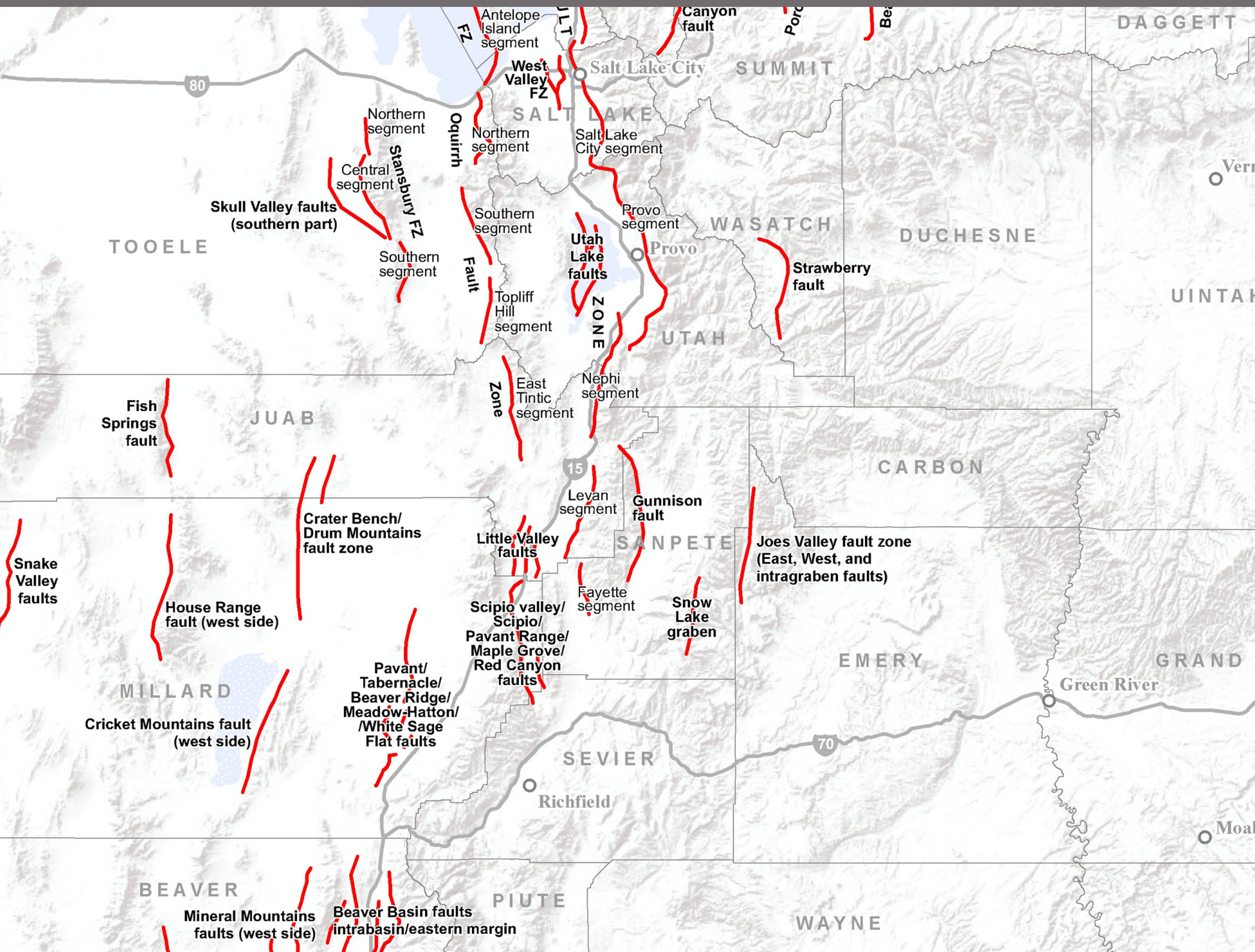
HAZUS LOSS ESTIMATION SOFTWARE EARTHQUAKE MODEL REVISED UTAH FAULT DATABASE

UPDATED THROUGH 2013
PREPARED FOR THE UTAH DIVISION OF EMERGENCY MANAGEMENT

by William R. Lund



Wah Wah Mountains (south end)
Parowan Valley faults
Enoch graben faults
IRON
Cedar City
Cedar City monocline
Cedar City segment
Sevier segment
Ash Creek segment
SAN JUAN

