2021 UTAH EARTHQUAKE WORKING GROUP MEETINGS
UTAH QUATERNARY FAULT PARAMETERS WORKING GROUP
SUMMARY

Tuesday, February 2, 2021
Virtual due to COVID-19 Pandemic

WELCOME AND INTRODUCTION

Emily Kleber (Utah Geological Survey [UGS]) called the 2021 Utah Quaternary Fault Parameters Working Group (UQFPWG) meeting to order at 8:00 a.m. This meeting was held online using the Zoom platform due to the ongoing COVID-19 pandemic. After welcoming Working Group members and guests and providing some technical information about the virtual meeting, she summarized the UQFPWG's past activities and outlined the Working Group's purpose and goals for the future.

UQFPWG Purpose and Goals

- Serves as a committee 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

Chris DuRoss, 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 2022 funding announcement for proposals. Alex Hatem, USGS, presented a summary of the fault data from Utah compiled from the 2023 National Seismic Hazard Map update.

Recent Studies in Utah Updates

- Preliminary Evaluation of Quaternary Activity on the Duchesne-Pleasant Valley Fault, Uinta Basin, Utah: Julia Howe, U.S. Bureau of Reclamation
- Paleoseismic Results from the Topliff Hills Fault, Rush Valley, Utah: Nathan Toke, Utah Valley University
- Recent Quaternary Fault Mapping in Utah: Adam Hiscock, Utah Geological Survey
- Fault Investigation Along the Central Weber Segment of the Wasatch Fault, Layton, Utah: Evidence for 4–5 Recent Paleoseismic Events: Robert Givler, Lettis Consultants International

TECHNICAL SESSIONS

Buried Urban Faults and Special Study Zones – Led by Ivan Wong
Presentations — 15 minutes each

- Is There a Potential Surface Fault Deformation Hazard in Downtown Salt Lake City?: Ivan Wong, Lettis Consultants International

- Seismic Land Streamer Results Highlight Earthquake Risks for the Salt Lake City Urban Center: Lee Liberty, Boise State University

Group Discussion Questions

- What is the potential for primary and secondary surface fault displacement and deformation in downtown Salt Lake City?
- Given the large uncertainties regarding such potential, what investigations and mitigative measures should be taken to reduce the potential hazard?

The discussion was led by Ivan Wong of Lettis Consultants International, using the questions listed above. Ivan shared that there are recently completed and upcoming large-scale development projects occurring in downtown Salt Lake City that warrant the discussion of the primary and secondary surface fault displacement and deformation. Geophysical investigations performed by Lee Liberty of Boise State University indicate that there is broad folding of sedimentary deposits through the downtown area, where there is active and future development. The group discussed a model for such a fold, with Scott Bennett, USGS, suggesting a relay ramp between en echelon strands of the northern Salt Lake City segment that could be a structural model that produces an intervening fold. Zach Anderson, UGS, also suggested that a rollover/hanging wall anticline/monocline could also be a structural model. The group discussed the complexity of the faulting in downtown Salt Lake City and how the connection is not well defined between the East Bench fault of the Salt Lake City segment and the Warm Springs fault to the north. A recent exposure at the Washington Elementary School from construction of a retaining wall exposed part of the Warm Springs fault. The UGS cleaned, documented, and sampled the exposure for later radiocarbon dating in earthquake-derived soils. The UGS is currently seeking funding for dating these samples to gain insight into the paleoearthquake timing on the Warm Springs fault. There is still more work that could be done with geophysics and geology to better understand the surface fault rupture hazard within Salt Lake City.

Magna Earthquake – Led by Emily Kleber
This session was recorded. Please look for recordings on the Utah Quaternary Fault Parameters Working Group webpage within a few months of the meetings.
Presentations — 15-minutes each

- Backprojection Imaging of the 2020 Magna, Utah, Earthquake Using a Local Dense Strong Motion Network: Maria Messimeri, University of Utah Seismograph Stations
- Coseismic Fault Slip and Afterslip Associated with the 18 March 2020 M 5.7 Magna, Utah, Earthquake: Fred Pollitz, U.S. Geological Survey
- Hypothetical Structural Model for the March 18 M 5.7 Magna, Utah, Earthquake: Adam McKean, Utah Geological Survey
- Alternative Models for the Subsurface Geometry of the Wasatch Fault in Light of the 2020 Magna, Utah, Earthquake: James C. Pechmann, University of Utah Seismograph Stations

Group Discussion Questions

- What is the likelihood that the Magna earthquake occurred on a subsidiary fault in the hanging wall of the Wasatch fault? And if it did, does this model require that the underlying Wasatch fault have a gentler dip than the subsidiary fault on which the Magna earthquake occurred?

