



2018 UTAH EARTHQUAKE WORKING GROUP MEETINGS UTAH QUATERNARY FAULT PARAMETERS WORKING GROUP SUMMARY

Wednesday, February 14, 2018

Utah Department of Natural Resources Building, Auditorium (1st Floor)
1594 West North Temple, Salt Lake City, Utah

WELCOME AND INTRODUCTION

Steve Bowman (Utah Geological Survey [UGS]) called the 2018 Utah Quaternary Fault Parameters Working Group (UQFPWG) meeting to order at 8:15 a.m. After welcoming Working Group members and guests, Steve summarized the UQFPWG's past activities and outlined the Working Group's purpose and goals for the future.

UQFPWG Purpose and Goals

- One of three standing committees created to help set and coordinate Utah's earthquake-hazard research agenda.
- Reviews ongoing paleoseismic research in Utah, and updates the Utah consensus slip-rate and recurrence-interval database as necessary.
- Provides advice/insight regarding technical issues related to fault behavior in Utah and the Basin and Range Province.
- Identifies and prioritizes future Utah Quaternary fault paleoseismic investigations.

U.S. Geological Survey Update

Ryan Gold, Intermountain West Coordinator for the U.S. Geological Survey (USGS), Earthquake Hazards Program, gave a summary and status of the External Research Support function, and information on the upcoming 2018 funding announcement for proposals.

TECHNICAL PRESENTATIONS

The following presentations were made on current paleoseismic research and related activities in Utah, most presentations are available at <http://geology.utah.gov/hazards/earthquakes-faults/utah-earthquake-working-groups/quaternaly-fault-parameters/>.

- Updated Seismic Imaging of the Salt Lake City Area from 2015 and 2017 Campaigns: Lee Liberty, Boise State University
- New Utah Earthquakes (1850 to 2016) and Quaternary Faults Map: Steve Bowman, Utah Geological Survey and Walter Arabasz, University of Utah Seismograph Stations
- Detailed Mapping of the Wasatch Fault Zone, Utah and Idaho, Using High-Resolution Lidar Elevation Data: Greg McDonald, Adam Hiscock, and Emily Kleber

- Technical Summary of the Traverse Ridge Paleoseismic Site in Draper, Utah: Joseph Phillips and Nate Toke, Utah Valley University
- Preliminary Findings from Trenches on the Levan and Fayette Segments of the Southern Wasatch Fault Zone, Central Utah: Greg McDonald, Adam Hiscock, and Mike Hylland, Utah Geological Survey
- New West Valley Fault Zone Mapping with Insights from Consultant Investigations: Adam McKean, Utah Geological Survey
- Wasatch Landslides and Paleoseismic Record: Brendon Quirk, University of Utah
- Reconnaissance Investigation of the Thousand Lake Fault near Bicknell, Utah: Joseph Phillips and Nate Toke, Utah Valley University
- Frontier Observatory for Research in Geothermal Energy (FORGE) – Milford Site Quaternary Faulting: Emily Kleber and Tyler Knudsen, Utah Geological Survey
- Update of Ongoing Studies to Evaluate the Seismic Potential of the Joes Valley Fault Zone, East-Central Utah: Julia Howe and Lucy Piety, U.S. Bureau of Reclamation
- Topliff Hills Fault Investigation Update: Mike Bunds, Utah Valley University
- A Review of the California Approaches for Evaluating Fault Activity: Robert Tepel, retired
- Progress Towards an Updated Nevada Seismic Hazards Model: Rich Koehler, Nevada Bureau of Mines and Geology
- Update from the 2017 8th International Workshop on Paleoseismology, Active Tectonics and Archeoseismology Meeting: Emily Kleber, Utah Geological Survey

TECHNICAL DISCUSSION ITEMS

Adam McKean led a discussion about the benefits of incorporating consultant surface-fault rupture investigations into urban geologic mapping. Steve Bowman and Emily Kleber led a discussion about the 2019 fault investigation priorities.

UQFPWG 2019 FAULT INVESTIGATION PRIORITIES

In 2005, the UQFPWG recommended that 20 Quaternary faults/fault segments in Utah be investigated to “adequately characterize Utah’s earthquake hazard to a minimally acceptable level” (table 1; Lund, 2005). Since then, the Working Group has added an additional 12 faults/fault segments to the list: five in 2007; one in 2009; one in 2010; four in 2011; three general recommendations regarding the five central segments of the Wasatch fault zone, fault zone mapping, and acquisition of high resolution imagery in 2012, 2014, 2015, respectively; one in 2016, plus the relationship of salt tectonics to eight faults or fault zones; and slightly modified the existing list of highest priorities in 2017 and 2018. Utah’s mapped Quaternary faults are shown on figure 1.

Table 2 lists faults and fault segments in the USGS National Seismic Hazard Maps or the UGS Hazus Utah fault database (figure 2; Lund, 2014) not listed in table 1 that may warrant additional investigation. Figure 1 shows the faults and fault segments listed in tables 1 and 2. Table 3 lists the current status of paleoseismic investigations for Utah priority faults and fault segments identified by the UQFPWG as priorities for investigation. Note that faults or fault segments listed in table 3 as having received some level of paleoseismic investigation does not imply that all of the paleoseismic data necessary to fully characterize those faults or fault segments has been acquired; further investigation of those structures may be necessary.

The UQFPWG conducts an annual review of progress made toward investigating the faults and fault segments on the priority list. Based on that review, the Working Group establishes a short list of the highest priority faults and fault segments for future investigation. The list of highest priority faults and fault segments is published on the UGS website (<http://geology.utah.gov/hazards/earthquakes-faults/utah-earthquake-working-groups/>), which is then referenced by the USGS Earthquake Hazards Program in their annual External Research Support (National Earthquake Hazards Reduction Program [NEHRP]) request for proposals. As part of Chris DuRoss's presentation, he proposed specific areas along the Wasatch fault zone where more work is needed; these areas are shown on figure 3.

The Working Group's highest priority list for 2019 includes (not in priority order):

- Acquire new paleoseismic information to address data gaps for (a) the five central segments of the Wasatch fault zone (including focusing on the youngest earthquakes [3-5 ka]; large, early Holocene–latest Pleistocene scarps; and secondary faulting [West Valley fault zone and Utah Lake faults and folds]), (b) the northern segment of the Oquirrh fault zone, (c) the Toplift Hills fault, and (d) the East and West Cache fault zones. Examples of paleoseismic data to be acquired include surface rupture extent, earthquake timing, displacement, and fault geometry.
- Use recently acquired lidar data to more accurately map the traces of the East and West Bear Lake, East and West Cache, and Hurricane fault zones, and search for and map previously undiscovered mid-valley Quaternary faults.
- Acquire earthquake timing information for the Utah Lake fault zone to investigate the relation of earthquakes on that fault system to large earthquakes on the adjacent Provo segment of the Wasatch fault zone (coseismic or independent rupture, fault pairs?).
- Acquire and analyze information on salt tectonics and its relation to the Main Canyon fault, Sevier detachment/Drum Mountains fault zone, Bear River fault zone, Spanish Valley (Moab area) faults, Joes Valley fault zone, Levan and Fayette segments of the Wasatch fault zone (in progress), Scipio Valley faults, and the Gunnison fault.

