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UTAH EARTHQUAKE WORKING GROUPS AND WASATCH FRONT URBAN SEISMIC HAZARD MAPS

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ABSTRACT

The Utah Geological Survey (UGS) and the U.S. Geological Survey (USGS) continued collaborative earthquake-hazard studies in Utah under a three-year cooperative agreement (calendar years [CY] 2007 to 2009) that builds on the efforts of a previous cooperative agreement (CY 2003 to 2006). The CY 2007 to 2009 cooperative agreement ensured that the annual Earthquake Working Group meetings were held to support the USGS in developing Wasatch Front urban seismic hazard maps, update various earthquake-related databases, host the Wasatch Front community velocity model (CVM), and help coordinate National Earthquake Hazards Reduction Program (NEHRP) related research in Utah.

During 2007-09, the UGS also (1) performed several scientific investigations to map and characterize faults, (2) provided assistance to USGS and NEHRP researchers, (3) published reports of completed research, (4) continued earthquake-related public outreach (including the *Putting Down Roots in Earthquake Country* publication), (5) and enhanced our Web site with new pages for the Paleoseismology of Utah publication series, CVM model and related geophysical data, and geologic hazard data for consultants and design professionals.

INTRODUCTION

The Utah Geological Survey (UGS) and the U.S. Geological Survey (USGS) continued collaborative earthquake-hazard studies in Utah under a cooperative three-year agreement (calendar years [CY] 2007 to 2009) that builds on the efforts of a previous cooperative agreement (CY 2003 to 2006, USGS Award #03HQAG0008). The 2007-09 cooperative agreement ensured that the annual Earthquake Working Group meetings were held to support the USGS in developing Wasatch Front urban seismic hazard maps, update various earthquake-related databases, host the Wasatch Front community velocity model (CVM), and help coordinate National Earthquake Hazards Reduction Program (NEHRP) related research in Utah.

RESULTS

Working Groups

The UGS, in cooperation with the USGS and the Utah Seismic Safety Commission, convened Earthquake Working Group meetings each February at the Department of Natural Resources Building in Salt Lake City, Utah. The Utah Quaternary Fault Parameters Working Group, Liquefaction Advisory Group, and Ground Shaking Working Group each met to review research activities, re-evaluate long-term plans for producing maps, and develop partnerships for investigations and topics for future NEHRP proposals. The results of the three working group meetings each year are reported in Annual Progress Reports for CY 2007 and 2008 (Christenson, 2007; Bowman, 2008), this Final Technical Report, and on the UGS Web site as described in the Data Availability section below. The 2009 working group meetings were held concurrently with the joint 2009 Earthquake Engineering Research Institute and Western States Seismic Policy Council (WSSPC) annual meeting.

Each working group has achieved consensus regarding the types of earthquake-hazard maps needed, new data required, and preferred data collection and mapping techniques. The working groups developed partnerships and identified projects for which to pursue funding. These results have been used by the USGS to develop Utah priorities for the annual USGS NEHRP external research support grant opportunity announcement for Intermountain West (IMW panel) projects. Because the meetings were held in February of each year, coincident with the annual grant opportunity release, discussions and momentum gained at the meetings were translated into proposals by researchers to the USGS.

Working group members (appendix) include geologists, engineers, seismologists, and geophysicists from the USGS, UGS, University of Utah, Utah State University, Brigham Young University, and various consulting companies and state agencies. In addition, representatives from the Utah Seismic Safety Commission, Utah Division of Homeland Security, American Society of Civil Engineers, Association of Environmental and Engineering Geologists, Salt Lake County, Utah Division of Water Rights – Dam Safety Program, and other organizations were invited to attend the meetings.