UTAH DNR GEOLOGICAL SURVEY

OPEN-FILE REPORT 631

UTAH GEOLOGICAL SURVEY

a division of

UTAH DEPARTMENT OF NATURAL RESOURCES

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Cover photo: *Map of faults included in the revised (through 2013) Hazus Loss Estimation Software Earthquake Model fault database for Utah.*

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2014

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INTRODUCTION

At the request of the Utah Division of Emergency Management, the Utah Geological Survey (UGS) has revised and updated the Utah fault database used with the Federal Emergency Management Agency's (FEMA) Hazus Earthquake Model (FEMA, no date). The Hazus Earthquake Model loss estimation software is designed to produce loss estimates for use by federal, state, regional, and local governments in planning for earthquake risk mitigation, emergency preparedness, response, and recovery (FEMA, no date). Hazus Earthquake Model loss estimates are based on a scenario earthquake (characteristic maximum magnitudes [M_{CHAR}]) on a fault(s) in an area of interest. The revised Hazus Utah fault database provides parameters for scenario earthquakes on significant Utah Quaternary-active faults statewide and for select faults/fault sections in adjoining states.

The previous Hazus Utah fault database contained 27 Quaternary faults/fault sections taken largely, but not exclusively, from Utah seismic sources (faults) found on the United States National Seismic Hazard Maps (NSHM) (Frankel and others, 1996, 2002; Petersen and others, 2008). This revision expands the Utah fault database to include all known Late Quaternary and younger faults/fault segments believed capable of generating a ≥M 6.75 earthquake in Utah. A M 6.75 earthquake is generally considered the lower limit for reliably recognizing surface faulting in the Intermountain West. The database also includes faults/fault segments that either (1) have an estimated M_{CHAR} <M 6.75, but are within or close to Utah population centers (e.g., West Valley fault), or (2) are in adjoining states, but are close to Utah urban centers or heavily used tourist destinations (e.g., Western Bear Lake fault).

The revised database includes 82 Quaternary-active faults/fault segments (some combined to form linked fault zones), and nine multisegment rupture scenarios, which, based on available paleoseismic data, represent credible seismic sources (Wong and others, in preparation). All Utah faults included as individual seismic sources on the 2008 update of the NSHM are in the revised fault database. Fault parameters in the database represent best available data through 2013, and are intended to provide input parameters for Hazus Earthquake Model scenario earthquakes.

SOURCES OF INFORMATION

The principal sources of information for the revised Utah fault database are (1) UGS Bulletin 134 *Consensus Preferred Recurrence-Interval and Vertical Slip-Rate Estimates, Review of Utah Paleoseismic-Trenching Data by the Utah Quaternary Fault Parameters Working Group* (Lund, 2005); (2) U.S. Geological Survey (USGS) *Quaternary Fault and Fold Database of the United States* (USGS, 2014), hereafter referred to as the QFFDUS; (3) the UGS *Paleoseismology of Utah* publication series (http://geology.utah.gov/ghp/consultants/paleoseismic_series.htm); (4) published paleoseismic investigations of faults that have not yet been incorporated into the QFFDUS; and (5) *Earthquake Probabilities for the Wasatch Front Region, Utah, Idaho, and Wyoming* (Wong and others, in preparation) prepared by the Working Group on Utah Earthquake Probabilities, hereafter referred to as WGUEP14.

FAULT SELECTION

The WGUEP14 study area encompasses approximately 32,640 square miles (85,558 km^2) of Utah, Idaho, and Wyoming, and includes numerous Quaternary-active faults/fault segments in addition to the Wasatch fault zone (WFZ; 10 segments) and the combined Oquirrh and Great Salt Lake fault zones (OGSLFZ; eight segments). The WFZ and OGSLFZ segments have experienced at least one Holocene surface-faulting earthquake, or show evidence for latest Quaternary (≤15ka) activity. All 18 segments were incorporated into the WGUEP14 earthquake forecast, and likewise all are included in the revised Hazus Utah fault database. WGUEP14 did not consider all of the remaining Quaternary-active faults/fault segments in their study area (104 total) capable of generating a ≥M 6.75 earthquake, and devised screening criteria to identify faults/fault segments that could not meet that magnitude threshold. Based on these criteria, faults not capable of producing a ≥M 6.75 earthquake were not included as individual seismic sources in the WGUEP14 earthquake forecast. WGUEP14 modeled earthquakes <M 6.75 as background seismicity. The WGUEP14 fault screening criteria were as follows:

1. Faults categorized by their "most recent prehistoric deformation" in the QFFDUS as late and middle Quaternary (<750 ka) or Quaternary (<1.6 Ma) if they could not be plausibly linked to more recently active faults. See http://earthquake.usgs.gov/hazards/qfaults/glossary.php for definitions of the four QFFDUS prehistoric deformation timing categories.
2. Faults less than 15 km long if they could not be plausibly grouped with other faults/fault segments to form longer linked fault zones. Faults <15 km long are considered unlikely to generate a ≥M 6.75 earthquake.
3. Wisdom of the group—which chiefly involved retaining both short faults (<15 km) and old faults (≥750 ka) if they could be plausibly joined with younger and/or longer faults to form linked fault zones, even though the component faults are individually mapped and described in the literature.

For the Hazus Utah fault database revision, the UGS adopted and applied the WGUEP14 fault screening criteria to (1) Utah faults in the QFFDUS exclusive of the WFZ and OGSLFZ fault segments (199 faults); (2) recently identified or revised Utah Quaternary-active faults/fault segments not yet incorporated in the QFFDUS (Helm, 1994, 1995; Dinter and Pechmann, 2005; Piety and others, 2010; Wong and others, in preparation; Knudsen, in press); and (3) individually mapped short (<15 km) faults in the QFFDUS that could be grouped with other faults to form plausible linked fault zones. Faults/fault segments or grouped fault zones identified by the WGUEP14 fault screening criteria as not capable of generating a ≥M 6.75 earthquake were not included in the revised Hazus Utah fault database with two exceptions: (1) faults/fault segments with an estimated M_{CHAR} <M 6.75 that are within or close to Utah population centers and considered capable of generating a damaging earthquake, and (2) faults/fault segments in adjoining states that represent a potential hazard to Utah urban centers or heavily used tourist destinations. Following elimination of the fault/fault segments identified by the WGUEP14 fault screening criteria as not capable of generating a ≥M 6.75 earthquake, the remaining 64 Quaternary-active faults/fault segments were incorporated into the revised Hazus Utah fault database (some as linked fault zones) together with the 18 combined segments of the WFZ and OGSLFZ, and the nine WGUEP14 WFZ and OGSLFZ multisegment ruptures.

FAULT DATABASE PARAMETERS

The fault parameters included in the revised Hazus Utah fault database are:

- Rupture Source – fault/fault segment name as reported in the QFFDUS, or if a newly identified or revised fault/fault segment not yet incorporated in the QFFDUS, the fault/fault section name as published in the geologic literature (e.g., Main Canyon fault).
- Rupture Model – AF = antithetic coseismic fault pairs that either form a narrow graben or are antithetic to a larger master fault, I = independent (not segmented), L = linked (combines faults otherwise too short and/or old into plausible linked fault zones), MS = multisegment rupture, S = fault segment/section.
- Fault Activity Class – defines one of four time categories adopted for the revised Hazus Utah fault database from the QFFDUS, in which the most recent prehistoric surface-rupturing or surface-deforming earthquake occurred based on geologically recognizable evidence of faulting, folding, or liquefaction. The categories are (1) latest Quaternary (<15 ka), (2) late Quaternary (<130 ka), (3) late and middle Quaternary (<750 ka), and (4) Quaternary (<1.6 Ma).
- Fault Type – N = normal fault; a fault characterized by predominantly vertical displacement in which one side of the fault moves downward (hanging wall) with respect to the other side of the fault (footwall). Generally, this type of fault indicates tectonic extension, and is the principal type of Quaternary-active fault in Utah.
- Weighted Mean M_{CHAR} – the characteristic weighted mean magnitude for a rupture source (fault/fault segment), which assumes full rupture of the source and is computed from magnitude relations relating length, area, or average displacement to magnitude. M_{CHAR} earthquake magnitude relations and relation weights used to determine M_{CHAR} for the revised Hazus Utah fault database follow conventions established by WGUEP14 (see table 3.5-2 in Wong and others, in preparation).
- Fault Length – measured straight line end-to-end as reported in the QFFDUS unless noted otherwise. Discrepancies between individual fault lengths and the length of linked fault zones is chiefly the result of overlapping faults, or gaps and stepovers between faults.
- Fault Dip Angle – range of crustal fault dips (50 ± 15 degrees) as recommended by the Basin and Range Province Earthquake Working Group II (Lund, 2012) to the USGS for the 2014 update of the NSHM and adopted by WGUEP14 for most normal faults in their study area. WGUEP14 selected a crustal fault dip of 70 ± 15 degrees

for narrow grabens having, or suspected to have, steeply dipping boundary faults. Both WGUEP14 dip-angle conventions are adopted here for the revised Hazus Utah fault database.