- Does the existence of the active West Valley fault zone require a listric geometry for the Wasatch fault, i.e., a decrease in the dip of the Wasatch fault below its intersection with the West Valley fault zone? Or are there alternative structural models for the presumed intersection between these two faults?

This is the first time the UQFPWG has met since the 2020 Magna earthquake and there was plenty to discuss. The presentations helped everyone get on the same page and presented the most recent data and additional thought questions.

A key topic of discussion was what additional data would be needed to better understand the context of the Magna earthquake and the Wasatch fault system in the Salt Lake Valley. Some of these data would include:

- Additional deep seismic lines and borehole data for the central Salt Lake Valley for determining the behavior of basin sediments from earthquake cycles over time.
- Additional processing of seismic data from the Magna sequence, including looking at deeper structures using conversions off reflectors in the basin from the Magna sequence (possibly being worked on at the University of Utah).

Other topics touched on in the group conversation:

- Possibility that a subsidiary west-dipping structure that was not the Wasatch fault zone was the source of the Magna sequence. Jim Pechmann's presentation went into detail about that possibility.
- Dips of subsidiary faults within the hanging wall.
- Length of the fault rupture described in Maria Messimeri's presentation.
- The earthquake depth of 9 vs. 12 km below the surface is still being discussed. Fred Pollitz compared shallow vs. steeper dipping models with GPS and InSAR data.
- A discussion of the possible role of the Rio Tinto Kennecott tailings piles on the earthquake cycle.
- Discussion of the Velasco and others (2010) seismic line and the interpretations associated with it.

For the complete discussion, please watch the recorded video available on the Utah Quaternary Fault Parameters Working Group webpage. Papers about the Magna sequence and response are listed in the references below.

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Velasco, M.S., Bennett, R.A., Johnson, R.A., and Hreinsdóttir, S., 2010, Subsurface fault geometries and crustal extension in the eastern Basin and Range Province, western US: Tectonophysics, v. 488, no. 1–4, p. 131–142.

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UQFPWG 2022 FAULT INVESTIGATION PRIORITIES

The Working Group's list of highest priority fault investigations is largely the same from 2021, with special emphasis on bolded items, which were discussed in more detail in the working group meeting.

- Acquire new paleoseismic information for areas with ongoing or completed lidar fault mapping projects:

    - **West Valley fault zone – Granger and Taylorsville faults**
    - Cache Valley faults – East Cache fault zone and West Cache fault zone
    - Five central segments of the Wasatch fault zone – Brigham City, Weber, Salt Lake City, Provo, and Nephi segments
    - Oquirrh fault zone
    - Sevier fault

- "Salvage paleoseismology" (i.e., earthquake timing investigations as rapid development is encroaching on un-modified paleoseismic trenching sites:
    - **West Valley fault zone – Granger and Taylorsville faults**
    - Cache Valley faults – East Cache fault zone and West Cache fault zone

- Use recently acquired lidar data to more accurately map the traces of the:
    - Scipio Valley faults
    - Beaver Basin faults (partial coverage)
    - **Hansel Valley faults**
    - **Paunsaugunt fault**
    - Mineral Mountains west side faults
    - Stansbury fault zone

- **Opportunistic trenching sites – Funding for dating samples left over from other projects that have been stored and would be useful**

- **Post-Magna earthquake research – Use new geophysical methods to collect more data about the subsurface of the Salt Lake Valley**

This does not include other priorities that have carried over from previous years. Those are identified in table 2.

WORKING GROUP PRODUCTS AND RELATED DATA

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

Utah Quaternary Fault and Fold Database

The UGS updated the *Utah Quaternary Fault and Fold Database* in May 2020, incorporating new mapping and fault attributes. Ongoing updates are being reviewed by the UGS for Quaternary faults mapped in peer-reviewed publications from 2013 to 2020. 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 (https://gis.utah.gov/data/geoscience/quaternary-faults/). This single, comprehensive feature class will be periodically updated as new and/or updated data become available

and replaces the six previously available feature classes of variable completeness. A web portal to view the Quaternary faults database is available at https://geology.utah.gov/apps/hazards/.