The main goal of the Utah Quaternary Fault Parameters Working Group is to characterize active fault sources in Utah. The working group began by developing consensus slip-rate and recurrence-interval data for all Utah trenched faults (Lund, 2005). The working group also developed an initial priority list of faults requiring additional study and, based on each year's paleoseismic investigations, has updated the list annually. As new paleoseismic data became available, the working group modified its consensus slip-rate and recurrence-interval values as necessary. Other working group issues included discussions regarding the need for a Wasatch Front community fault model and a Wasatch fault time-dependent earthquake model, and discussions related to the generalization of the surface trace of the Salt Lake City segment of the Wasatch fault on the National Seismic Hazard Maps (NSHM), and the relation of the West Valley fault zone to the Wasatch fault. In addition, the working group and the UGS made recommendations regarding which faults should be included in future USGS NSHM updates.

The Liquefaction Advisory Group continued its long-term goal to produce maps showing annual probabilities of liquefaction and liquefaction-induced ground displacement, and focused on extending their pilot-project investigations in Salt Lake Valley to Utah and Davis Counties, particularly regarding compilation of a comprehensive regional geotechnical database. The working group discussed issues related to under-sampling of geologic units, uncertainty analysis, compilation of newly available geotechnical data, and conducting additional cone penetrometer investigations in downtown Salt Lake City. Work is underway to complete current projects and publish liquefaction maps in a format for use by local government planners and other users.

The Ground Shaking Working Group continued to develop the CVM for use by the USGS, UGS, and their partners in order to develop large-scale spectral acceleration maps for the Wasatch Front that incorporate site and basin-shape effects. A team from San Diego State University (SDSU) recently updated the prior model with newly available data that included both shallow-shear-wave velocity (Vs30) and deep-basin-structure effects on ground motion. The UGS has received the CVM from the SDSU team, and is distributing it on our Web site (see Data Availability section). Current efforts involve validating the CVM, expanding the CVM to include Tooele and Rush Valleys and the Wasatch back valleys, updating the CVM with intermediate-depth data, and continuing to work toward producing Wasatch Front Urban Seismic Hazard Maps.

Database Updates

The Ground Shaking Working Group is discussing the need for and analysis of large-scale ground-shaking maps for the Wasatch Front, based on a CVM incorporating shallow shear-wave velocity (Vs30) and deep-basin structure, and new liquefaction-hazard maps. The UGS has compiled databases that identify existing data on shallow shear-wave velocities (Vs30), deep-basin structure, geotechnical landslide shear strengths, and Quaternary faults and folds. We updated the databases to include new data available through mid-2009.

We continue to track new geologic mapping and studies of Quaternary faults in Utah for updates to the *Utah Quaternary Fault and Fold Database and Map*. Presently, about two dozen faults and fault sections need updated database files; we have completed draft updates for seven of these. Once through

the UGS review process, the revised database files will be forwarded to the USGS for incorporation into the *Quaternary Fault and Fold Database of the United States*.

We continue to develop an interactive map and database of Utah's Quaternary faults and folds that will be accessible through the UGS Web site. This version of the map and database supplements the *Quaternary Fault and Fold Database of the United States* by highlighting structures for which new data exist, but may not yet be available through the national database. The map will be served on the Internet with ESRI's ArcServer technology, for user on-the-fly location querying and map generation.

Wasatch Front Community Velocity Model

We distributed the CVM to interested researchers upon request and developed a Web page describing the CVM and providing information on how to download the data files for use by end-users. UGS staff have not yet worked with the CVM sufficiently to determine our capability to update and make it available as an interactive product on the UGS Web site.

Assistance to USGS and NEHRP Researchers

During 2007, the UGS provided database information to assist the USGS in site selection for their micro-tremor surveys in summer 2007. We reviewed the draft report on USGS geophysical studies in Utah from 2003 to 2005, and the 2007 draft NSHMs for Utah with respect to incorporation of the 2006 Basin and Range Province Earthquake Working Group recommendations (Lund, 2006). We also worked with the USGS to determine which Utah faults should be added to the NSHMs and to develop earthquake parameters for those faults. We assisted University of Utah researchers with geologic interpretations for the liquefaction geotechnical database and mapping in southern Salt Lake Valley as a follow-up to our NEHRP-funded work in the first years of the project in northern Salt Lake Valley. We reviewed draft probabilistic lateral-spreading maps for Salt Lake County, and worked with potential local-government users of the maps to determine the final map format and content.

