO) will be considering new information brought forward by UGS which indicates that the Wasatch Front may belong in UBC seismic zone 4, up from the current zone 3. But for all its successes, the State Earthquake Program is still very limited. It needs much broader representation, and the authority and funding to bring Utah to the necessary state of readiness that the danger requires.

So where does the State Earthquake Program go from here? After two years of significant effort with the Utah Legislature, not a single bill has resulted. Costs of some measures doomed them, other bills just did not seem to get anyone's attention, and overall there was no sense of urgency to deal with the earthquake problem.

The UGS and our partners in the program will continue to do what we can. The three groups have staff, expertise, and a strong sense of commitment. Progress is made every day. But our concern is that it won't be enough and it won't be done in time. Money is always a problem. CEM has more demands on its publications, speakers, and trainers than it can support. Reduced federal funding and lack of state support is threatening to reduce the contributions that the UUSS can make. Years of keeping the state seismic network operating by neglecting other research duties is coming to an end and the debt must be repaid. The desperately needed strong-motion program still has not received a dollar of funding. And what use is it if we scientists gather the best and most complete data possible, if society does not put it to use to reduce risks?

Over and over we hear "all we need is a moderate earthquake in Salt Lake City and things would happen." Unfortunate, but perhaps true.

UGS RECEIVES NEHRP GRANT TO STUDY LIQUEFACTION-INDUCED LANDSLIDES

The UGS was notified by the USGS in February, 1991, that its 1990 research proposal entitled "Hazard potential and paleoseismic implications of liquefaction-induced landslides along the Wasatch Front, Utah" had been approved for funding from supplemental 1990 NEHRP funds. The purpose of the study is to: 1) date movement on liquefaction-induced slope failures (for example, the Farmington Siding lateral spread in Davis County) as closely as possible, 2) infer the geologic and hydrologic conditions under which they first moved, 3) determine if there is evidence for recurrent movement, 4) evaluate failure mechanisms, and 5) assess the potential for future movement and for failure in other areas of similar conditions during future earthquakes. Investigators on the project will be Mike Lowe, Kimm Harty, and Gary Christenson.

The one-year study will involve detailed surficial geologic mapping and field checking of 15 "lateral spreads" identified in the literature as possible liquefaction-induced slope failures. Subsurface investigations (principally trenches and test pits) will then be undertaken in areas with the highest potential for yielding information on the timing of landslide movements. These data will then be correlated with earthquake chronologies developed from fault trenching and with paleoclimatic records based on latest Pleistocene and Holocene Lake Bonneville and Great Salt Lake levels. It is hoped that such correlations will yield information on the causes of the slope failures and help to infer hydrologic conditions at the time of failure, as well as help assess the present hazard potential of the landslides and adjacent areas. The study may also contribute to paleoseismic information for the Wasatch Front by further constraining events dated in fault studies, and perhaps extending the paleoseismic record beyond the 6,000 years attainable in conventional fault trenches.

EARTHQUAKE AWARENESS AND RISK REDUCTION IN UTAH

An exciting new video, produced by Utah State University in Logan, Utah, is now available for sale from the Utah Geological Survey. "Earthquake awareness and risk reduction in Utah" asks if Utahns are prepared for a major earthquake in their own backyards. Are citizens aware of the hazards associated with earthquakes? Do they know the risks and the potential for damaging consequences? What can and should they do to protect themselves, their families, and their communities?

In clear language and employing excellent graphics, the authors make the case that the threat in Utah is very real and that a sense of urgency must exist in order for citizens to take informed, responsible actions to prepare and protect themselves and their communities. They document the considerable risk in Utah and detail Utah's past and present seismicity. Although earthquake prediction is an inexact science, the chances are that Utah will experience a damaging earthquake in the not-so-distant future. Surveys by Utah State University show that more than half of Utah's residents are aware of the earthquake threat and believe there is a high likelihood of a major earthquake in Utah in the next 50 years.

The authors detail the causes of earthquakes in Utah and explain the measurement of magnitude of an earthquake. The various kinds of damages associated with earthquakes due to surface faulting, ground shaking, subsidence, liquefaction, landslides, seiches, dam failure inundation, and fires, are graphically illustrated with examples from Hansel Valley, Utah; Cache Valley, Utah; Borah Peak, Idaho; and Hebgen Lake, Montana, as well as from earthquakes occurring in California, Alaska, and Japan. Parallels are drawn to the specific problems associated with each of these hazards in the context of Utah's setting.

Because earthquakes cannot be prevented, the authors go on to discuss what needs to be done in advance to mitigate the effects of a large-magnitude event. They first discuss personal planning and the securing of an individual's home and family. Their surveys show that the general public is not prepared for even a moderate earthquake. They go on to deal with the much more difficult issues of how a community must prioritize needs and allocate scarce resources for activities such as major structural upgrades of existing facilities, especially lifelines (roads, utilities), critical facilities (hospitals, police stations, fire stations), and high occupancy buildings (schools, multi-story buildings). They emphasize that new structures must be built strictly to appropriate standards and that building codes must be enforced. Siting of new facilities must take geologic hazards into account. And communities must prioritize and begin the upgrading of existing facilities. Surveys by Utah State University show that 74% of Utah's population supports the enforcement of land-use planning that is currently in place and 76% support the passage and implementation of zoning ordinances that take geologic hazards into account. And finally, 77% are in favor of more stringent building codes being put into place.

"Earthquake awareness and risk reduction in Utah", Public Information Series 10, runs 25 minutes and is available from the Publication Sales Office, Utah Geological Survey, 606 Black Hawk Way, Salt Lake City, UT 84108-1280, for $6.00 plus $2.50 for mailing (Utah residents must add 6.25% sales tax). Bulk discounts are available. For more information, call UGS at (801) 581-6831 or FAX 801-581-4450.

PALEOSEISMOLOGY OF UTAH SPECIAL STUDIES SERIES

The first two volumes in the Utah Geological Survey's Special Studies Series on the

Paleoseismology of Utah are now available. Volume 1, Fault behavior and earthquake recurrence on the Provo segment of the Wasatch fault zone at Mapleton, Utah County, Utah by William R. Lund, David P. Schwartz, William E. Mulvey, Karin E. Budding, and Bill D. Black is Special Studies 75, 1991, 41 p., and is available for $7.00. Volume 2, Paleoseismic analysis of the Wasatch fault zone at the Brigham City trench site, Brigham City, Utah and Pole Patch trench site, Pleasant View, Utah, by Stephen F. Personius is Special Studies 76, 1991, 39 p., and is available for $6.00. Volume 3, The number and timing of Holocene paleoseismic events on the Nephi and Levan segments, Wasatch fault zone, Utah by Michael E. Jackson is in press and will be available later this year. From the introduction by the Series Editor, William R. Lund:

The Wasatch Front is located within a recognized zone of earthquake activity, the Intermountain seismic belt, and is faced with the threat of significant property damage and loss of life due to large earthquakes. Nearly eighty-five percent of Utah's population of 2.2 million people live within 16 km (10 mi) of the Wasatch fault zone; the longest and most active extensional fault in the western United States. Although the Wasatch fault zone has not experienced a surface-faulting earthquake in historical time, there is abundant geologic evidence to indicate that numerous faults are located in Utah, and the historical seismic record indicates that an unknown number of buried faults capable of causing damaging earthquakes are also present in the state.