Utah Lidar Elevation Data Availability

A significant coverage of high-resolution (≤ 1 meter) lidar elevation data in the state of Utah is from AGRC (https://gis.utah.gov/data/elevation-terrain-data/) and OpenTopography (https://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 1 shows the existing and planned lidar data available in Utah. The UGS is currently using lidar data to map fault traces of the East and West Bear Lake, Oquirrh, and Topliff Hills fault zones (USGS G19AP00072, submitted March 2021), and the Sevier, Washington, and Hurricane faults in southern Utah (G20AP00008, report due June 2021). This mapping is being completed at a scale 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 areas around fault traces, where paleoseismic investigations are highly recommended by the UGS for new development (see Lund and others, 2020, *Guidelines for Evaluating Surface-Fault-Rupture Hazards in Utah*, UGS Circular 128, pages 21 to 58, https://ugspub.nr.utah.gov/publications/circular/c-128.pdf).

MEETING ATTENDANCE

Registration for the virtual meeting was done via EventBrite. Below is the list of people who signed up for the zoom meeting. Specific attendance was not taken.

Last Name	First Name
Ali	Aamir
Anderson	Zach
Bennett	Scott
Biek	Bob
BLOOM	JACK
Bloszies	Chris
bono	Emilio
Bowman	Steve
Briggs	Rich
Cal	Cagatay
Carey	Bob
Clark	Don
Copfer	Torrey
Dinter	David
Doumit	Pete
DuRoss	Chris
Ege	Carl
Emery	Patrick
Forbes	Berkley
Garbrecht	David
Giraud	Richard
Givler	Robert
Gold	Ryan
Hardwick	Christian
Harris	Ron
Hatem	Alexandra
Hiscock	Adam
Howe	Julia
Hyland	Michael
Janecke	Susanne
Kleber	Emily
Knudsen	Tyler
Koehler	Rich
Liberty	Lee
Lifton	Zach
Lund	William
Maxfield	Brent
McDonald	Greg
McDonald	Greg
McGowan	Sean
McKean	Adam
Mesimeri	Maria
Pankow	Kristine
Pechmann	James
Piety	Lucy
Pollitz	Fred
Reed	Tomsen
Reiman	Kaitlin
Reitman	Nadine
Smith	Robert
Smith	Bob
Thomas	Patricia
Toke	Nathan
Vargo	Ana
Wetmore	Paul
WILLIAMSON	CHUCK
Zelman	Mark

History of the Utah Quaternary Fault Parameters Working Group Since 2005

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, 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.

In 2005, the UQFPWG developed a list of Quaternary faults and fault segments (Lund, 2005; table 2; figure 2) that the working group identified as requiring additional investigation to adequately characterize Utah's earthquake hazard to a minimally acceptable level. 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, 2018, 2019, and 2020. Table 1 lists the faults and fault segments (earthquake sources) incorporated in 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 may need additional investigation.