The Working Group's other priority list for 2019 was not modified.

Table 4 shows the 2019 highest priority fault and fault segment recommendations, table 5 shows the list of other priority faults and fault segment recommendations, and both tables show the current investigation status for all faults and fault segments identified by the UQFPWG as requiring additional investigation. All of the faults/fault sections listed in table 3 remain priorities and should be considered for future investigation if a compelling case can be made for the need to acquire additional paleoseismic data.

WORKING GROUP PRODUCTS AND RELATED DATA

The final agenda, speaker presentations, and this summary document are available on the UQFPWG web page at <http://geology.utah.gov/hazards/earthquakes-faults/utah-earthquake-working-groups/quaternary-fault-parameters/>. Paleoseismic investigations that developed out of the UQFPWG meetings and published by the UGS are available in the *Paleoseismology of Utah* series at <http://geology.utah.gov/hazards/technical-information/paleoseismology-of-utah-series/>. Most of the USGS NEHRP funded investigations for Utah that were not published by the UGS are compiled in USGS Miscellaneous Publication 13-03 (http://ugspub.nr.utah.gov/publications/misc_pubs/mp-13-3/mp13-03.pdf).

Utah Quaternary Fault and Fold Database

The UGS last updated the *Utah Quaternary Fault and Fold Database* (figure 1) on January 26, 2017, incorporating new data and updates. Users of any Quaternary fault trace and related data acquired from the UGS or the Utah Automated Geographic Reference Center (AGRC) State Geographic Information Database (SGID) in the past are advised to use the updated database available from the AGRC SGID (<http://gis.utah.gov/data/how-to-connect-to-the-sgid-via-sde/>) as the SGID10.GEOSCIENCE.QuaternaryFaults feature class (<https://gis.utah.gov/data/geoscience/quaternary-faults/>). This single, comprehensive feature class will be periodically updated as new/updated data become available (anticipated several times per year) and replaces the six previously available feature classes of variable completeness. A web map application for the database is available at <http://geology.utah.gov/resources/data-databases/qfaults/>.

Utah Lidar Data

Lidar data collected by the UGS and its partners (figure 4) are in the public domain and available from OpenTopography (<http://opentopography.org/>) and AGRC (<https://gis.utah.gov/data/elevation-terrain-data/>). General information and previous acquisitions are available at <http://geology.utah.gov/resources/data-databases/lidar-elevation-data/>.

Since 2013, about 150 billion points and more than 175 GB of raster lidar data collected by the UGS and its partners have been downloaded by users from OpenTopography. In terms of point cloud usage, the *2013–2014 State of Utah Acquired Lidar Data—Wasatch Front* and *2011 Utah Geological Survey Lidar* datasets are currently ranked by OpenTopography as number 9 and 15, respectively, out of 268 point cloud datasets. In terms of raster usage, the *2013–2014 State of Utah Acquired Lidar Data—Wasatch Front* dataset is currently ranked by OpenTopography as number 9 out of 268 datasets.

MEETING ATTENDANCE
Working Group Members (* Speaker)

Steve Bowman	Utah Geological Survey (UQFPWG Co-Chair)
Michael Bunds*	Utah Valley University
David Dinter	University of Utah, Department of Geology & Geophysics
Chris DuRoss	U.S. Geological Survey, Earthquake Hazards Program
Ryan Gold*	U.S. Geological Survey, Earthquake Hazards Program, IW Coordinator
Adam Hiscock*	Utah Geological Survey (UQFPWG UGS Liaison)
Michael Hylland	Utah Geological Survey
Susanne Janecke	Utah State University
Emily Kleber*	Utah Geological Survey (UQFPWG Co-Chair)
William Lund	Utah Geological Survey, Emeritus
Johnny MacLean	Southern Utah University
Greg McDonald*	Utah Geological Survey
Jim Pechmann	University of Utah Seismograph Stations
Mark Petersen	U.S. Geological Survey, National Seismic Hazard Maps Liaison
Joanna Redwine	U.S. Bureau of Reclamation
Nathan Toke*	Utah Valley University
Ivan Wong	Lettis Consultants International
Adolph Yonkee	Weber State University

Guests (* Speaker)

Zack Anderson	Utah Geological Survey
Bob Biek	Utah Geological Survey
Bob Carey	Utah Division of Emergency Management
David Dinter	Utah Geological Survey
Patrick Emery	Gordon Geotechnical
Ben Erickson	Utah Geological Survey
Rich Giraud	Utah Geological Survey
Michael Hansen	RB&G Engineering
Julia Howe*	Bureau of Reclamation
Michael Hylland	Utah Geological Survey
Paul Jewell	University of Utah
Tyler Knudsen	Utah Geological Survey
Rich Koehler*	Nevada Bureau of Mines and Geology
Mark Larzen	CMT Engineering
Lee Liberty*	Boise State University
Cecily Light	Citizen (none given)
Elliott Lips	Great Basin Earth Science
Joss Lonn	Montana Bureau of Mines and Geology
Bill Lund	Utah Geological Survey (retired)
Adam McKean*	Utah Geological Survey
Kristine Pankow	University of Utah Seismic Stations
Phil Pearthree	Arizona Geological Survey
Jim Pechmann	University of Utah Seismic Stations
Joseph Phillips*	Utah Valley University
Brendon Quirk*	University of Utah
Gordon Seitz	California Geological Survey
Greg Schinker	GLS Geoscience

David Simon	Simon Associates
Mike Stickney	Montana Bureau of Mines and Geology
Robert Tempel*	Retired consultant
Alessandro Valentni	University of Chieti, Italy
Seth Wittke	Wyoming Geological Survey
Cianna Wyshnytzky	National Resource Conservation Service (NRCS)
Petr Yakovlev	Montana Bureau of Mines and Geology