In 1983, the U.S. Geological Survey (USGS) and the Utah Geological Survey (UGS) initiated a 5-year research program under the auspices of the National Earthquake Hazard Reduction Program to assess earthquake hazard and risk along the Wasatch Front. Although broadly based in all aspects of earthquake science, the "Wasatch Front Earthquake Hazard and Risk Assessment Program" particularly served to renew interest in the earthquake history of the Wasatch fault zone and the region's other active faults. Scientists from government, academia, and the private sector conducted a number of paleoseismic studies on the Wasatch and other fault zones as part of the Wasatch Front Program. Paleoseismic investigations commonly include mapping of fault scarps and associated geologic deposits, trenching across active fault traces, geomorphic analysis of fault-related or fault-modified features, and investigation of fault-zone structures in both consolidated and unconsolidated deposits. Techniques for dating Quaternary sediments are used to constrain the timing of past events. The resulting information on earthquake timing, recurrence, displacement, and fault geometry permit the characterization of seismic source zones and determination of the long-term earthquake potential of Quaternary faults. Information on the size and timing of paleoearthquakes and on the ground deformation that accompanies them is fundamental to the evaluation of earthquake hazards and risk.

The purpose of this Special Studies series is to make the results of these studies available to the general public, the scientific and engineering communities, and individuals and organizations charged with mitigating earthquake hazards and risk along the Wasatch Front. In addition, they are tangible evidence of the close cooperation that exists at State and Federal levels on an issue that affects the life, safety, and well being of the citizens of Utah.

Special Studies 75 and 76 are available from the Publication Sales Office, Utah Geological Survey, 606 Black Hawk Way, Salt Lake City, UT 84108-1280, (801) 581-6831, FAX 801-581-4450.

INTERNATIONAL FORUM ON SEISMIC ZONATION

A one-day extension of the Fourth International Conference on Seismic Zonation is being planned for August 30, 1991, the day after the Conference closes (see Meetings and Conferences, August 26-29, 1991, this issue). Sponsored by the U.S. Geological Survey and the United Nations Educational, Scientific and Cultural Organization, the Forum will provide an opportunity for international scientists, engineers, and urban planners to identify the best ways to leverage scarce technical and fiscal resources through international cooperation and to initiate or extend the practice of seismic zonation in their countries.

The State of California has a new seismic zonation program which will begin in July 1991. The program goal is to map ground shaking and ground failure throughout the State and to identify "special study zones" to guide future development.

This program was created in 1990 and is funded from assessments on insurance premiums and permits for new buildings. From an international perspective, this legislation will make California a "laboratory for seismic zonation" for many years. One session will be devoted to lectures describing the new program. International colleagues are invited to exchange ideas on California's program and urged to create similar programs in their own countries.

Three other sessions will be devoted to brainstorming and exchanging ideas on three different themes: seismic sources and seismic wave attenuation; site effects-soil response and ground failure; and applications of seismic zonation products.

Participants attending both the Conference and the Forum will pay no additional registration fee and will receive special materials. The only additional cost for each participant will be food and lodging for one day - approximately $100 if they make arrangements to stay on the campus of Stanford University. For further information, contact Ms. Linda Huey, U.S. Geological Survey, 905 National Center, Reston, VA 22092, (703) 648-6712, FAX 703-648-6717.

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

By William J. Kockelman
U.S. Geological Survey

[This is the fourth excerpt from the publication entitled "Reducing Earthquake Hazards in Utah: The Crucial Connection Between Researchers and Practitioners" to be reprinted in the Forum (see WFF, v.6, no.1-2, p. 16-25, 1990, v.6, no. 3-4, p. 9-17, 1990, and v. 7, no. 1, p. 6-13, 1990). Although the full paper will be included in the USGS Professional Paper "Assessment of Regional Earthquake Hazards and Risk Along the Wasatch Front, Utah" currently in press, the editors feel the information to be timely and relevant enough to reprint herein. This information is available now as USGS Open-File Report 90-217. Questions can be directed to Bill Kockelman at (415) 329-5158. Ed.]

EXAMPLES OF SUCCESSFUL TRANSLATION IN UTAH

An unusual effort is being made in Utah to translate earthquake research information for nontechnical users. During 1986, the Utah State Geologist convened several meetings to discuss and develop criteria for "translated" research and to identify potential translators. D.A. Sprinkel, Utah Geological Survey Deputy Director (written commun., December 24, 1986), reported that a common understanding was established, a logical progression from the research to its use was identified, and a tentative definition of translation was developed, namely, occurrence, location, and consequences.

Translators in Utah include university, state, and federal researchers, geotechnical consultants, and county geologists. Hazards being addressed include surface fault rupture, ground shaking, and failures induced by shaking -- liquefaction, landslides, rockfalls, tectonic subsidence, and dam failure. An example and illustration of translated information from Utah for each of these hazards follows.

Surface Fault Rupture

Machette and others (1989) have prepared a report on surface fault rupture for the segments in the Wasatch fault zone. Their text includes a discussion of recurrence of large earthquakes; includes a table giving the number of faulting events on seven of the segments; and introduces the idea of a composite-recurrence-interval between 340 and 415 yr. See figure 2. Personius (1988) shows the location of faults that offset the surficial material on a topographic map (scale 1:50,000). Similar maps are being prepared for the urbanized portion of the Wasatch Front.

In an earlier report, Machette and others (1987) conclude that "recurrence intervals vary widely" on some segments, that some "earthquakes tend to occur in clusters," and that "recurrence intervals within clusters may be as short as 100 years" (revised to 180 yr). They suggest that the lack of faulting events in the past 400-500 yr, and

[All values for age and time intervals (columns A-C) are rounded to the nearest 100 years. Ages based on calendar-corrected radiocarbon dates and thermoluminescence analyses. The average recurrence interval is determined by dividing the sum of time intervals (column C) by the sum of intervals between faulting events (column D). Time intervals (column C) for some segments include time between the oldest (undated) event at a site and the age of the datum; thus, some values in column C are maximum values. N/A indicates a value that is not applicable to the calculation]

Fault segment	Trench site	A Oldest event (t) or datum (d) (years ago)	B Estimated time since most recent faulting (years)	C Time interval (A-B) (years)	D Number of faulting events (and intervals) Events	Intervals
Brigham City..	Brigham City	4,700t	3,600	1,100	2	1
Weber.........	East Ogden..	4,000t	500	3,500	4	3
Salt Lake City	Dry Creek...	5,500t	1,500	4,000	2	1
American Fork.	AF-1, AF-2..	5,300t	500	4,800	3	2
Spanish Fork..	Mapleton....	3,000t	600	2,400*	2*	1*
Nephi.........	North Creek.	5,300d	400	4,900	3	2
Levan.........	Deep Creek..	7,300d	1,000	>6,300 N/A	1	0
Totals* (based on five segments; segments 1-4, 6)...............				18,300	14	9
Totals (based on six segments; segments 1-6)..................				20,700	16	10
Calculated recurrence intervals (in years) for segments of the WFZ having repeated Holocene movement#					Minimum value	Maximum value
Average recurrence interval (RI) on a single segment..........................					2035	2070
Average composite recurrence interval (CRI)..................................					340	415

Notes: t—Time of oldest well-dated faulting event.
d—Age of datum from dating, stratigraphic, or tectonic considerations (rounded to nearest 100 years).
*—For a five segment model we use only the number of events and intervals from American Fork for the Provo segment).
#—Three significant figures are used to compute average values of recurrence from the totals in columns C and D. Values are rounded to nearest 5 years. Minimum values calculated from 20,700 years, 10 intervals, and 6 segments. Maximum values calculated from 18,300 years, 9 intervals, and 5 segments. The latter model (maximum value) is based on our preferred model of segmentation.