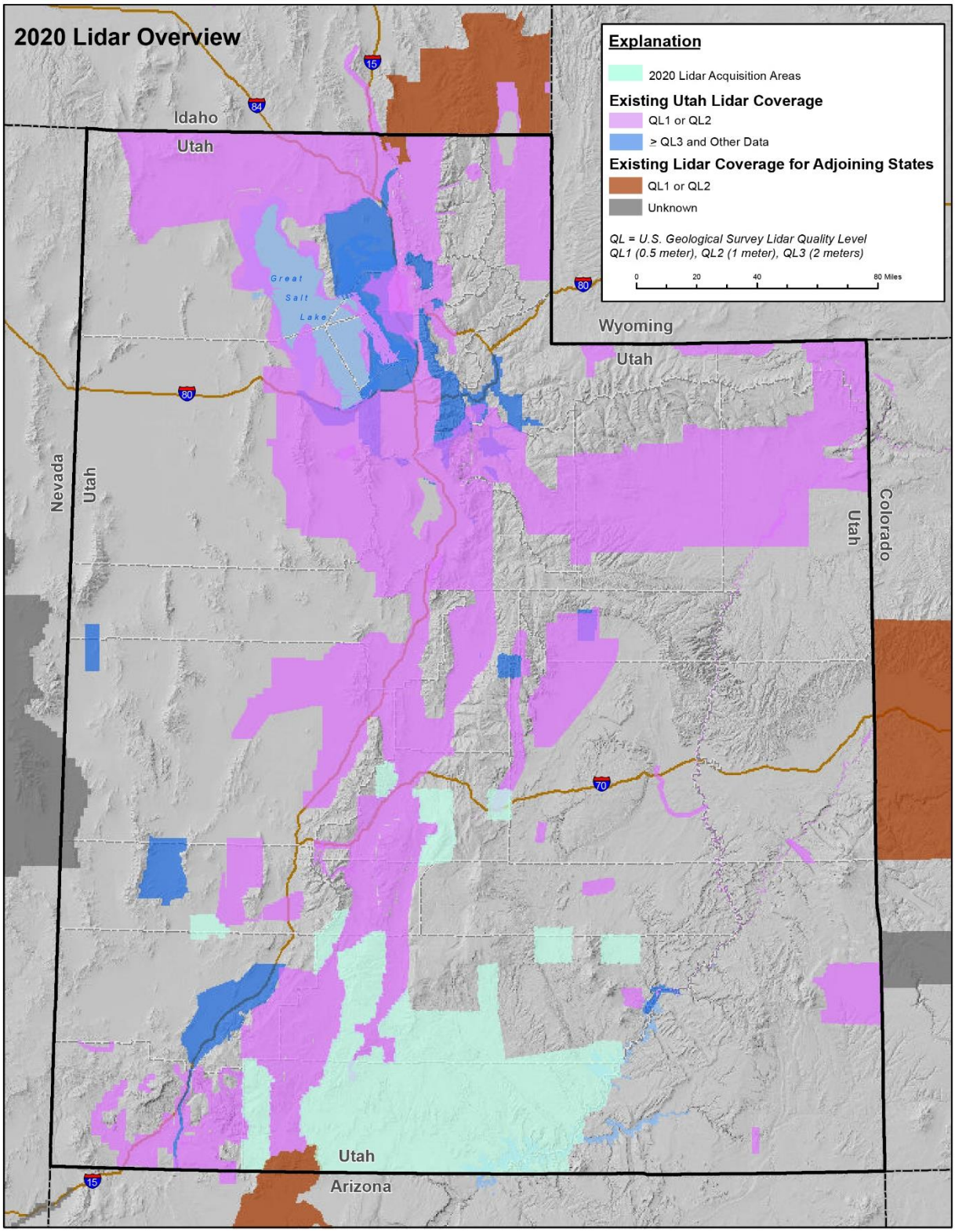

Figure 1. Map of lidar data availability in Utah and the surrounding area.