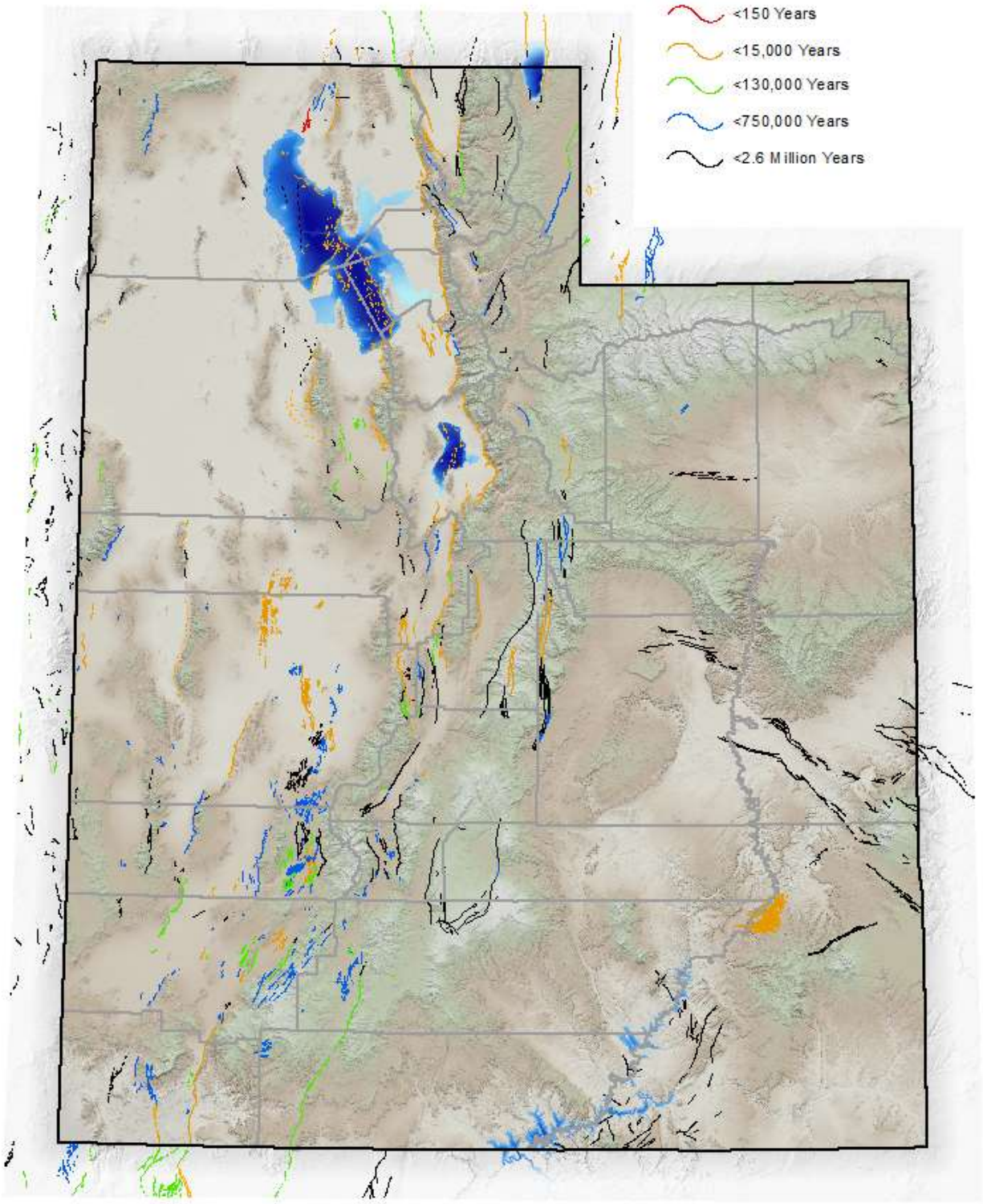


Figure 1. Utah and surrounding area Quaternary faults and folds (for Utah from the [Utah Quaternary Fault and Fold Database](#); Utah Geological Survey, 2017). Nevada faults are from the [Quaternary Faults in Nevada](#) map database (dePolo, 2008), and faults in Arizona, Colorado, Idaho, and Wyoming are from the [Quaternary Fault and Fold Database of the United States](#) (USGS, 2006). Additional Quaternary faults may exist, but they have not been mapped, may not have surface exposures, or were mapped subsequent to the latest database revisions.

Utah Lidar Elevation Data Availability

A significant area of high-resolution (≤ 1 meter) lidar elevation data in the state of Utah is now available totaling over 6846 square miles (mi^2) from AGRC (<https://gis.utah.gov/data/elevation-terrain-data/>) and OpenTopography (<http://opentopography.org>). UGS and AGRC led partnerships of multiple, diverse local, state, and federal agencies, and non-governmental organizations have been instrumental in acquiring new, high-quality public domain lidar data. Figure 3 shows the existing and planned lidar data available in Utah. An additional 14,452 mi^2 is planned for acquisition in 2018. For major Quaternary faults, data is now available for the East and West Cache, Hurricane, Wasatch, and West Valley fault zones. The UGS is using this data to map fault traces associated with these fault zones at scales of 1:10,000, where possible, or 1:24,000, where the ground surface has been significantly disturbed by urbanization and other activities. The mapping is used to define Special Study Zones around fault traces, where paleoseismic investigations are highly recommended by the UGS for new development (see Lund and others, 2016, *Guidelines for Evaluating Surface-Fault-Rupture Hazards in Utah*, in UGS Circular 122, pages 33 to 58, <https://ugspub.nr.utah.gov/publications/circular/c-122.pdf>).

Utah Consensus-Based Quaternary Fault Parameters

The main goal of the UQFPWG is to characterize hazardous earthquake fault sources in Utah. The working group began in 2003 by developing consensus slip-rate (SR) and recurrence-interval (RI) data for all Utah trenched faults (Lund, 2005; <https://ugspub.nr.utah.gov/publications/bulletins/B-134.pdf>), based on a comprehensive evaluation of paleoseismic-trenching data available at that time for Utah's Quaternary faults, and where the data permitted, assigned consensus preferred RI and vertical SR estimates for the faults and/or fault sections reviewed. Trenching data were available for 33 of Utah's known 211 Quaternary faults/fault sections and related structures. The available paleoseismic trenching data are most abundant on the six central, active segments of the Wasatch fault zone (WFZ), and are much less abundant for faults elsewhere in Utah.

Based on recent work by the Working Group on Utah Earthquake Probabilities (that included a comprehensive evaluation of all paleoseismic data in the Wasatch Front region as defined by the group http://ugspub.nr.utah.gov/publications/misc_pubs/mp-16-3/mp-16-3.pdf), and the UGS Hazus Utah fault database (https://ugspub.nr.utah.gov/publications/open_file_reports/ofr-631.pdf), the UGS is incorporating these updated Quaternary fault parameters in the UGS *Utah Quaternary Fault and Fold Database* for release in 2018.

Working Group Fault Investigation Priorities

In 2005, the UQFPWG developed a list of Quaternary faults and fault segments (table 1) that the working group identified as requiring additional investigation to adequately characterize Utah's earthquake hazard to a minimally acceptable level. The list was expanded during subsequent UQFPWG meetings in 2007, 2009, and annually between 2010 and 2017. Table 2 lists the faults and fault segments (earthquake sources) incorporated in the UGS *Utah Quaternary Fault and Fold Database*, the USGS National Seismic Hazard Maps, and/or the UGS Hazus Utah fault database (updated through 2013, UGS Open-File Report 631). Faults not listed in table 1 may need additional investigation. Table 3 lists the current status of paleoseismic investigations for priority faults and fault segments in table 1. Tables 4 and 5 list the 2018 UQFPWG priority faults and fault segments. Figure 4 shows recommended WFZ future paleoseismic investigations by DuRoss (from 2016 UQFPWG presentation), based on data gaps. The UQFPWG will review the 2018 fault-investigation priorities and make changes as necessary for the 2019 priority list.