FIGURE 2. -- Example of a table showing average recurrence intervals on a single segment and average composite recurrence interval for several segments by Machette and others (1989, table 2).

the relatively imprecise dating (± 100 yr) of the most recent events, may indicate that "a major surface-rupturing earthquake is overdue on one or more of the segments." They include displacement, slip rates for the segments, and length of surface rupture from recent large earthquakes in the northern Basin and Range province.

Machette and others (1987) begin their report; the "heavily urbanized part of the Wasatch Front -- between Ogden and Provo -- coincides with the part of the fault zone that shows the highest slip rates, shortest recurrence intervals ... and most recent fault activity" and conclude that major earthquakes have struck the central, heavily urbanized section of the Wasatch fault zone on an average of once every 310 yr (revised to 415 yr) during the last 4,000-8,000 yr; that a form of temporal clustering of earthquakes has been (and may still be) active; and that lack of movement along the Brigham City segment during the late Holocene (past 3,600 yr) is somewhat ominous.

Their work on recurrence intervals is applicable to, and frequently provides the likelihood of occurrence element for, the Wasatch Front hazards which are discussed in the following subsections. In addition, McCalpin (1987) has analyzed the geometry of near-surface ground breakage across some normal faults, and defined reasonable setback distances.

The three county geologists serving Davis, Juab, Weber, Salt Lake, and Utah counties are combining this and other information to show a surface fault rupture study zone on county maps (see figure 3). In addition, they are transferring this map information to nontechnical users by use of texts that discuss and illustrate fault characteristics, segments, boundaries, recurrence intervals, displacement, and by suggesting use of the maps for hazard reduction. For example, Robison (1988a) summarizes displacement per event for each of the segments.

Ground Shaking

Youngs and others (1987, fig. 37. p. M88) show location and severity (peak ground acceleration) by areas on a map for ground shaking. Likelihood of occurrence is conveyed by probability (percent) of being exceeded for various exposure times (10, 50, and 250 yr) in their figure caption.

Tinsley (in press) has prepared a report and map showing increased shaking due to ground conditions in Salt Lake Valley. Figure 4 is a generalized version of this map at an original scale of 1:200,000. Location of increased ground shaking on unconsolidated deposits is shown by contour lines on the map. Severity is conveyed by use of Modified Mercalli intensity (MMI) units representing an increase in damage intensities to that which would occur on the underlying bedrock.

The size and location of a credible earthquake can be obtained by referring to Machette and others (1987). A map of MMI on bedrock for such an earthquake is available and Tinsley's increased intensities can be added to such a map to meet the needs of a nontechnical user.

Liquefaction Potential

Anderson and others (1986) have prepared a liquefaction potential map and report for Utah County. The base map used is a USGS 7½-minute quadrangle showing topography which has been reduced to a scale of 1:48,000 (1 in. equals 4,000 ft). See figure 5. They have also prepared similar maps and reports for other counties -- Davis, Salt Lake, Weber, Cache, Millard, Sanpete, Sevier, and Wasatch counties and the eastern portions of Box Elder and Juab counties.

The boundaries of four liquefaction potential areas are shown -- high, moderate, low, and very low. These four areas are based on the probability that a critical acceleration will be exceeded in a 100-yr period. The critical acceleration for a given location is defined as "the lowest value of the maximum ground surface acceleration required to induce liquefaction." The categories of high, moderate, low, and very low correspond to probabilities of exceeding critical acceleration in the ranges of greater that 50 percent, 10 to 50 percent, 5 to 10 percent, and less than 5 percent, respectively. All of the information needed by a nontechnical user is shown on the map. The text includes discussions on methods, geotechnical conditions, existing ground failures, and techniques for reducing the susceptibility of site sediments to the liquefaction process.

In addition, Anderson and others (1986) have provided maps showing some information on soils, groundwater, geology, and slope which can be used in combination with the liquefaction potential map (fig. 5) to assess the type of ground failure likely to occur -- loss of bearing capacity, lateral spreading, landslides, flows, and translational landslides. These maps require further translation which is being done by county geologists.

Landslide Potential

Keaton and others (1987) have prepared an earthquake-induced landslide potential map and report for the urban corridor of Davis and Salt Lake counties. The base map used is a USGS 7½-minute quadrangle showing topography which has been reduced to a scale of 1:48,000 (1 in. equals 4,000 ft). See figure 6.

Boundaries of four landslide potential zones are shown -- high, moderate, low, and very low. These qualitative terms were assigned on the basis of failure criteria, landslide susceptibilities, and acceleration exceedence probabilities. In the text, displacement related to these terms are given; for example, 10 cm or more in a "moderate" zone during a wet condition, 10 cm or more in a "high" zone during a dry condition. Severity is then provided by the sentence: "Such ... displacement would certainly cause substantial damage to structures on ... or utilities buried within a sliding mass" (p. 75).

These four zones depend upon the probability that a critical acceleration will be exceeded in a