- Seismogenic Depth – range of seismogenic depths (15 ± 3 km) determined by WGUEP14 for normal faults in their study area and adopted here for the revised HAZUS Utah fault database.
- Fault End Coordinates – fault end coordinates as defined for the QFFDUS (Kathy Haller, USGS, written communication, 2014) unless noted otherwise. The faults in the QFFDUS were digitized from maps having a wide variety of scales, and as such can only be considered approximately located (particularly for faults digitized from small-scale [<1:24,000] maps) when displayed on QFFDUS interactive maps or in Google Earth.

SUMMARY

The Hazus Utah fault database has been expanded and revised to incorporate best available fault-parameter data current through 2013, for (1) late Quaternary-active and younger faults/fault segments statewide capable of generating a ≥M 6.75 earthquake, (2) faults/fault segments with an estimated M_{CHAR} <M 6.75 that are within or close to Utah population centers and are considered capable of generating a damaging earthquake, and (3) faults/fault segments in adjoining states that represent a potential hazard to Utah urban centers or heavily used Utah tourist destinations. Significant caveats associated with the revised Hazus Utah fault database include (1) comparatively few Utah Quaternary-active faults/fault segments have received a detailed paleoseismic trenching investigation, so available data are often based on limited paleoseismic study, or are estimates based on geomorphic expression, reconnaissance geologic mapping, etc., (2) several newly identified or revised faults/fault segments are incorporated into the revised Hazus Utah fault database, but have not yet been incorporated into the QFFDUS, and (3) QFFDUS fault/fault segment locations and lengths were originally digitized from then (chiefly 1980s or older) best available geologic maps at a wide variety of scales; few fault locations or lengths have been updated since that time. Therefore, faults/fault segments in the revised Hazus Utah fault database should be considered approximately located—a condition that will not significantly affect ground shaking scenarios, but location data are not sufficiently accurate for detailed surface-fault-rupture-hazard evaluations.