During 2008, the UGS worked with the USGS in support of revisions to the NSHMs—in particular, issues related to the West Valley fault zone. We also assisted the University of Utah Department of Geology and Geophysics with a seismic refraction study of the Washington fault and with liquefaction studies by the University of Utah and Brigham Young University. The UGS also assisted WSSPC in revising Policy Recommendation 08-2: Definitions of Fault Activity for the Basin and Range Province.

During 2009, the UGS again worked with the USGS in support of revisions to the NSHMs—in particular, issues related to the West Valley fault zone, and with a paleoseismic investigation of the Bear River fault in northeastern Utah. In cooperation with the Arizona Geological Survey, the UGS funded a paleoseismic investigation of the Washington fault in Arizona, a few miles south of the Utah-Arizona border. The Washington fault trends northward from that location into the rapidly urbanizing St. George metropolitan area. The investigation consisted of excavating three fault trenches, mapping and sampling trench exposures, and optically stimulated luminescence dating of four samples. Due to UGS funding limitations, additional radiocarbon dating and data analysis has not been completed. The UGS also assisted WSSPC in revising Policy Recommendations 10-3: Post-Earthquake Technical Clearinghouses, 10-5: Basin and Range Province Earthquake Working Group(s), and 10-6: Post-Earthquake Information Management System.

REPORTS PUBLISHED

We have posted the results of the 2009 working group meetings on the UGS Web site at http://geology.utah.gov/ghp/workgroups/index.htm. The report of the ongoing fault trenching investigation for the Brigham City segment of the Wasatch fault is anticipated to be published in 2010. Reports in support of the earthquake working groups and NEHRP-funded projects published by the UGS or written by UGS authors in 2007 to 2009 are listed below:

- Bowman, S.D., Beisner, K., and Unger, C., 2009, Compilation of 1970s Woodward-Lundgren & Associates Wasatch fault investigation reports and oblique aerial photography, Wasatch Front and Cache Valley, Utah and Idaho: Utah Geological Survey Open-File Report 548, 3 p., 6 plates, DVD. (http://geology.utah.gov/ghp/consultants/aerial_compilations.htm)

- DuRoss, C.B., 2008, Holocene vertical displacement on the central segments of the Wasatch fault zone, Utah: Bulletin of the Seismological Society of America, v. 98, no. 6, p. 2918-2933.

- DuRoss, C.B., McDonald, G.N., and Lund, W.R., 2008, Paleoseismic investigation of the northern strand of the Nephi segment of the Wasatch fault zone at Santaquin, Utah – Paleoseismology of Utah, Volume 17: Utah Geological Survey Special Study 124, 33 p., 1 plate, CD. (http://geology.utah.gov/online/ss/ss-124.pdf)

- DuRoss, C.B., McDonald, G.N., Crone, A.J., Personius, S.F., and Lidke, D.J., 2008, Paleoseismology of the northern Weber segment at the Rice Creek site, Wasatch fault zone, Utah: Seismological Research Letters, v. 79, no. 2, p. 337.

- DuRoss, C.B., Personius, S.F., Crone, A.J., McDonald, G.N., and Lidke, D.J., 2009, Paleoseismic investigation of the northern Weber segment of the Wasatch fault zone at the Rice Creek trench site, North Ogden, Utah – Paleoseismology of Utah, Volume 18: Utah Geological Survey Special Study 130, 37 p., 2 plates, CD. (http://geology.utah.gov/online/ss/ss-130.pdf)

- DuRoss, C.B, Briggs, R.W., Crone, A.J., Lund, W.R., McDonald, G.N., and Personius, S.F., 2009, Holocene paleoseismology of the Nephi, Weber, and Brigham City segments of the Wasatch fault zone, Utah - insights from recent trench investigations [abs.]: Geological Society of America Abstracts with Programs, Rocky Mountain Section, v. 41, no. 6, p. 42.