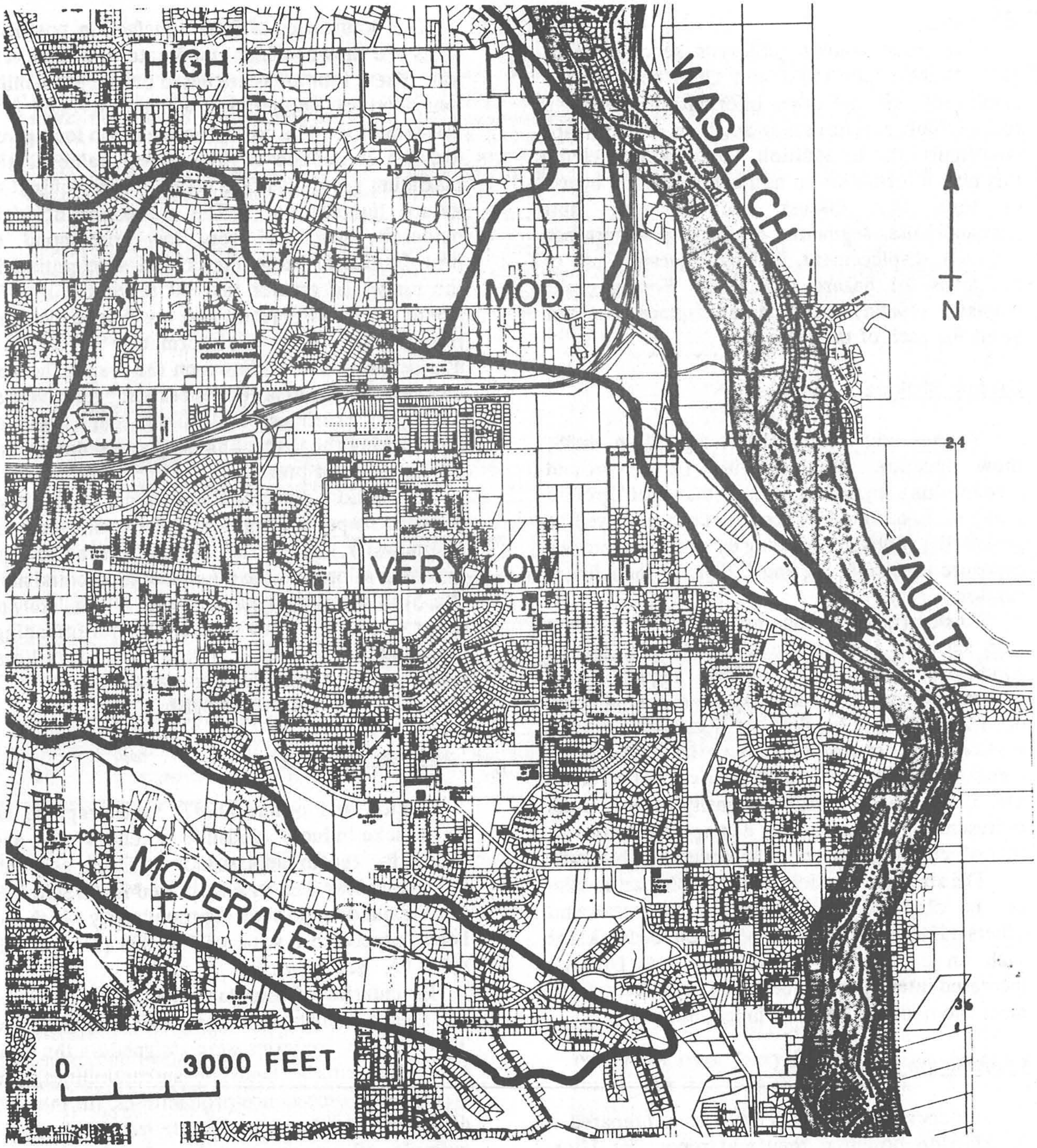

FIGURE 3. -- Part of a cadastral map (scale 1:36,000) of Salt Lake County upon which Nelson (1987) shows a surface fault rupture zone and potential liquefaction areas. Fault traces are indicated by a solid line where location is known from scarps or trenching; dashed where approximately located or infer-red; dotted where concealed. Bar and ball symbol indicates downthrown side. Shaded area indicates where site specific studies addressing surface rupture should be performed prior to construction. Areas labeled high, moderate, and very low indicate their potential for liquefaction during an earthquake.

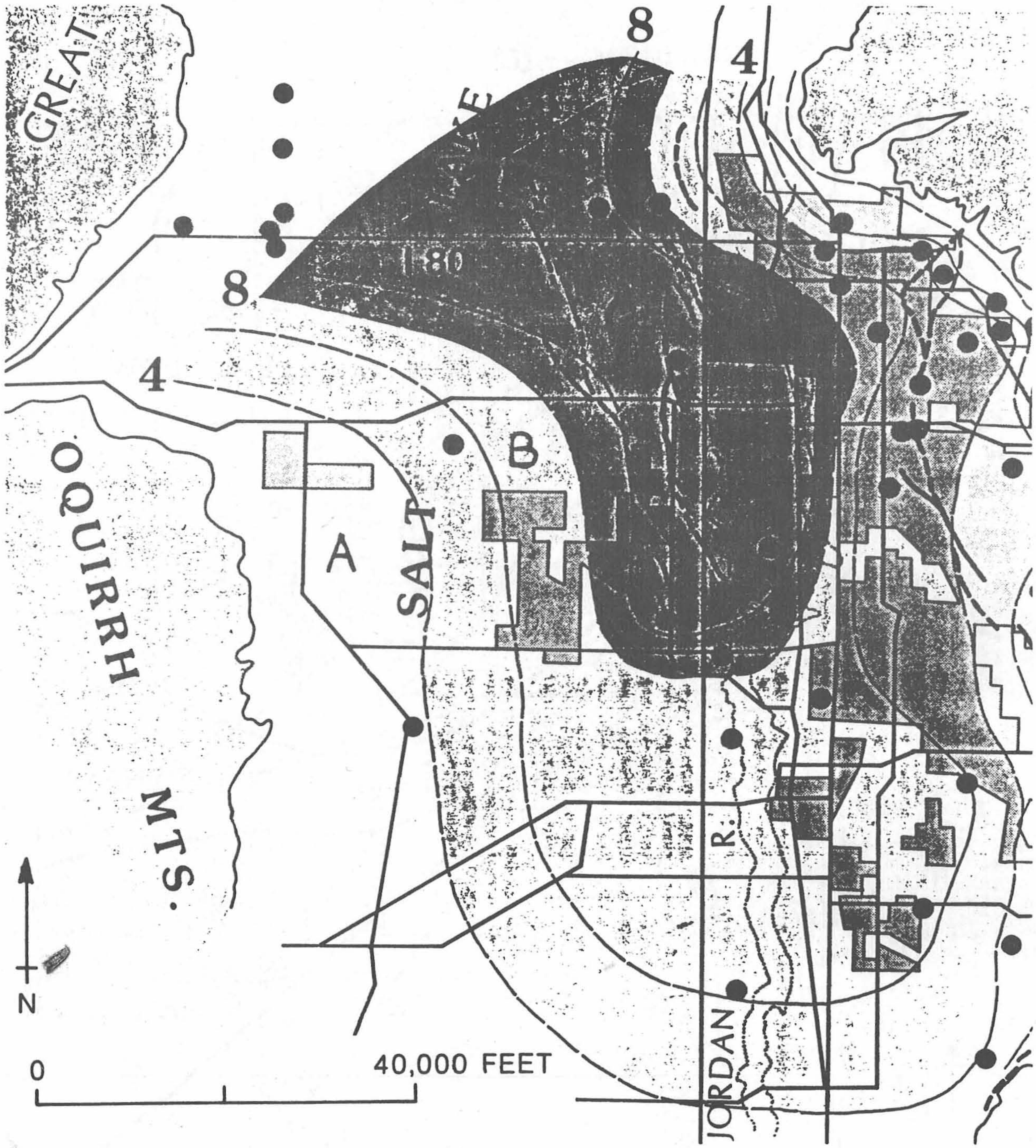

FIGURE 4. -- Map (scale 1:200,000) showing three levels of ground shaking on alluvium relative to bedrock in the period band 0.2-0.7 sec in the Salt Lake Valley by Tinsley (this volume). Contours were drawn on the basis of geology and show alluvium/rock spectral ratios recorded and computed by Kenneth King and Robert Williams. Map is preliminary and contours may be modified owing to further analysis of the data. Letters indicate an increase in Modified Mercalli intensity units: A(+1), B(+2), and C (greater than 2).