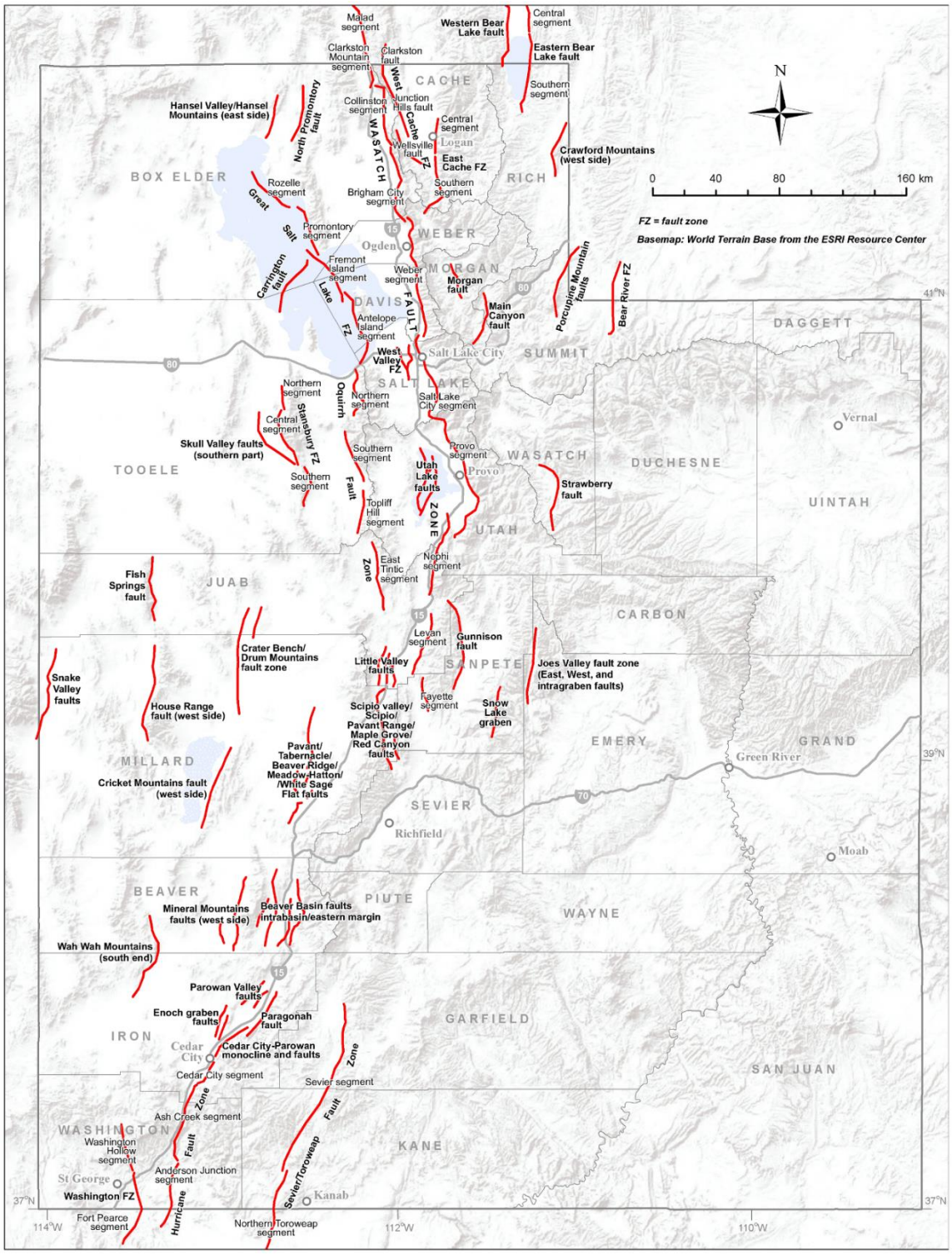

Figure 2. Faults included in the UGS Hazus Utah fault database, except the Cedar City-Parowan monocline and faults were removed in 2016 (see table 1; database updated through 2013, UGS Open-File Report 631).

Table 1. 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). These faults may warrant additional investigation.

Utah Fault or Fault Segments	Included In	
	2015 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 Mountains (south end)	--	Yes
West Cache fault, Wellsville section	Yes	Yes
West Bear Lake fault	--	Yes

Table 2. Status of proposed and published paleoseismic-related investigations based on priorities developed by the UQFPWG since 2005. If there are any missing publications, please send the reference to ekleber@utah.gov.

Study Type	Utah Fault or Fault Segment	UQFPWG Priorities		Investigation Status (as of 3/2021)
		2005	Additions	
Earthquake Timing	Nephi segment, Wasatch fault zone	1	2012 2017	UGS FTR Report, 05HQGR0098 (2005) USGS SI Map 2966 (2007) UGS Special Study 124 (2008) UGS FTR Report, G12AP20076 (2014) UGS Special Study 151 (2014) UGS Special Study 159 (2017) UGS FTR, G17AP00001 (2018)
	West Valley fault zone	2		
	Granger fault		2017	UGS Special Study 149 (2014)
	Taylorsville fault		2011 2017	UGS FTR, G15AP00117 (2017)
	Weber segment, Wasatch fault zone – most recent event and multiple events	3 4	2012 2017	UGS Miscellaneous Publication 05-8 (2006) UGS FTR, 07HQGR0093 (2007) UGS Special Study 130 (2009)
	Utah Lake faults and folds	5		
	Acquire earthquake timing information to investigate the relation of earthquakes to large earthquakes on the Provo segment		2015 2017	UUGG FTR Report, G08AP0016 (2014)
	Great Salt Lake fault zone	6		
	Rozelle section, East Great Salt Lake fault Carrington fault, Great Salt Lake fault zone		2007	UUGG FTR Report, G08AP0016 (2014) Janecke and Evans (2017)
	Collinston and Clarkston Mountain segments, Wasatch fault zone	7	--	UGS Special Study 121 (2007) UGS Open-File Report 638 (2015)
	Sevier and Toroweap faults	8	2016	UGS Special Study 122 (2008)
	Washington fault zone (includes Dutchman Draw fault)	9	--	UGS Open-File Report 583 (2011) UGS Miscellaneous Publication 15-6 (2015)
	Cedar City-Parowan monocline (removed 2016) and Paragonah fault	10	--	UGS Map 270 (2015) 2016 presentation file Paragonah fault, no activity
	Enoch graben	11	--	UGS Open-File Report 628 (2014)
	East Cache fault zone	12	2013	USU FTR Report, 07HQGR0079 (2012)
	Clarkston fault	13	--	UGS Special Study 98 (2000) UGS Special Study 121 (2007) UGS Open-File Report 638 (2015) UGS FTR, G17AP00001 (2018)