- DuRoss, C.B., Personius, S.F., Crone, A.J., McDonald, G.N., and Briggs, R.W., 2009, Timing of the most-recent surface-faulting earthquake on the Brigham City segment, Wasatch fault zone, Utah: Seismological Research Letters, v. 80, no. 2, p. 292.

- DuRoss, C.B., dePolo, C.M., Koehler, R.D., Bowman, S.D., McDonald, G.N., and Shaw, L.M., in press, Immediate scientific response to the 2008 Wells, Nevada, earthquake: Nevada Bureau of Mines and Geology Anniversary Volume on the Wells Earthquake.

- Hylland, M.D., 2007, Surficial-geologic reconnaissance and scarp profiling on the Collinston and Clarkston Mountain segments of the Wasatch fault zone, Box Elder County, Utah ─ paleoseismic inferences, implications for adjacent segments, and issues for diffusion-equation scarp-age modeling – Paleoseismology of Utah, Volume 15: Utah Geological Survey Special Study 121, 18 p., CD. (http://ugspub.nr.utah.gov/publications/special_studies/SS-121.pdf)

- Hylland, M.D., and Machette, M.N., 2008, Surficial geologic map of the Levan and Fayette segments of the Wasatch fault zone, Juab and Sanpete Counties, Utah: Utah Geological Survey Map 229, 37 p., scale 1:50,000. (http://geology.utah.gov/online/m/m-229.pdf)

- Hylland, M.D., 2009, The West Valley fault zone, Salt Lake Valley, Utah—what do we really know about its seismic hazard [abs.]: Geological Society of America Abstracts with Programs, Rocky Mountain Section, v. 41, no. 6, p. 41.

- Knudsen, T.R., and Lund, W.R., 2009, Paleoseismic investigation of the Washington fault in southwestern Utah: 2009 EERI-WSSPC Annual Meeting, Salt Lake City, Utah, poster presentation.

- Lund, W.R., Hozik, M.J., and Hatfield, S.C., 2007, Paleoseismic investigation and long-term slip history of the Hurricane fault in southwestern Utah – Paleoseismology of Utah, Volume 14: Utah Geological Survey Special Study 119, 81 p., CD. (http://ugspub.nr.utah.gov/publications/special_studies/SS-119.pdf)

- Lund, W.R., 2008, Utah post-earthquake technical clearinghouse ─ a critical component of earthquake emergency response, recovery, and mitigation [abs.]: National Earthquake Conference Abstracts with Programs, April 22-26, 2008, Seattle, WA, p. 76, www.earthquakeconference.org.

- Lund, W.R., 2008, Utah's earthquake threat ─ how much do we know, how do we know it, and what are we doing about it?: Utah Geological Association Newsletter, v. 40, no. 7, p. 1-2.

- Lund, W.R., Knudsen, T.R., and Vice, G.S., 2008, Paleoseismic reconnaissance of the Sevier fault, Kane and Garfield Counties, Utah – Paleoseismology of Utah, Volume 16: Utah Geological Survey Special Study 122, 37 p., CD. (http://ugspub.nr.utah.gov/publications/special_studies/SS-122.pdf)

- McDonald, G.N., and Ashland, F.X., 2008, Earthquake site conditions in the Wasatch front urban corridor, Utah: Utah Geological Survey Special Study 125, 41 p., 1 plate, CD. (http://geology.utah.gov/online/ss/ss-125.pdf)

- Olsen, M.J., Bartlett, S.F., and Solomon, B.J., 2007, Lateral spread hazard mapping of the northern Salt Lake Valley, Utah, for a M 7.0 scenario earthquake: Earthquake Spectra, v. 23, no. 1, p. 95-113.

- Olig, S.S., McDonald, G.N., Black, B.D, DuRoss, C.B., and Lund, W.R., 2009, Lessons learned from the Mapleton megatrench about the rupture behavior of the Wasatch fault zone, Utah [abs.]: Geological Society of America Abstracts with Programs, Rocky Mountain Section, v. 41, no. 6, p. 42.