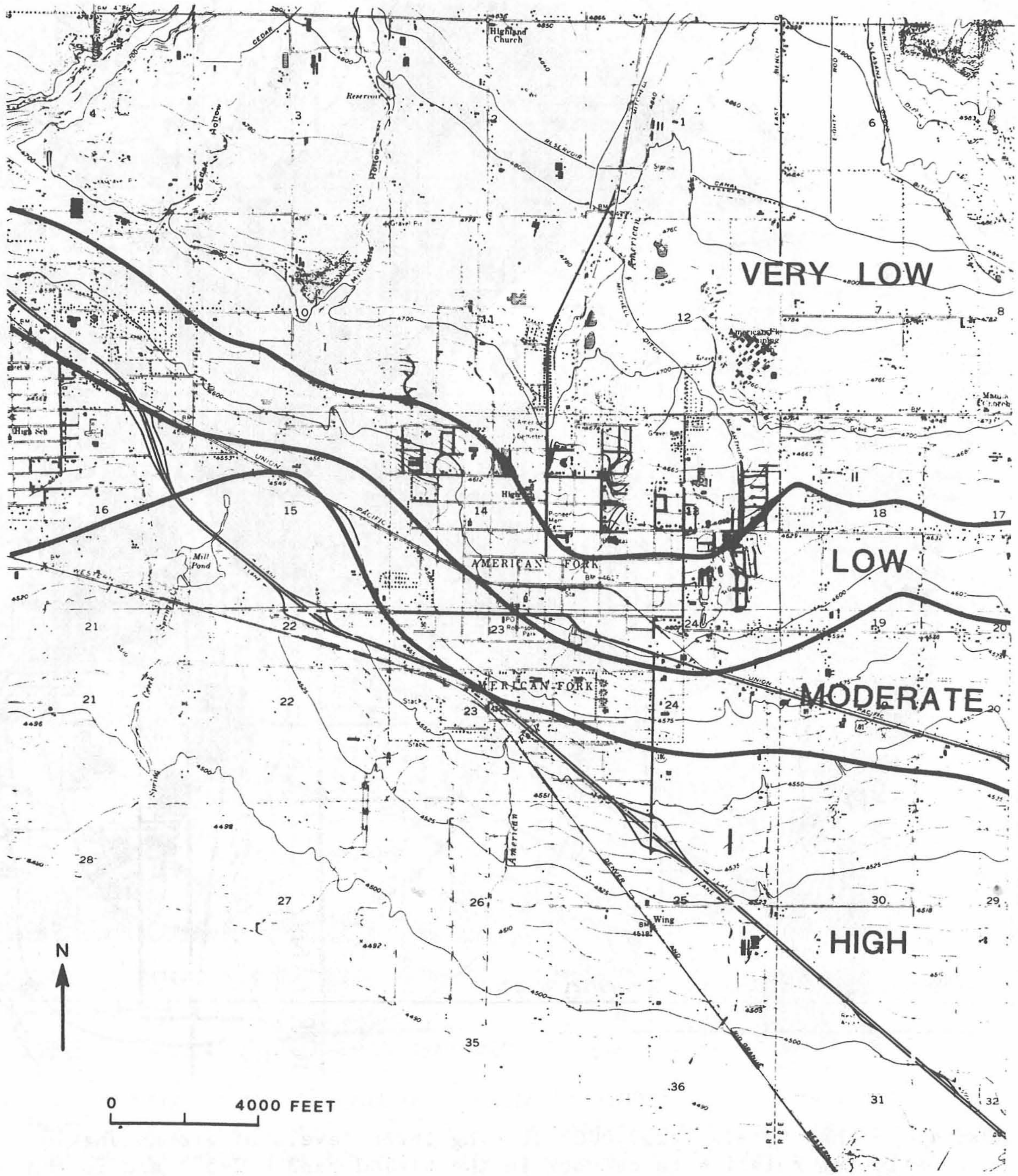

FIGURE 5. -- Part of a topographic map (scale 1:48,000) of Utah County upon which Anderson and others (1986, plate 4B) show areas with high, moderate, low, and very low potential for liquefaction corresponding to the probability of exceeding a critical acceleration.

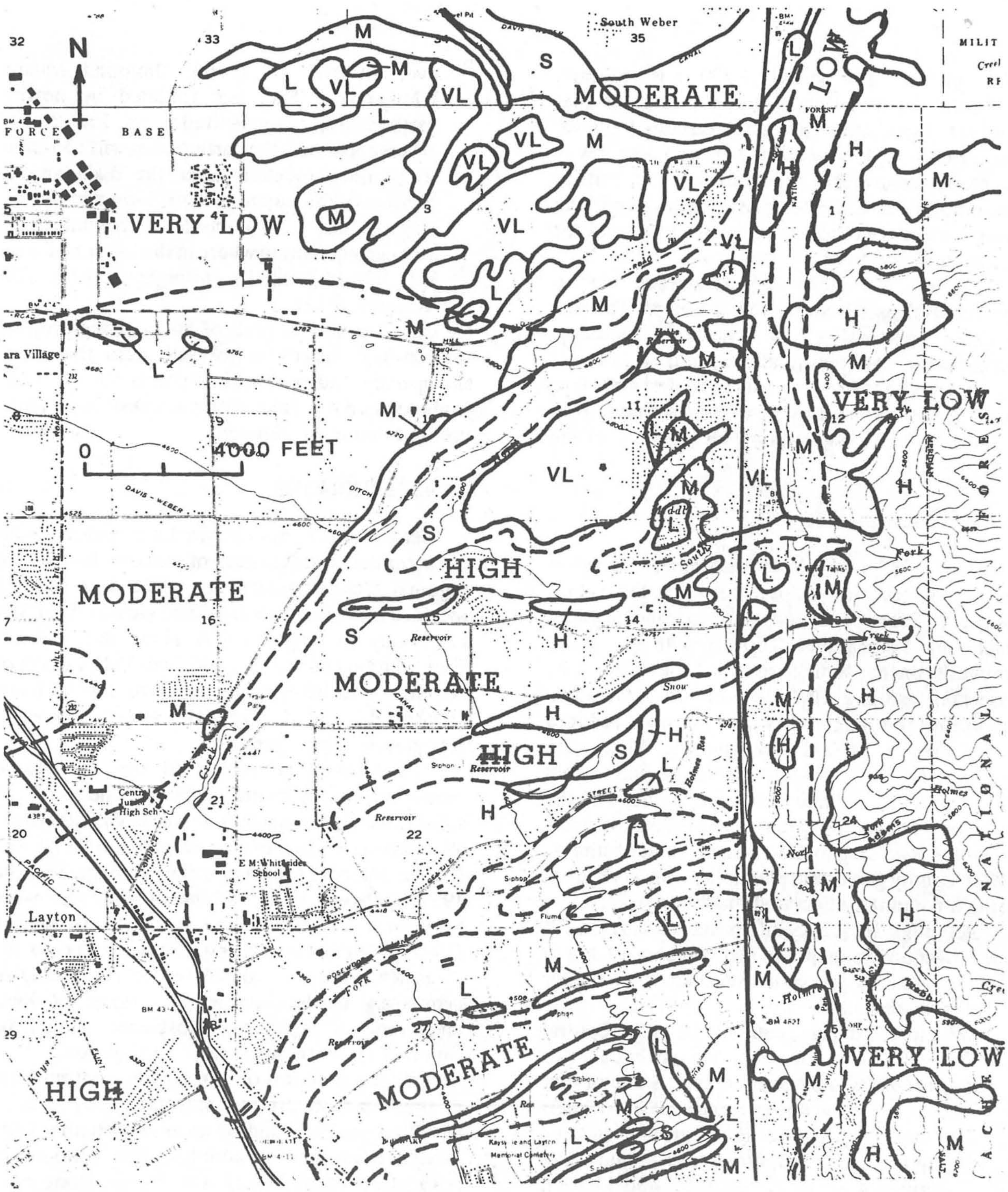

FIGURE 6. -- Part of a topographic map (scale 1:48,000) of Davis County, Utah, upon which Keaton and others (1987, plate 1b) show potential for earthquake-induced landslides and liquefaction. Letters H, M, L, and VL indicate high, moderate, low, and very low potential for landslides. The letter S indicates existing landslide. Words -- high, moderate, low, and very low -- indicate potential for liquefaction.

100-yr period. The period of 100 yr is arbitrary, but useful for planning, and is the same as that used for liquefaction potential discussed above. The terms -- high, moderate, low, and very low -- for these zones are functions of the critical acceleration exceedence probabilities and the ground water conditions similar to those used for liquefaction potential.