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HAZUS EARTHQUAKE MODEL UTAH FAULT DATABASE — UPDATED THROUGH 2013

Rupture Source[1]	Rupture Model[2]	Fault Activity Class[3]	Fault Type[4]	Wt. Mean M_{CHAR}[5]	Fault Length (km)[6]	Fault Dip Angle[7] (degrees)	Seismogenic Depth (km)[8]	Fault End Coordinates[9]	
								Latitude (N)	Longitude (W)
Wasatch – Malad segment[10]	S	<15 ka	N	7.2	48[11]	50 ± 15	15 ± 3	42°25'09.52 42°04'09.66	112°18'31.10 112°12'29.37
Wasatch – Clarkston Mountain segment	S	<15 ka	N	6.8	19[11]	50 ± 15	15 ± 3	41°59'58.12 41°54'23.43	112°11'19.52 112°12'04.81
Wasatch – Collinston segment	S	<130 ka	N	7.0	30[11]	50 ± 15	15 ± 3	41°54'44.09 41°39'18.43	112°09'07.11 112°02'49.70
Wasatch – Brigham City segment (BC)	S	<15 ka	N	7.1	35[11]	50 ± 15	15 ± 3	41°39'07.79 41°19'01.69	112°02'51.18 111°59'54.45
Wasatch – Weber segment (W)	S	<15 ka	N	7.3	56[11]	50 ± 15	15 ± 3	41°20'42.72 40°50'27.96	111°57'16.61 111°52'10.98
Wasatch – Salt Lake City segment (SLC)	S	<15 ka	N	7.1	40[11]	50 ± 15	15 ± 3	40°52'46.79 40°29'42.30	111°50'12.74 111°49'15.17
Wasatch – Provo segment (P)	S	<15 ka	N	7.3	59[11]	50 ± 15	15 ± 3	40°29'42.38 39°58'17.66	111°49'15.17 111°41'33.45
Wasatch – Nephi segment (N)	S	<15 ka	N	7.1	43[11]	50 ± 15	15 ± 3	40°05'04.60 39°42'00.04	111°43'59.08 111°49'10.52
Wasatch – Levan segment (L)	S	<15 ka to <750 ka	N	7.0	31[11]	50 ± 15	15 ± 3	39°38'36.35 39°22'50.32	111°49'36.56 111°55'18.71
Wasatch – Fayette segment (F)	S	<15 ka	N	6.8	22[11]	50 ± 15	15 ± 3	39°21'45.19 39°13'20.84	111°52'13.82 111°50'41.62
Wasatch – BC+W	MS	*[12]	N	7.4	91[11]	50 ± 15	15 ± 3	41°39'07.79 40°50'27.96	112°02'51.18 111°52'10.98
Wasatch – SLC+P	MS	*[12]	N	7.4	99[11]	50 ± 15	15 ± 3	40°52'46.79 39°58'17.66	111°50'12.74 111°41'33.45
Wasatch – W+SLC	MS	*[12]	N	7.5	104[11]	50 ± 15	15 ± 3	41°20'42.72 40°29'42.30	111°57'16.61 111°49'15.17
Wasatch – P+N	MS	*[12]	N	7.4	88[11]	50 ± 15	15 ± 3	40°29'42.38 39°42'00.04	111°49'15.17 111°49'10.52
Wasatch – SLC+P+N	MS	*[12]	N	7.5	128[11]	50 ± 15	15 ± 3	40°52'46.79 39°42'00.04	111°50'12.74 111°49'10.52
Wasatch – L+F	MS	*[12]	N	7.2	46[11]	50 ± 15	15 ± 3	39°38'36.35 39°13'20.84	111°49'36.56 111°50'41.62