- Personius, S.F., and Scott, W.E., 2009 (digital release), Surficial geologic map of the Salt Lake City segment and parts of adjacent segments of the Wasatch fault zone, Davis, Salt Lake, and Utah Counties, Utah (digitized from U.S. Geological Survey Miscellaneous Investigations Series Map I-2106 [1992]): Utah Geological Survey Map 243DM, GIS data, scale 1:50,000. (http://ugspub.nr.utah.gov/publications/GIS_maps/m-243.zip)

- Utah Geological Survey, 2008, The Wasatch fault flyby video: Utah Geological Survey Public Information Series 92. (http://geology.utah.gov/utahgeo/hazards/eqfault/wfault_flyby.htm)

- Utah Seismic Safety Commission, 2008, Putting down roots in earthquake country ─ your handbook for earthquakes in Utah: Utah Seismic Safety Commission, Salt Lake City, Utah, 33 p. (http://www.ussc.utah.gov/publications/roots_earthquake.pdf)

DATA AVAILABILITY

We have posted the results of the 2009 working group meetings on the UGS Web site at http://geology.utah.gov/ghp/workgroups/index.htm. In addition, the UGS Geologic Hazards Program revised significant portions of its Web site (http://geology.utah.gov/ghp/index.htm) by making information and publications easier to locate, scanning documents and maps not previously in digital format, developing a new Web page for the Paleoseismology of Utah Series (http://geology.utah.gov/ghp/consultants/paleoseismic_series.htm), developing a new Web page for the CVM model and related data, and developing new Web pages focused on consultant and design professional needs (http://geology.utah.gov/ghp/consultants/index.htm). The shallow-shear-wave velocity, deep-basin-structure, and landslide geotechnical shear-strength databases are currently available from Greg McDonald, UGS at (801) 537-3383, email: gregmcdonald@utah.gov. During 2010, the CVM model Web page will be updated to include geophysical database information.

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Table 1 – Earthquake Working Group Liaisons and Facilitators

Working Group	UGS Liaison	Facilitator
Quaternary Fault Parameters	Bill Lund	Bill Lund
Liquefaction Advisory Group	Barry Solomon (2007 - 2008) Mike Hylland (2009)	Dr. Steve Bartlett, UU
Ground Shaking Working Group	Gary Christenson (2007 - 2008) Greg McDonald (2008 - 2009)	Ivan Wong, URS Corp.

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Christenson, G.E., 2007, Utah Earthquake Working Groups and Wasatch Front urban seismic hazard maps, 2007 progress report (year 1): Salt Lake City, Utah Geological Survey Progress Report to the U.S. Geological Survey, Award number 07HQAG0003, 6 p.

Lund, W.R., 2005, Consensus preferred recurrence-interval and vertical slip-rate estimates—review of paleoseismic-trenching data by the Utah Quaternary Fault Parameters Working Group: Utah

Geological Survey Bulletin 134, CD. (http://ugspub.nr.utah.gov/publications/bulletins/B-134.pdf)

Lund, W.R., 2006, Basin and Range Province Earthquake Working Group seismic-hazard recommendations to the U.S. Geological Survey National Seismic Hazard Mapping Program: Utah Geological Survey Open-File Report 477, 23 p. (http://geology.utah.gov/online/ofr/ofr-477.pdf)

APPENDIX – 2009 UTAH EARTHQUAKE WORKING GROUP MEMBERS

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Michael Hylland, Utah Geological Survey
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James Pechmann, University of Utah Seismograph Stations
Steve Personius, U.S. Geological Survey
Mark Petersen, U.S. Geological Survey
Lucy Piety, U.S. Bureau of Reclamation (for Larry Anderson)
Christine Puskas, University of Utah Department of Geology and Geophysics (for Robert Smith)
Ivan Wong, URS Corporation

Ground Shaking Working Group
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Mark Petersen, U.S. Geological Survey
Travis Gerber, Brigham Young University Civil and Environmental Engineering Department
Grant Gummow, Utah Department of Transportation