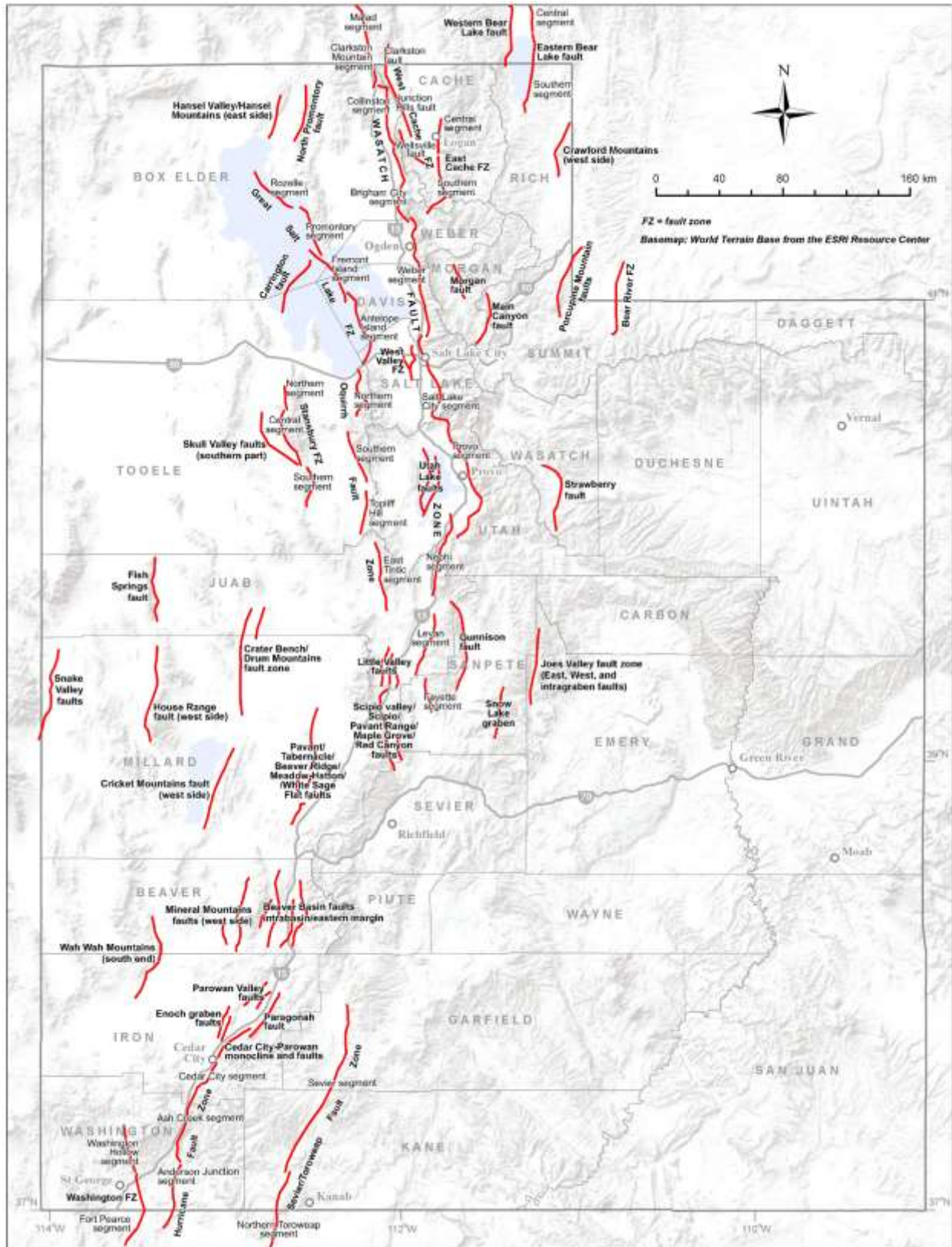


Figure 2. Faults included in the UGS Hazus Utah fault database, except the Cedar City-Parowan monocline and faults were removed in 2016 (see table 1; database updated through 2013, [UGS Open-File Report 631](#)).

Table 1. List of Quaternary faults and fault segments identified by the UQFPWG since 2005 as requiring additional investigation to adequately characterize Utah's earthquake hazard to a minimally acceptable level.

Utah Fault or Fault Segment	UQFPWG Priorities	
	2005 ¹	Additions
Nephi segment, Wasatch fault zone ^{2,3}	1	--
West Valley fault zone ^{2,3}	2	--
Weber segment, Wasatch fault zone ^{2,3} – most recent event	3	--
Weber segment, Wasatch fault zone ^{2,3} – multiple events	4	--
Utah Lake faults and folds ³	5	--
Great Salt Lake fault zone ^{2,3}	6	--
Collinston and Clarkston Mountain segments, Wasatch fault zone ³	7	--
Sevier and Toroweap faults ^{2,3}	8	--
Washington fault zone ³ (includes Dutchman Draw fault ²)	9	--
Cedar City-Parowan monocline (removed 2016) ^{3,4} and Paragonah fault ^{2,3}	10	--
Enoch graben ³	11	--
East Cache fault zone ^{2,3}	12	--
Clarkston fault ^{2,3}	13	--
Wasatch Range back-valley faults (includes Morgan fault ² and Main Canyon fault ³)	14	--
Hurricane fault zone ^{2,3}	15	--
Levan segment, Wasatch fault zone ^{2,3}	16	--
Gunnison fault ³	17	--
Scipio Valley faults ³	18	--
Faults beneath Bear Lake	19	--
Eastern Bear Lake fault zone ^{2,3}	20	--
Bear River fault zone ^{2,3}	--	
Brigham City segment, Wasatch fault zone ^{2,3} – most recent event	--	2007
Carrington fault, Great Salt Lake fault zone ³	--	
Provo segment, Wasatch fault zone ^{2,3} – penultimate event	--	
Rozelle section, East Great Salt Lake fault ³	--	
Salt Lake City segment, Wasatch fault zone ^{2,3} – northern part	--	2009
Warm Springs fault/East Bench fault ^{2,3} subsurface geometry and connection	--	2010
Brigham City segment, Wasatch fault zone ^{2,3} rupture extent (north and south ends)	--	2011
Northern Provo segment, Wasatch fault zone ^{2,3} – long-term earthquake record	--	
Taylorville fault, West Valley fault zone ³	--	
Hansel Valley fault ^{2,3}	--	
Acquire new paleoseismic information to address data gaps for the five central segments of the Wasatch fault zone.	--	2012
<i>Focus on the youngest earthquakes (3-5 ka); large, early Holocene–latest Pleistocene scarps; and secondary faulting (West Valley fault zone^{1,2,3} and Utah Lake faults and folds^{1,3}).</i>	--	Modified 2017
Improve the long-term earthquake record for Cache Valley (East ^{1,2,3} and West Cache ^{2,3} fault zones).	--	2013
Use recently acquired lidar data to more accurately map the traces of the Wasatch, West Valley, and Hurricane fault zones, and search for and map as appropriate previously undiscovered mid-valley Quaternary faults ⁵ .	--	2014
<i>East^{1,2,3} and West Bear Lake, East and West Cache^{1,2,3}, and Hurricane^{1,2,3} fault zones</i>	--	Modified 2017
Acquire earthquake timing information for the Utah Lake faults ^{1,3} to investigate the relation of earthquakes to large earthquakes on the adjacent Provo segment of the Wasatch fault zone ^{3,4} .	--	2015
Acquire new paleoseismic information to address data gaps for the northern Oquirrh fault zone ³ .	--	
Acquire high resolution aerial imagery (Lidar, Structure from Motion, etc.) and map high-risk (chiefly urban) Utah hazardous faults ⁵ . Identify future paleoseismic trench sites.	--	Modified 2017
<i>East^{1,2,3} and West Bear Lake, East and West Cache^{1,2,3}, Oquirrh^{2,3}, and Hansel Valley^{2,3} fault zones</i>	--	
Acquire and analyze information on salt tectonics and its relation to the Main Canyon fault ^{1,3} , Sevier detachment/Drum Mountains fault zone ³ , Bear River fault zone ^{2,3} , Spanish Valley (Moab area), Joes Valley fault zone ^{2,3} , Levan ¹ and Fayette segments ^{2,3} of the Wasatch fault zone, Scipio Valley faults ³ , and the Gunnison fault ^{1,3} .	--	2016
Refine the latest Quaternary earthquake chronology for the Toppliff Hills fault ³ .	--	