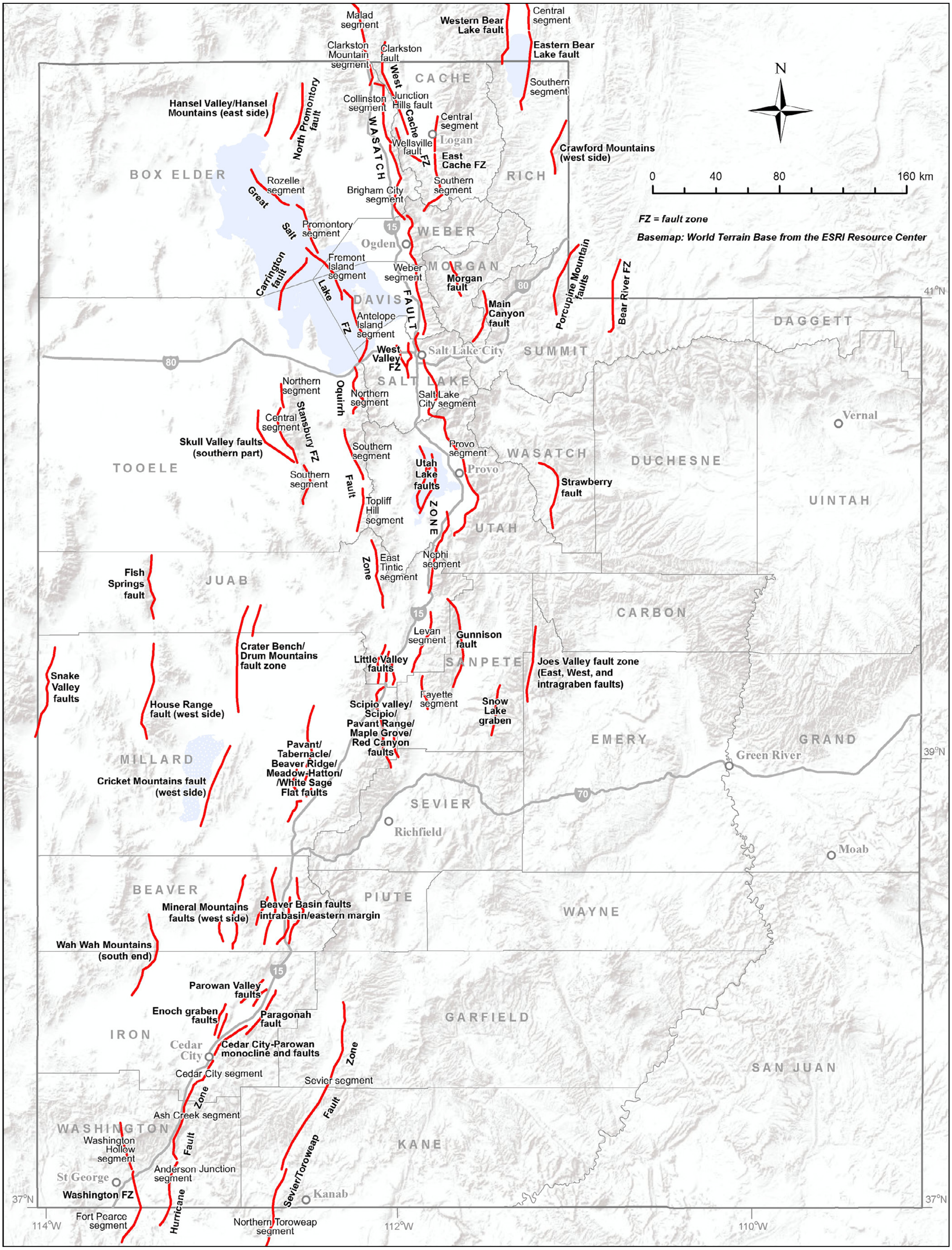
Great Salt Lake – Rozelle segment	S	<15 ka?	N	6.9	27[11]	50 ± 15	15 ± 3	*[13] 41°32'03.16	*[13] 112°50'07.99
Great Salt Lake –Promontory segment	S	<15 ka?	N	6.8	22[11]	50 ± 15	15 ± 3	41°32'03.16 41°11'30.15	112°50'07.99 112°27'28.63
Great Salt Lake – Fremont Island segment (FI)	S	<15 ka	N	6.9	26[11]	50 ± 15	15 ± 3	41°12'36.51 40°59'33.38	112°31'15.66 112°18'18.41
Great Salt Lake – Antelope Island segment (AI)	S	<15 ka	N	7.0	34[11]	50 ± 15	15 ± 3	41°02'04.42 40°43'25.97	112°19'08.74 112°13'47.18
Great Salt Lake – FI+AI	MS	*[12]	N	7.3	58[11]	50 ± 15	15 ± 3	41°12'36.51 40°43'25.97	112°31'15.66 112°13'47.18
Oquirrh – Northern segment[14] (NO)	S	<15 ka	N	7.0	30[11]	50 ± 15	15 ± 3	*[13]	*[13]
Oquirrh – Southern segment[14] (SO)	S	<15 ka	N	7.0	31[11]	50 ± 15	15 ± 3	*[13]	*[13]
Oquirrh – Topliff Hills segment[14] (TH)	S	<130 ka?	N	6.9	23[11]	50 ± 15	15 ± 3	40°10'40.75 39°59'57.24	112°12'32.88 112°14'29.87
Oquirrh – East Tintic segment[14]	S	<130 ka?	N	7.1	40[11]	50 ± 15	15 ± 3	39°57'12.26 39°39'25.40	112°09'34.78 112°06'01.74
Oquirrh – NO+SO	MS	*[12]	N	7.3	57[11]	50 ± 15	15 ± 3	*[13]	*[13]
Oquirrh – SO+TH	MS	*[12]	N	7.2	52[11]	50 ± 15	15 ± 3	*[13] 39°59'57.24	*[13] 112°14'29.87
Bear River	I	<15 ka	N	7.0	35	50 ± 15	15 ± 3	41°09'37.46 40°51'40.83	110°45'05.72 110°47'24.75
Beaver Basin intrabasin/eastern margin	L	<130 ka to <1.6 ma	N	7.0	39	50 ± 15	15 ± 3	38°30'50.71 38°09'56.22	112°42'12.39 112°46'14.95
Carrington[15]	I	<15 ka	N	6.9	30	50 ± 15	15 ± 3	*[13]	*[13]
Cedar City – Parowan monocline and faults	I	<15 ka	N	6.8	25	50 ± 15	15 ± 3	37°50'03.68 37°41'28.99	112°49'49.34 113°02'52.67
Crater Bench and Drum Mountains	L	<15 ka	N	7.1	52[11]	50 ± 15	15 ± 3	39°40'26.18 39°12'29.27	112°46'45.52 112°54'45.49
Crawford Mountains (west side)	I	<15 ka	N	6.8	25	50 ± 15	15 ± 3	41°45'17.46 41°31'52.86	111°03'13.94 111°07'14.85
Cricket Mountains (west side)	I	<15 ka	N	7.0	41	50 ± 15	15 ± 3	39°03'21.08 38°42'24.51	112°57'28.39 113°07'11.96
East Cache – Central segment	S	<15 ka	N	6.7	17	50 ± 15	15 ± 3	41°46'04.18 41°37'10.83	111°46'45.86 111°48'00.07
East Cache – Southern segment[16]	L	<130 ka	N	7.0	29[11]	50 ± 15	15 ± 3	41°37'10.83 41°21'55.64	111°48'00.07 111°51'37.02