All of the information needed by a nontechnical user is shown on the map. The text includes discussion of method, geology, groundwater, and ground motion; a list of historical earthquake-induced landslides; and maps showing the historical limit of landsliding due to magnitude 7.5 earthquakes for all segments of the Wasatch fault.

Rockfall Susceptibility

Case (1987, p. V1-V36) has prepared a report and map concerning rockfall hazards in the central Wasatch Front between Layton and Draper (including Magna and Tooele) with particular emphasis on earthquake-induced rockfalls. The base map use is a USGS 7½-minute quadrangle map showing topography which has been reduced to a scale of 1:100,000. See figure 7. Field work was at a scale of 1:24,000 and is available from Case. Rockfall source areas are shown but the maximum downslope extent of the hazardous areas are not. According to C.V. Nelson (oral commun., 1988), county geologists plan to identify such areas using a computer-simulated model program.

Although frequency of rockfall occurrence is not shown on the map, the text contains a table of historic rockfalls and conclusion based on Keefer (1984) that reads:

> Widespread damage could occur in the Central Wasatch Front area if an earthquake of magnitude 7.0-7.5 should occur. Some of that damage would be due to thousands of rockfalls that would be the result of ground shaking during the event and aftershocks greater than magnitude 4. The Borah Peak and Hebgen Lake earthquakes are examples of such earthquakes that can be reasonably expected in the future somewhere along the Wasatch Front.

W.F. Case (written commun., 1988) makes the frequency of occurrence quite clear:

> Ground shaking during an earthquake can produce hundreds to thousands of rockfalls over an area of several thousand square kilometers. They are initiated by nearby earthquakes of magnitudes as low as 4. Aftershocks of large earthquakes will continue to produce rockfalls after the main shock, particularly if outcrops were loosened by the main shock. a "characteristic" (magnitude 7-7.5) earthquake anywhere in the Wasatch Front will trigger rockfalls throughout the entire Wasatch Front.

He describes the purpose of his mapping project: to "red-flag" hazardous rockfall areas that need site-specific studies. He then points out that such studies would require additional translation before use by community planners.

Tectonic Subsidence

Keaton (1987) has prepared a report and map on potential consequences of earthquake-induced regional tectonic subsidence. The area covered includes the Great Salt Lake and vicinity from Salt Lake City to Brigham City along the Wasatch Front, Provo and vicinity, and Juab Valley north of Nephi. The base maps used are USGS maps (1:100,000 and 1:125,000 scales) showing topography. See figure 8.

The location of effects of two earthquake events are shown on the maps: (1) the predicted subsidence that would accompany a "characteristic" Wasatch earthquake of moment magnitude 7.1, and (2) the observed subsidence that accompanied the 1959 Hebgen Lake, Montana, surface wave magnitude 7.5 earthquake. In the report, Keaton (1987, p. 19) restates earthquake occurrence as the "Wasatch fault is ... considered to be capable of generating earthquakes in the range of local magnitude ... 7.5" and "subsidence should be expected to accompany major earthquakes."

Severity is shown on the map by contour lines of subsidence in five-foot increments, by areas of potential ponding, and by areas of potential lake-margin flooding. In addition, the locations of sewage-treatment plants are shown along with directions and amount of tilt. Relatively slight change in hydraulic gradients at plants, outfalls, or other major drain lines will interrupt gravity flows. Such interruptions may cause ponding of sewage and health hazards.

The text contains general discussions of the effects of subsidence on several critical facilities -- transportation, oil refineries, and wastewater

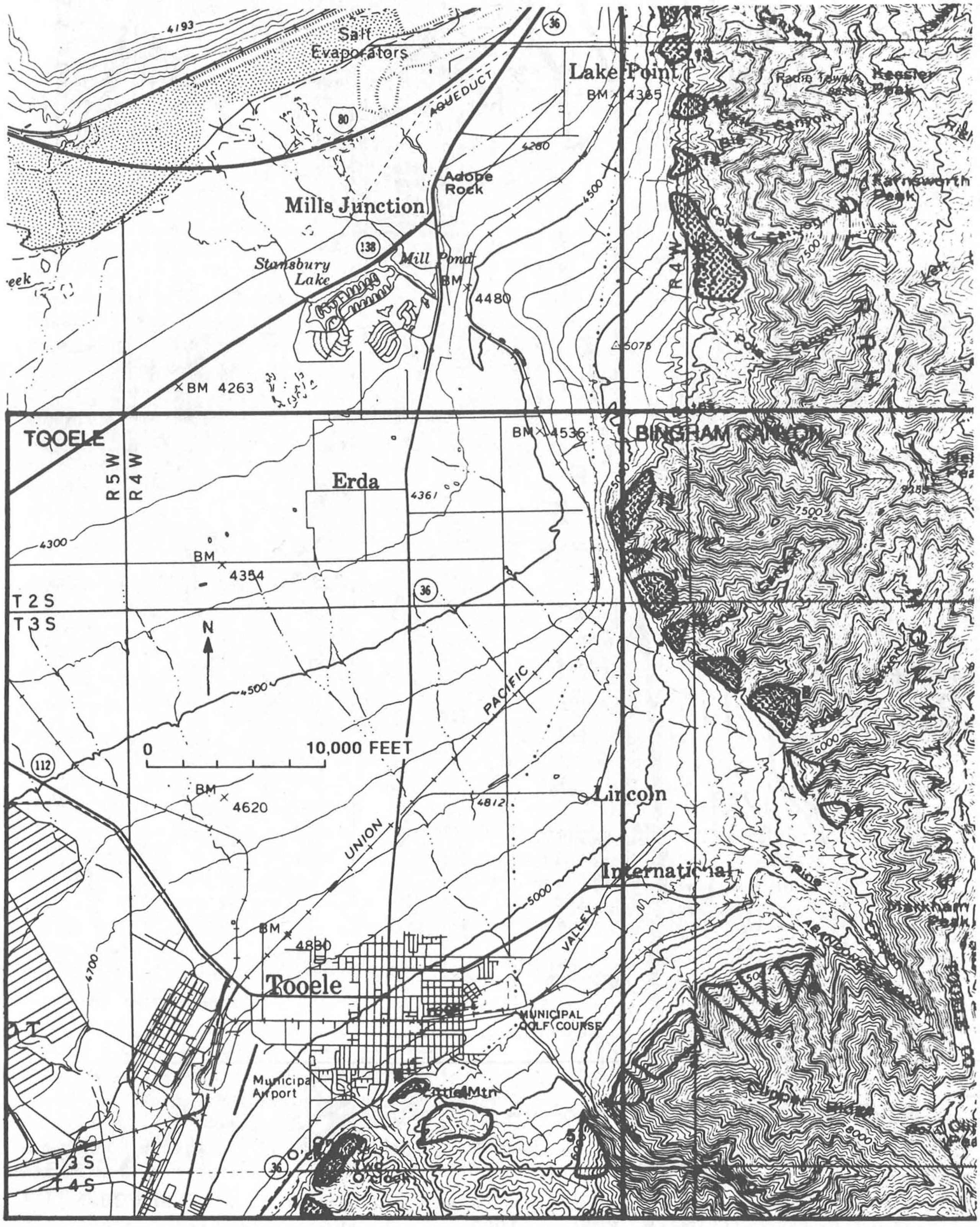

FIGURE 7. -- Part of a topographic map (scale 1:100,000) of Salt Lake and Tooele counties upon which Case (1987, p. V-11) shows mountain spur areas susceptible to rockfalls. Those areas with a rockfall hazard are stippled. Numbers within each USGS 7½-minute quadrangle are referred to in his text.