¹ Original priorities from the 2005 UQFPWG meeting.

² Earthquake source on the USGS National Seismic Hazard Maps.

³ Earthquake source listed in the UGS Hazus Utah fault database ([UGS Open-File Report 631](#)).

⁴ Fault removed from the list at the 2016 UQFPWG meeting, based on new information about the structure.

⁵ See figure 3 for a map of lidar data availability in Utah and the surrounding area.

Table 2. Earthquake sources (faults and fault segments) in the USGS National Seismic Hazard Maps (NSHM) or the UGS Hazus Utah fault database ([UGS Open-File Report 631](#)) that are not listed in table 1. These faults may warrant additional investigation.

Utah Fault or Fault Segment	Included In	
	NSHM	Utah Hazus
Beaver Basin intrabasin/eastern margin faults	--	Yes
Crater Bench/Drum Mountains fault zone	--	Yes
Crawford Mountains (west side)	--	Yes
Cricket Mountains fault (west side)	--	Yes
Fish Springs fault	--	Yes
House Range (west side) fault	--	Yes
Joes Valley fault zone	Yes	Yes
Little Valley faults	--	Yes
Malad segment, Wasatch fault zone	--	Yes
Mineral Mountains (west side) faults	--	Yes
North Promontory fault	Yes	Yes
Oquirrh fault zone	--	Yes
Oquirrh-Southern Oquirrh Mountains fault zone	Yes	Yes
Parowan Valley faults	--	Yes
Pavant/Tabernacle/Beaver Ridge/Meadow-Hatton/White Sage Flat faults	--	Yes
Porcupine Mountain faults	--	Yes
Scipio/Pavant Range/Maple Canyon/Red Canyon faults	--	Yes
Skull Valley faults (southern part)	--	Yes
Snake Valley faults	--	Yes
Snow Lake graben	--	Yes
Stansbury fault zone	Yes	Yes
Strawberry fault	Yes	Yes
Wah Wah Mountains (south end)	--	Yes
West Cache fault, Wellsville section	Yes	Yes
Western Bear Lake fault	--	Yes

Table 3. Current status of paleoseismic investigations for Utah priority faults and fault segments identified by the UQFPWG as requiring additional investigation to adequately characterize Utah’s earthquake hazard to a minimally acceptable level. Note that faults or fault segments listed as having received some level of paleoseismic investigation does not imply that all of the paleoseismic data necessary to fully characterize those faults or fault segments has been acquired; further investigation of those structures may be necessary. All of the faults/fault sections or segments listed remain priorities and should be considered for future investigation if a compelling case can be made for the need to acquire additional paleoseismic data.

Fault or Fault Segment	UQFPWG Priority ¹	Investigations	
		Status ^{2,3} (as of 1/2018)	Institution ⁴
Nephi segment, Wasatch fault zone ^{5,6}	1	UGS Special Study 124 and 151 USGS SI Map 2966 UGS FTR Report	UGS/USGS
		Fault trace hazard mapping ongoing	UGS
Granger fault, West Valley fault zone ^{5,6}	2	UGS Special Study 149	UGS/USGS
		Fault trace hazard mapping ongoing	UGS
Weber segment, Wasatch fault zone ^{5,6} – most recent event	3	UGS Miscellaneous Publication 05-8 UGS Special Study 130	UGS/USGS
Weber segment, Wasatch fault zone ^{5,6} – multiple events	4	UGS Miscellaneous Publication 05-8 UGS Special Study 130	UGS/USGS
Utah Lake faults and folds ⁶	5	UUGG FTR Report	UUGG/ BYU
Great Salt Lake fault zone ^{5,6}	6	UUGG FTR Report Janecke and Evans (2017)	UUGG USU
Collinston and Clarkston Mountain segments, Wasatch fault zone ⁶	7	UGS Special Study 121 Map: UGS Open-File Report 638 Fault trace hazard mapping ongoing	UGS
Sevier and Toroweap faults ^{5,6}	8	UGS Special Study 122	UGS
Washington fault zone ⁶	9	UGS Miscellaneous Publication 15-6 UGS Open-File Report 583	UGS
<i>Cedar City-Parowan monocline (removed 2016)</i> ^{5,6,7} and Paragonah fault ^{5,6}	10	Map: UGS Map 270 2016 presentation file	UGS
Enoch graben ⁶	11	Map: UGS Open-File Report 628	UGS
East Cache fault zone ^{5,6}	12	USU FTR Report	USU
		Fault trace hazard mapping ongoing	UGS
Clarkston fault ^{5,6}	13	UGS Special Study 98 Fault trace hazard mapping ongoing	UGS
Wasatch Range back-valley faults	14	UGS Miscellaneous Publication 11-2	USBR
Main Canyon fault ⁶		UGS Miscellaneous Publication 10-5	USBR
Hurricane fault zone ^{5,6}	15	UGS Special Study 119	UGS
Levan segment, Wasatch fault zone ^{5,6}	16	UGS Map 229 Map: UGS Open-File Report 640 Fault trace hazard mapping ongoing Paleoseismic investigation ongoing	UGS
Gunnison fault ⁶	17	No activity	--
Scipio Valley faults ⁶	18	No activity	--
Faults beneath Bear Lake	19	No activity	--
Eastern Bear Lake fault zone ^{5,6}	20	No activity	--
Bear River fault zone ^{5,6}	2007	AGU Abstracts: 2012 and 2013 USGS ongoing	USGS/USGS
Brigham City segment, Wasatch fault zone ^{5,6} – most recent event		UGS Special Study 142	UGS/USGS
Carrington fault, Great Salt Lake fault zone ⁵		No activity	--
Provo segment, Wasatch fault zone ^{5,6} – penultimate event		No activity	--
Rozelle section, East Great Salt Lake fault ⁶		Janecke and Evans (2017)	USU
Salt Lake City segment, Wasatch fault zone ^{5,6} – north part	2009	UGS Special Study 149	UGS/USGS
		Fault trace hazard mapping ongoing	UGS
Warm Springs fault/East Bench fault ^{5,6} subsurface geometry and connection	2010	BSU FTR Report Ongoing	BSU