Eastern Bear Lake – Central segment[10]	S	<15 ka	N	6.9	24[11]	50 ± 15	15 ± 3	42°19'24.34 42°06'33.81	111°17'18.67 111°15'37.68
Eastern Bear Lake – Southern segment	S	<15 ka	N	7.1	35[11]	50 ± 15	15 ± 3	42°06'33.81 41°47'48.57	111°15'37.68 111°18'27.25
Enoch graben	AF	<15 ka	N	6.7	17	70 ± 15	15 ± 3	37°54'41.76 37°45'39.80	112°58'46.29 113°01'39.11
Fish Springs	I	<15 ka	N	6.6	15	50 ± 15	15 ± 3	39°53'15.07 39°37'05.94	113°24'03.82 113°23'49.77
Gunnison	I	<15 ka	N	7.0	42	50 ± 15	15 ± 3	39°41'53.18 39°19'06.05	111°43'29.71 111°41'33.29
Hansel Valley/Hansel Mountains (east side)[17]	AF	Historical to <750 ka	N	6.5	30[11]	50 ± 15	15 ± 3	41°54'39.55 41°41'02.17	112°37'41.04 112°45'20.00
House Range (west side)	I	<15 ka	N	7.1	46	50 ± 15	15 ± 3	39°29'59.82 39°05'22.09	113°23'38.34 113°26'02.69
Hurricane – Cedar City segment	S	<15 ka	N	6.7	13?	50 ± 15	15 ± 3	37°39'39.10 37°34'04.86[18]	113°03'16.38 113°08'11.19[18]
Hurricane – Ash Creek segment	S	<15 ka	N	7.0	32	50 ± 15	15 ± 3	37°34'04.86[18] 37°17'49.60	113°08'11.19[18] 113°16'56.66
Hurricane – Anderson Junction segment	S	<15 ka to <130 ka	N	7.2	42	50 ± 15	15 ± 3	37°17'49.60 36°55'09.89	113°16'56.66 113°21'26.75
Joes Valley (East, West, and intragraben faults[19]	AF	<15 ka	N	6. 7	37[11]	70 ± 15	15 ± 3?	39°35'10.20[18] 39°14'57.92[18]	111°13'42.74[18] 111°16'07.02[18]
Little Valley	I	<15 ka	N	6.7	20	50 ± 15	15 ± 3	39°29'58.63 39°19'32.67	112°04'44.29 112°04'58.71
Main Canyon[20]	I	<15 ka	N	6.8	26[11]	50 ± 15	15 ± 3	41°01'35.96 40°48'47.92	111°31'49.76 111°35'14.98
Mineral Mountains (west side)	I	<15 ka	N	7.0	38	50 ± 15	15 ± 3	38°29'02.72 38°09'34.67	112°51'51.63 112°57'10.69
Morgan – northern, central, and southern sections	L	<15 ka to 1.6 ma	N	6.6	17[11]	50 ± 15	15 ± 3	41°09'15.95 41°00'33.34	111°42'19.79 111°39'16.13
North Promontory	I	<15 ka	N	6.8	26	50 ± 15	15 ± 3	41°54'05.66 41°40'24.89	112°32'59.15 112°37'02.25
Paragonah	I	<15 ka	N	6.8	27	50 ± 15	15 ± 3	37°58'42.09 37°46'39.10	112°42'05.73 112°52'56.28
Parowan Valley	I	<15 ka	N	6.6	16	50 ± 15	15 ± 3	38°01'36.90 37°55'05.38	112°46'13.61 112°53'48.01
Pavant/ Tabernacle/ Beaver Ridge/Meadow-Hatton/White Sage Flats	L	<15 ka to <750 ka	N	7.2	57	50 ± 15	15 ± 3	39°14'09.91 38°44'01.20	112°28'58.12 112°38'13.90