Study Type	Utah Fault or Fault Segment	UQFPWG Priorities		Investigation Status (as of 3/2021)
		2005	Additions	
Earthquake Timing	Wasatch Range back-valley faults (includes Morgan fault and Main Canyon fault)	14	--	UGS Miscellaneous Publication 11-2 (2011) UGS Miscellaneous Publication 10-5 (2010)
	Hurricane fault zone	15	--	UGS Special Study 119 (2007)
	Levan and Fayette segments, Wasatch fault zone	16	--	UGS Map 229 (2008) UGS Open-File Report 640 (2015) UGS FTR G17AP00071 (2019)
	Gunnison fault	17	--	No activity
	Scipio Valley faults	18	2017	No activity
	Faults beneath Bear Lake	19		No activity
	Eastern Bear Lake fault zone	20	--	No activity
	Provo segment, Wasatch fault zone			
	Penultimate event and long-term earthquake record	--	2007 2011 2012 2017	UGS Map 02-7 (2002) URS FTR Report, 02HQGR0109 (2011) UGS FTR Report, G13AC00165 (2015) Bennett, and others, 2018 (BSSA)
	Fort Canyon fault, Traverse Mountains salient	--	2012	UVU FTR, G16AP00104 (2017)
	Brigham City segment, Wasatch fault zone			
	Most recent event and rupture extent	--	2007 2011	UGS Special Study 142, (2012)
	Salt Lake City segment, Wasatch fault zone	--	2009	
	Penrose Drive site	--	2012	UGS FTR Report, G10AP00068 (2010) UGS Special Study 149 (2014)
	Corner Canyon site	--	2012	UGS FTR Report, G14AP00057 (2014)
	Bear River fault zone	--	2007	AGU Abstracts: 2012 and 2013
	Acquire new paleoseismic information to address data gaps for the five central segments of the Wasatch fault zone	--	2012	DuRoss and Hylland, 2015 (BSSA) DuRoss and others, 2018 (GRL)
	Topliff Hills fault	--	2016	Trenching by Toke, Bunds, and UVU students, ongoing
	Northern Oquirrh fault zone	--	2015 2017	Bunds and others, Poster 1 and Poster 2
High Res. Mapping & Trench Site ID	Wasatch and West Valley fault zones	--	2014 2017	UGS Open-File Report 638 (2015) UGS Open-File Report 640 (2015) UGS FTR G17AP00001 (2018) UGS RI-280 (2020)
	Hansel Valley fault zone	--	2011	No activity

Study Type	Utah Fault or Fault Segment	UQFPWG Priorities		Investigation Status (as of 3/2021)
		2005	Additions	
High Resolution Fault Mapping and Paleoseismic Trench Identification	East Bear Lake fault zone	--	2015 2017	USGS/IGS/UGS co-op award G19AP00072 (FTR due Spring 2021)
	East and West Cache fault zones	--	2015 2017	UGS FTR Report, G17AP00071 (2020)
	Hurricane fault zone	--	2014 2017	USGS/UGS co-op award G20AP00008 (FTR due Spring 2021)
	Oquirrh fault zone	--	2015 2017 2018 2021	Bunds and others, Poster 1, Poster 2, and Poster 3, and presentation Bunds, USGS/UGS co-op award G19AP00072 (FTR due Spring 2021)
	Southern Utah faults			
	Sevier/Toroweap faults		2018	USGS/UGS/AZGS co-op award G20AP00008 (FTR due Spring 2021)
	Mineral Mountains (west side) faults		2018	None
	Beaver Basin faults		2018	None
	Crater Bench/Drum Mountain faults		2018	None
	Scipio Valley faults		2018	None
	Little Valley faults		2018	None
	Paunsaugunt fault		2021	None
Salt Tectonics	Levan and Fayette segments of the Wasatch fault zone	--	2016	UGS FTR G17AP00071 (2019)
	Main Canyon fault Sevier detachment/Drum Mountains fault zone Bear River fault zone Spanish Valley (Moab area) Joes Valley fault zone Scipio Valley faults Gunnison fault	--	2016	Scipio Valley and Bear River lidar data collected in 2018
Other	Warm Springs fault/East Bench fault subsurface geometry and connection	--	2010	BSU FTR G15AP00054 (2015) BSU FTR G17AP00052 (2017)