Fault or Fault Segment	UQFPWG Priority ¹	Investigations	
		Status ^{2,3} (as of 1/2018)	Institution ⁴
Brigham City segment, Wasatch fault zone ^{5,6} rupture extent (north and south ends)	2011	Fault trace hazard mapping ongoing	UGS
Northern Provo segment, Wasatch fault zone ^{5,6} – long-term earthquake record		USGS work ongoing UGS FTR Report	USGS/UGS
Hansel Valley fault zone ^{5,6}		Robinson (1986) McCalpin (1985), McCalpin and others (1992), Janecke and Evans (2017)	UUGG USU
Acquire new paleoseismic information to address data gaps for the five central segments of the Wasatch fault zone ^{5,6}	2012	--	--
Nephi segment ^{5,6} – long-term earthquake record		UGS Special Study 159	UGS/USGS
Provo, Salt Lake City and Nephi segments, Wasatch fault zone ^{5,6} segmentation		Ongoing	--
Corner Canyon site		UGS FTR Report	UGS/USGS
Flat, Maple, and Alpine sites		USGS work ongoing UGS FTR Report	USGS/UGS
Fort Canyon fault ^{5,6} , Traverse Mountains salient		Ongoing	UVU
Focus on the youngest earthquakes (3-5 ka); large, early Holocene–latest Pleistocene scarps; and secondary faulting (West Valley fault zone and Utah Lake faults and folds).	<i>Modified 2017</i>	Ongoing	--
Taylorville fault, West Valley fault zone		UGS ongoing	UGS/USGS
Improve the long-term earthquake record for Cache Valley (East and West Cache fault zones ^{5,6}).	2013	No activity	--
East Cache fault zone ^{5,6}		Evans and McCalpin (2012)	USU/GEO-HAZ
Use lidar to map portions of the Hurricane ^{5,6} , Wasatch ^{5,6} , and West Valley ^{5,6} fault zones.	2014	Lidar data of the Wasatch and West Valley fault zones acquired.	UGS/State of Utah
		UGS Open-File Reports 638 and 640 Hurricane, Wasatch, and West Valley fault zones mapping ongoing.	UGS
East ^{5,6} and West ⁶ Bear Lake, East and West Cache ^{5,6} , and Hurricane ^{5,6} fault zones	<i>Modified 2017</i>	East and West Cache fault zones lidar and mapping ongoing.	UGS
Acquire new paleoseismic information to address data gaps for the northern Oquirrh fault zone ^{5,6} .	2015	No activity	--
Acquire high resolution aerial imagery (Lidar, Structure from Motion [SfM], etc.) and map high-risk (chiefly urban) Utah hazardous faults. Identify future paleoseismic trench sites.		Lidar: Portions of the Little Valley, Scipio, Strawberry, Paunsaugunt, Pavant Range, and other faults, and the Bear River, Sevier/Toroweap, and Topliff Hills fault zones planned in 2018.	UGS/State of Utah
East ^{5,6} and West ⁶ Bear Lake, East and West Cache ^{5,6} , Oquirrh ^{5,6} , and Hansel Valley ^{5,6} fault zones		<i>Modified 2017</i>	Mapping: Hansel Valley fault zone Janecke and Evans (2017)
	Lidar: Remaining portions of the East and West Bear Lake, East and West Cache, and Oquirrh fault zones planned in 2018.		UGS/State of Utah
Acquire and analyze information on salt tectonics and its relation to the Main Canyon fault ⁶ , Sevier detachment/Drum Mountains faults ⁶ , Bear River fault zone ^{5,6} , Spanish Valley (Moab area), Joes Valley fault zone ^{5,6} , Levan ^{5,6} and Fayette ⁶ segments of the Wasatch fault zone, Scipio Valley faults ⁶ , and the Gunnison fault ⁶ .	2016	Lidar/Mapping: East and West Cache fault zones lidar and mapping ongoing.	UGS
		Levan and Fayette segments, Wasatch fault zone paleoseismic investigation ongoing.	UGS/USGS
		Joes Valley fault zone trenching ongoing in 2017, and planned for 2018.	USBR
		Lidar: Most of Moab/Spanish Valley planned in 2018.	UGS/State of Utah

Fault or Fault Segment	UQFPWG Priority ¹	Investigations	
		Status ^{2,3} (as of 1/2018)	Institution ⁴
Refine the latest Quaternary earthquake chronology for the Topliff Hills fault ⁶ .	2016	Lidar: planned in 2018.	UGS/State of Utah

¹ See table 1 for complete working group priority list.

² FTR (Final Technical Report) to the USGS, Earthquake Hazards Program (https://geohazards.usgs.gov/cfusion/external_grants/research.cfm).

³ Click on URL links to investigation report files available online.

⁴ BSU (Boise State University), BYU (Brigham Young University), GEO-HAZ (GEO-HAZ Consulting, Inc.), USBR (U.S. Bureau of Reclamation), USGS (U.S. Geological Survey, Earthquake Hazards Program), UGS (Utah Geological Survey), USU (Utah State University), UUGG (University of Utah Department of Geology & Geophysics), UVU (Utah Valley University).

⁵ Earthquake source on the USGS National Seismic Hazard Maps (<https://earthquake.usgs.gov/hazards/hazmaps/>).

⁶ Earthquake source listed in the UGS Hazus Utah fault database ([UGS Open-File Report 631](#)).

⁷ Fault removed from the list at the 2016 UQFPWG meeting, based on new information about the structure.