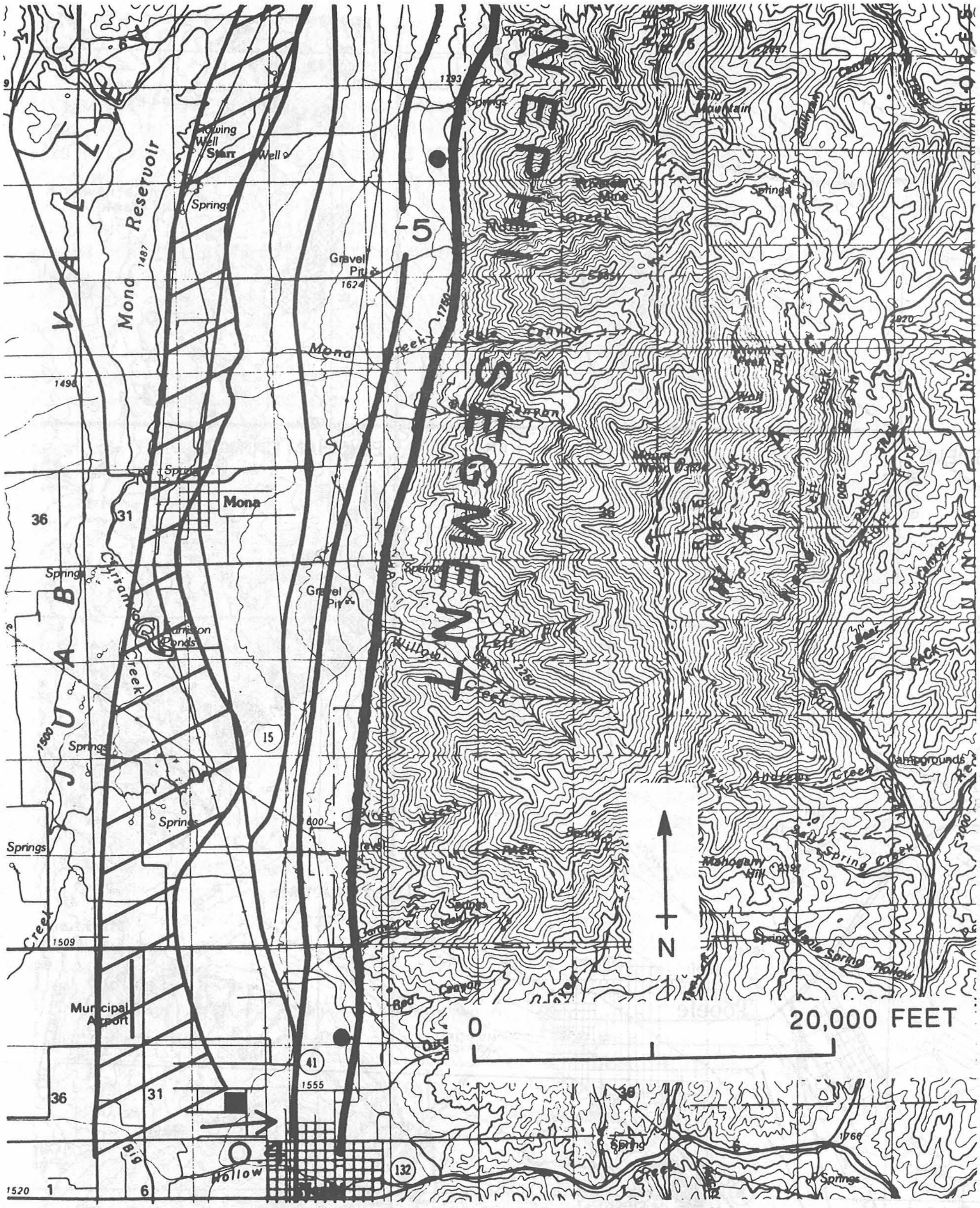

Figure 8. -- Part of a topographic map (scale 1:100,000) of northern Juab Valley, Utah, upon which Keaton (1987, pl. 6) shows potential consequences of tectonic deformation along the Nephi segment of the Wasatch fault. Fault trace is indicated by a heavy line and contours of subsidence in ft by a less heavy line. Cross-hatched area indicates potential ponding of shallow (less than 3 ft) groundwater due to subsidence. Solid square indicates the location of a sewage treatment plant with direction and amount of anticipated tilt (ft/mi) shown.

treatment plants. Similar critical facilities are likely to be interrupted by the same event reducing system backup and redundancy.

Dam Failure

McCann and Boissonnade (1985) assessed the impact of shaking on the Pineview Dam and its failure on portions of the city of Ogden. The base map used is a USGS 7½-minute quadrangle which has been reduced to a scale of 1:48,000. A design earthquake of Richter magnitude 7.5 with an epicenter in downtown Ogden is assumed. Several feet of vertical offset along the 31.5 mi of fault rupture is estimated. Ground acceleration in the range of 50 to 80 percent of gravity at the dam site is estimated. Since the Pineview dam is only 6 mi from the fault trace, they assumed (p. 5-1) that the ground motion exceeds the design basis of the dam and failure occurs.

In the event that Pineview Dam fails, the breach of the dam will release the reservoir. The boundaries of the inundated parts of Ogden for a filled reservoir are shown on a map (fig. 9) with peak flood depths. The flood wave is expected to travel with velocities as high as 20 mph. As part of the study, damage to commercial and residential buildings from the design earthquake and flooding that results from the dam failure is assessed. In addition, casualties from both the earthquake and the dam failure are also estimated.

Even though likelihood, location, and severity are given for the inundation hazard, the example is one of a failure and damage scenario only for the purposes of emergency management planning. McCann and Boissonnade (1985, p. 3-2) are careful to point out that "no speculation is made concerning the likelihood that the consequences evaluated ... could occur."

This example is one of the uses of translated research for the purpose of assessing the impact of a secondary hazard (dam failure) as well as earthquake shaking. All dams impounding greater than 20 acre-ft of water, and all dams for which dan-failure inundation studies have been completed in Utah have been compiled by Harty and Christenson (1988).

Comment

In all of these Utah examples, the three elements -- likelihood, location, and severity -- may be found, although various scales, parameters, and formats are used. Some require further translation for the nontechnical user. If these examples are easy to understand and use, it means that the researchers/authors are meeting major goals of the Utah work plan.

In some cases, the translators have taken the opportunity to include discussions or illustrations of past casualties or damage. Some include recommendations concerning use of their work for hazard reduction. In other cases, county geologists are transferring this information by providing guidelines for use of the translated information: for debris flows and liquefaction (Lowe, in press); surface fault rupture and tectonic subsidence (Robison, 1988a, b); landslides (Robison, in press); rockfalls (Nelson, in press); and other geologic hazards (Lowe and Eagan, 1987).

Often the simplicity of format and ease of use misleads users to believe that the translated products are easy to produce. A familiarity with the references cited in each report will remind the reader that numerous geologic, geophysical, and engineering studies over many years along with many innovative and creative ideas were necessary to produce these examples.

According to C.V. Nelson (oral commun., 1988), the county geologists and others are performing additional studies or compilations which will result in translated information. For example, nonearthquake-induced landslide potential information will be combined with the earthquake-induced landslide potential map prepared by Keaton and others (1987) to produce a composite landslide-hazards evaluation. A text has also been prepared discussing other hazards such as failure in sensitive clays, seiches, subsidence in granular materials, and hydrologic changes (Lowe, in press). Emmi (in press) has created maps showing the ground shaking hazard of Salt Lake County using Modified Mercalli intensity scales.