Table 4. Utah Quaternary Fault Parameters Working Group 2018 list of highest priority Quaternary faults or fault segments requiring additional investigation to adequately characterize Utah's earthquake hazard to a minimally acceptable level. The list will be reviewed at this meeting and revised as needed to develop the 2019 priority list.

Fault or Fault Segment (Not in Priority Order)	Investigations	
	Status (as of 1/2018) ^{1,2}	Institution
Acquire new paleoseismic information to address data gaps for (a) the five central segments and northern three segments of the Wasatch fault zone ^{3,4} (including focusing on the youngest earthquakes [3-5 ka]; large, early Holocene–latest Pleistocene scarps; and secondary faulting [West Valley fault zone ^{3,4} and Utah Lake faults and folds ⁴]), (b) northern segments of the Wasatch fault zone (b) the northern segment of the Oquirrh fault zone ^{3,4} , (c) refining the latest Quaternary earthquake chronology for the Topliff Hills fault ⁴ , and (d) the East and West Cache ^{3,4} fault zones. Examples of paleoseismic data to acquire include extent of surface-faulting rupture, earthquake timing, displacement, and subsurface fault geometry.	Nephi segment, Spring Lake and North Creek sites: UGS Special Study 159	UGS/USGS
	Provo segment, Flat Canyon site: USGS ongoing, UGS FTR Report	USGS/UGS
	Salt Lake City segment, Corner Canyon site: UGS FTR Report	UGS/USGS
	Provo segment, Dry Creek and Maple Canyon sites: USGS ongoing, UGS FTR Report	USGS/UGS
	Fort Canyon fault, Traverse Mountains salient: ongoing	UVU
	Southern segment, East Cache fault zone: FTR Report	USU/GEO-HAZ
Acquire earthquake timing information for the Utah Lake and Great Salt Lake faults ⁴ to investigate the relation of earthquakes on that fault system to large earthquakes on adjacent segments of the Wasatch fault zone (independent or coseismic ruptures, fault pairs?).	No activity	--
Acquire high-resolution aerial imagery (lidar ⁵ , Structure from Motion, etc.), map high-risk (chiefly urban) Utah hazardous faults (including the East ^{3,4} and West ⁴ Bear Lake, East and West Cache ^{3,4} , Great Salt Lake ⁴ , Oquirrh ^{3,4} , and Hansel Valley ^{3,4} , and Hurricane ^{3,4} fault zones), and identify new paleoseismic trench sites.	Mapping: East and West Cache fault zones ongoing.	UGS
	Lidar: Remaining portions of the East and West Bear Lake, East and West Cache, and Oquirrh fault zones planned in 2018.	State of Utah/UGS
Acquire and analyze information on salt tectonics and its relation to the Main Canyon fault ⁴ , Sevier detachment/Drum Mountains faults ⁴ , Bear River fault zone ^{3,4} , Spanish Valley (Moab area), Joes Valley fault zone ^{3,4} , Levan ^{3,4} and Fayette ⁴ segments of the Wasatch fault zone, Scipio Valley faults ⁴ , and the Gunnison fault ⁴ .	Levan and Fayette segments paleoseismic investigation ongoing.	UGS
	Moab quadrangle salt-tectonics-related ground subsidence hazard mapping ongoing.	UGS
	Lidar: Most of Moab/Spanish Valley planned in 2018.	UGS/State of Utah

¹ FTR (Final Technical Report) to the USGS, Earthquake Hazards Program.

² Click on URL link to investigation report files available online.

³ Earthquake source on the USGS National Seismic Hazard Maps.

⁴ Earthquake source listed in the UGS Hazus Utah fault database ([UGS Open-File Report 631](#)).

⁵ See figure 3 for a map of lidar data availability in Utah and the surrounding area.

Table 5. *Utah Quaternary Fault Parameters Working Group 2018 list of other priority faults or fault segments requiring further investigation to adequately characterize Utah’s earthquake hazard to a minimally acceptable level. The list will be reviewed at this meeting and revised as needed to develop the 2019 priority list.*

Fault or Fault Segment	UQFPWG Priority ¹	Investigations	
		Status (as of 1/2018) ²	Institution
Paragonah fault ^{3,4}	10 ⁵	No activity	--
Enoch graben ⁴	11	Map: UGS Open-File Report 628	UGS
Clarkston fault, West Cache fault zone ^{3,4}	13	UGS Special Study 98 Mapping ongoing	UGS
Gunnison fault ⁴	17	No activity	--
Scipio Valley faults ⁴	18	Lidar: planned in 2018.	State of Utah/UGS
Faults beneath Bear Lake	19	No activity	--
Eastern Bear Lake fault zone ⁴	20	Lidar: planned in 2018.	State of Utah/UGS
Carrington fault, Great Salt Lake fault zone ⁴	2007	No activity	--
Rozelle section, Great Salt Lake fault zone ^{4,6}	2007	Janecke and Evans (2017)	USU

¹ See table 1 for complete working group priority list.

² Click on URL link to investigation report files available online.

³ Earthquake source on the USGS National Seismic Hazard Maps.

⁴ Earthquake source listed in the UGS Hazus Utah fault database ([UGS Open-File Report 631](#)).

⁵ The Cedar City-Parowan monocline was removed from Priority 10 in the 2016 meeting, based on new information from geologic mapping in the area ([UGS Map 270](#) and [2016 presentation file](#)).

⁶ Previous highest priority fault or fault segment.