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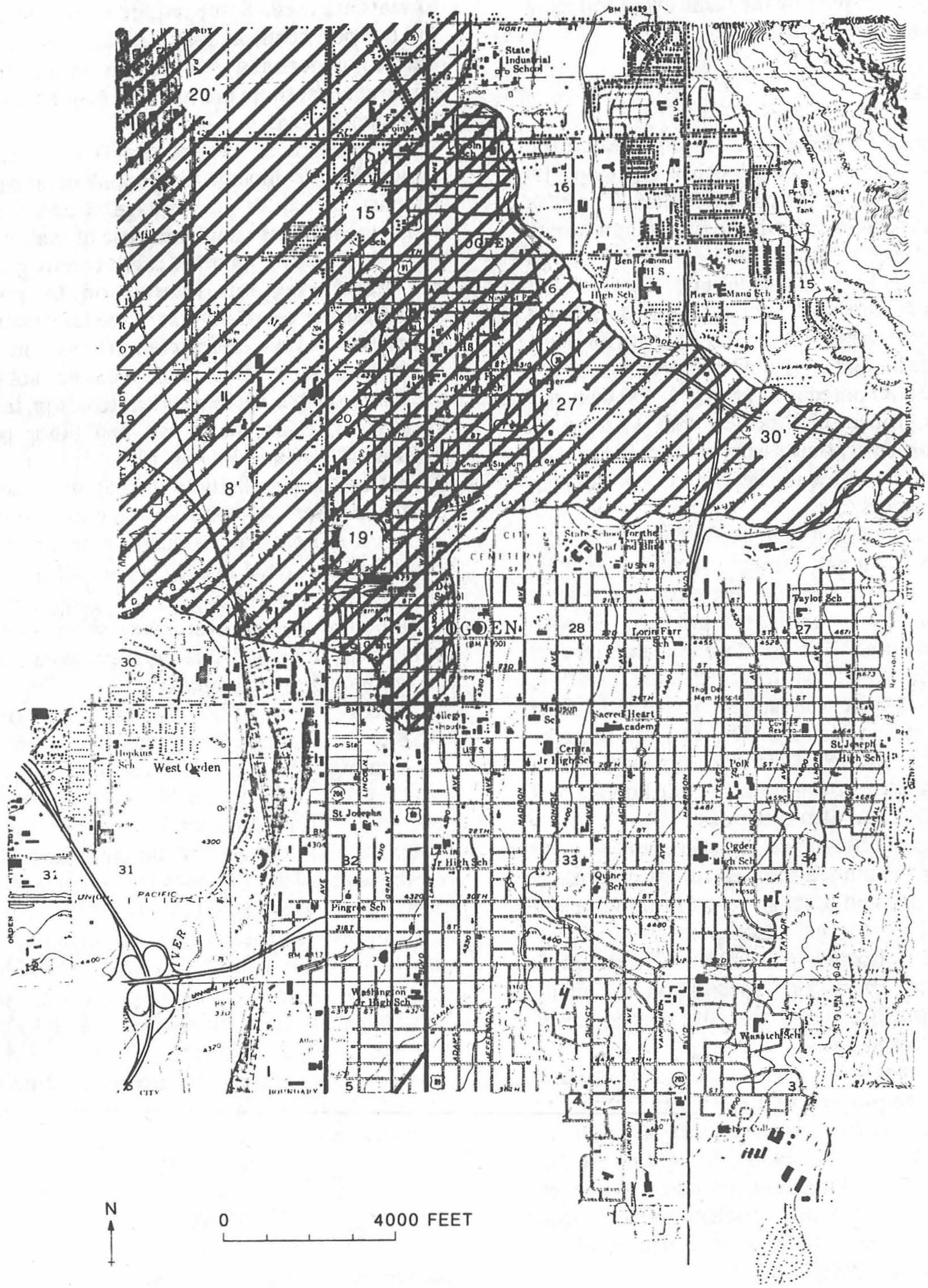

FIGURE 9. -- Topographic map (scale 1: 48,000) of Ogden/Pineview, Utah, study area upon which McCann and Boissonnade (1985, fig. 3-4a, p. 3-27) show inundation area from a failure of Pineview Dam. Numbers indicate peak flood depths in ft.

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MEETINGS AND CONFERENCES

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 for Safer Construction and Reduction of Life and Property Losses from Future Earthquakes, 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 advances in seismic zonation, integrating earth sciences, engineering, urban 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. Recent tragic earthquakes in Mexico City (1985), Armenia (1988), northern California (1989), and the Philippines (1990) have emphasized the importance of using zonation techniques to reduce earthquake damage. Tragic life losses in each of the earthquakes occurred as a result of building collapses which showed strong correlations with types of underlying geologic deposits, building designs, and proximity to and characteristics of earthquake rupture zones. Lessons learned from these events have led to multidisciplinary advances pertinent to reduction of life and property losses in future earthquakes. The conference is intended to be a major event for the International Decade for Natural Disaster Reduction. The format has been designed to ensure that multidisciplinary earthquake hazard mitigation efforts in major seismic regions of the world are represented in depth. Tours of active earthquake faults and earthquake engineering research facilities are planned to complement other conference activities. Registration for technical participants for the Conference is $325 before August 1, 1991, and $375 after August 1, 1991. For more detailed registration, housing, and travel information, contact the Earthquake Engineering Research Institute, 499 14th Street, Suite 320, Oakland, CA 94612-1902, (415) 451-0905, FAX 415-451-5411.

August 30, 1991, International Forum on Seismic Zonation, held at Stanford University in Palo Alto, California. See related article, this issue.

October 2, 1991, Contingency Planning for Business Recovery, held at the Salt Lake Airport Hilton Hotel in Salt Lake City, Utah, sponsored by the Salt Lake City Chapter of the Association of Contingency Planners. Presenters will include Gerald Ventelo or AT&T, Jed Erickson of the University of Utah Medical Center, Cole Emerson of Stanford Research Institute, and Cynthia Crose of IBM. Topics will range from the setup of emergency operations centers to the human factors in a disaster. For further information, contact Jim Tingey, Utah Division of Comprehensive Emergency Management, (801) 538-3400.

October 11-13, 1991, Rocky Mountain Friends of the Pleistocene 1991 Field Trip. The Quaternary geology of Lake Bonneville in the Sevier Desert, near Delta, Utah will be the focus of the 1991 field trip. In addition to the stratigraphy of the Wisconsin age lake, wildlife (ostracods and gastropods), sedimentary structures, isostatic rebound (helped by salt-dome tectonics), fossil soils, and volcanic ash will be examined. This is a hands-on field trip with many unsolved problems. Expect some lively academic disagreements among the co-leaders (Jack Oviatt, Dave Varnes, and Dick Van Horn) and the participants. Both camping and moteling are available. For further information, contact Dick Van Horn, U.S. Geological Survey, Box 25046, MS 966, Denver, CO 80225.

July 19-25, 1992, Tenth World Conference on Earthquake Engineering, held in Madrid, Spain, one week prior to the 1992 Olympics in Barcelona, Spain. The official language of the conference will be English. Abstract deadline is April, 1991 and the deadline to receive papers is May, 1992. Individuals wishing to receive the first, and subsequent, announcement circulars should request them from 10WCEE, Steering Committee, c/o Tilesa, Londres 39 - 1 B, 28028 Madrid, Spain.

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