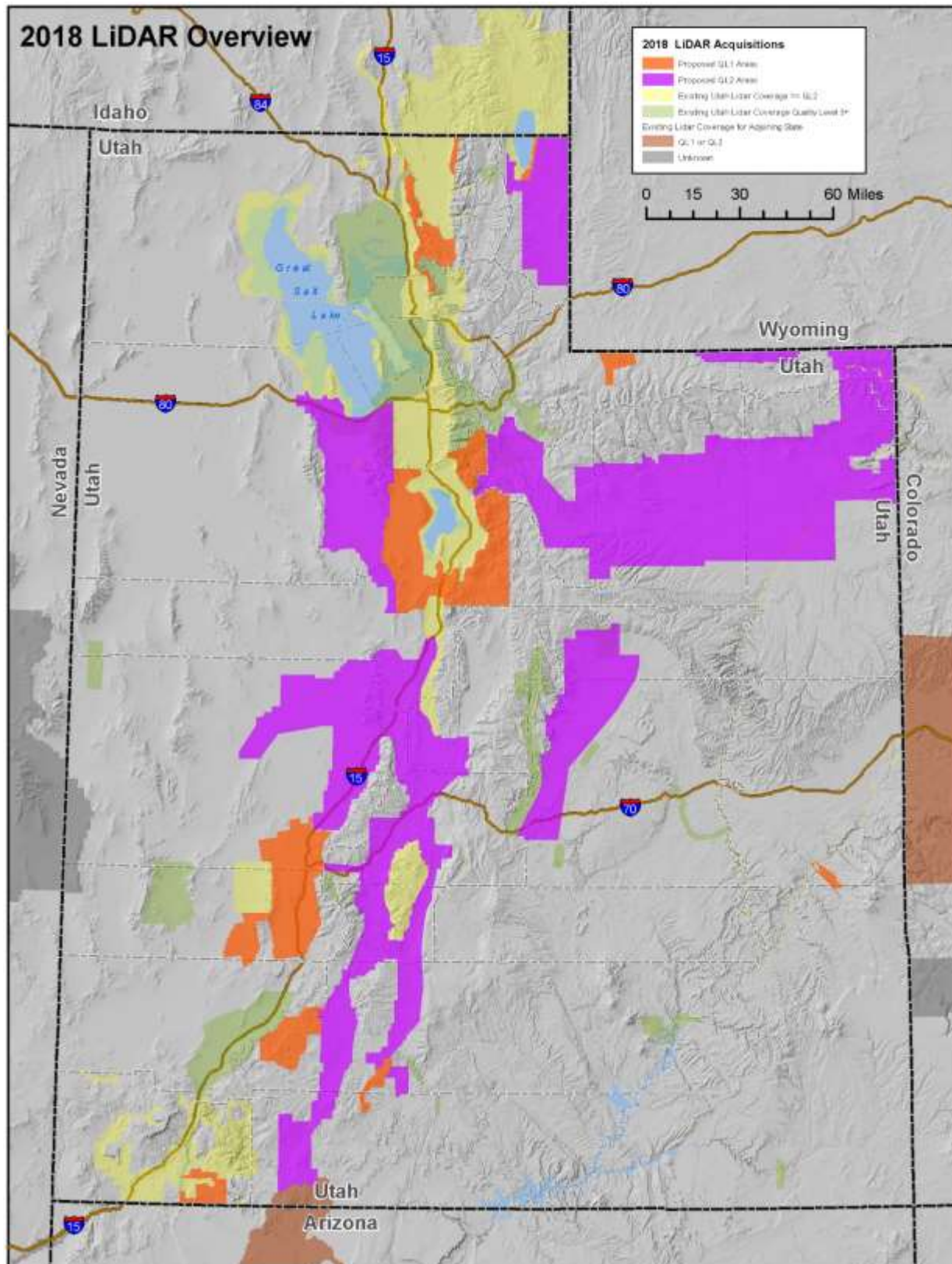


Figure 3. Map of lidar data availability in Utah and the surrounding area. Proposed data to be acquired in 2018 with USGS Quality Level (QL) 1 (0.5 m) in bright orange and QL2 (1 m) in purple, data acquired prior to 2018 with QL2 or better in yellow and \geq QL3 in green, other state \leq QL2 data in dark orange, and unknown quality in gray.

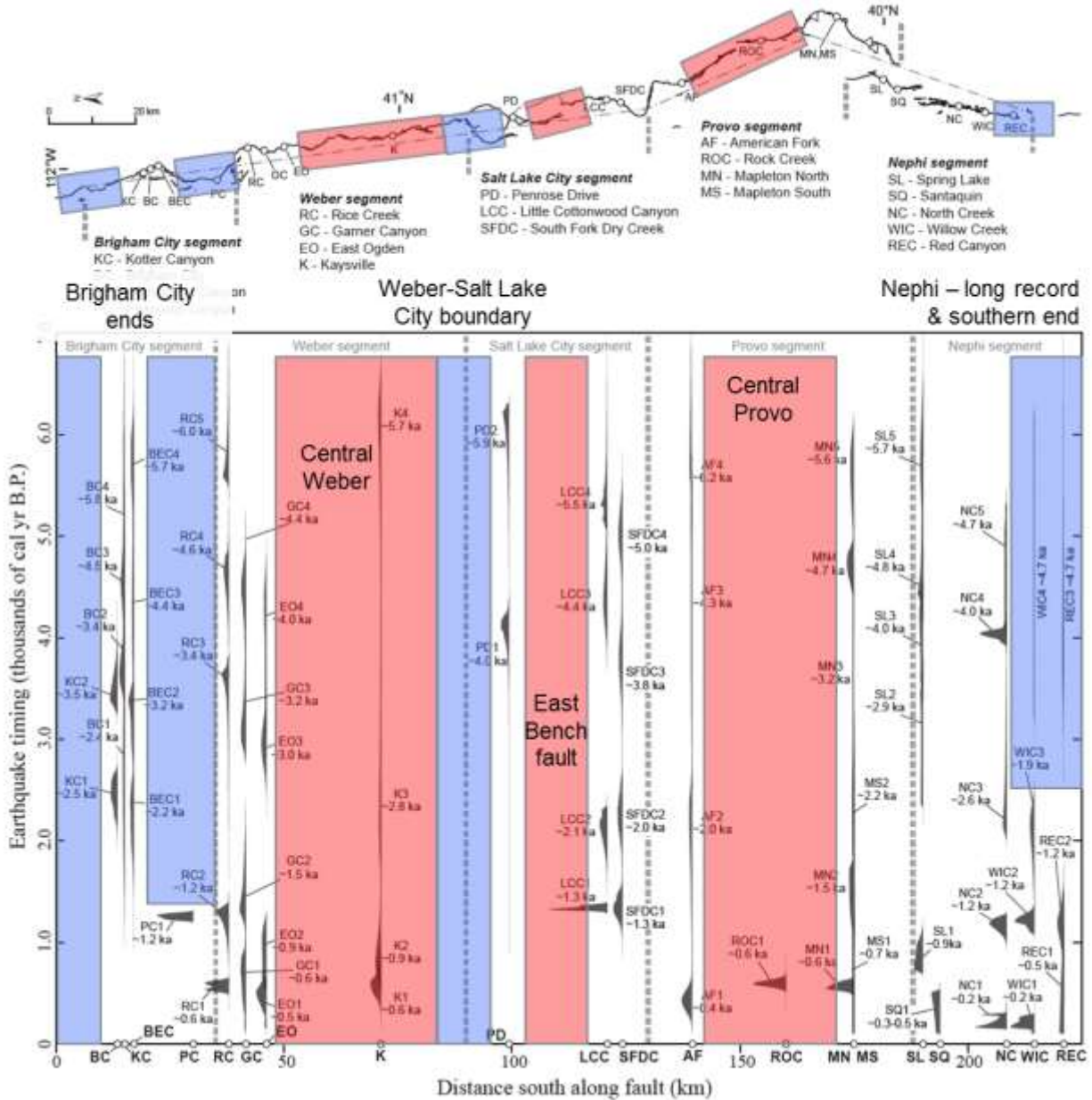


Figure 4. Recommended Wasatch fault zone future paleoseismic investigations by DuRoss (from 2016 UQFPWG presentation). Red shading denotes areas along faults where additional basic paleoseismic data is needed and blue shading denotes areas near and on

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