Porcupine Mountain	I	<130 ka to 1.6 ma	N	7.0	35	50 ± 15	15 ± 3	41°13'01.58 40°55'09.11	110°59'16.85 111°06'50.25
Scipio Valley/ Scipio/ Pavant Range/ Maple Grove/ Red Canyon	L	<15 ka to 1.6 ma	N	7.1	45[11]	50 ± 15	15 ± 3	39°19'20.96 38°55'10.43	112°07'21.67 112°02'31.92
Sevier/Toroweap – Sevier segment[21]	S	<130 ka	N	7.4	89	50 ± 15	15 ± 3	37°55'14.39 37°10'07.97	112°19'29.01 112°39'55.16
Sevier/Toroweap – Northern Toroweap segment[21]	S	<130 ka	N	7.4	81	50 ± 15	15 ± 3	37°10'46.07 36°30'24.59	112°38'46.35 112°59'45.24
Skull Valley (southern part)	S	<15 ka	N	6.9	34	50 ± 15	15 ± 3	40°30'53.52[18] 40°14'56.28	112°46'46.73[18] 112°34'22.22
Snake Valley	I	<15 ka	N	7.1	46	50 ± 15	15 ± 3	39°29'23.54 39°05'21.25	113°57'04.70 114°03'51.76
Snow Lake graben[22]	AF	<15 ka	N	6.5	26	70 ± 15	15 ± 3	39°19'36.33 39°05'55.78	111°25'43.47 111°27'50.50
Stansbury – Northern segment[23]	S	<15 ka	N	6.9	24[11]	50 ± 15	15 ± 3	*[13]	*[13]
Stansbury – Central segment[23]	S	<15 ka	N	7.0	33[11]	50 ± 15	15 ± 3	*[13]	*[13]
Stansbury – Southern segment[23]	S	<15 ka to 1.6 ma	N	6.7	17[11]	50 ± 15	15 ± 3	*[13]	*[13]
Strawberry	I	<15 ka	N	6.9	32	50 ± 15	15 ± 3	40°17'23.34 40°00'22.25	111°12'44.77 111°08'36.25
Utah Lake[24]	AF	<15 ka	N	6.8	31	50 ± 15	15 ± 3	40°21'31.85 40°04'47.91	111°53'20.39 111°53'17.38
Wah Wah Mountains (south end)[25]	I	<130 ka	N	7.0	35	50 ± 15	15 ± 3	38°18'48.42 37°57'18.74	113°25'15.39 113°30'33.96
Washington – Washington Hollow segment[26]	S	<130 ka	N	6.9	22	50 ± 15	15 ± 3	37°22'51.38[27] 37°08'52.45[27]	113°33'39.32[27] 113°30'42.89[27]
Washington – Ft. Pearce segment[28]	S	<15 ka	N	7.1	37	50 ± 15	15 ± 3	37°08'52.45 36°49'30.12	113°30'42.89 113°34'16.65
Western Bear Lake[10,29]	AF	<15 ka	N	65	26	50 ± 15	15 ± 3	42°33'51.05 42°02'45.46	111°30'20.80 111°22'57.08
West Cache – Clarkston fault	S	<15 ka	N	6.8	21	50 ± 15	15 ± 3	41°59'51.42 41°53'46.63	112°08'48.98 112°03'58.49
West Cache – Junction Hills fault	S	<15 ka	N	6.9	24	50 ± 15	15 ± 3	41°53'45.68 41°41'38.24	112°03'53.97 111°56'57.98
West Cache – Wellsville fault	S	<15 ka	N	6.8	20	50 ± 15	15 ± 3	41°43'15.87 41°34'46.97	112°01'22.57 111°52'30.62
West Valley – includes Granger and Taylorsville faults[30]	AF	<15 ka	N	6.3	16	50 ± 15	15 ± 3	40°48'16.45 40°39'35.48	111°56'52.04 111°57'13.67

[1]Wasatch, Oquirrh, and Great Salt Lake fault zones placed first in database because they are the largest and most active Quaternary faults in close proximity to Wasatch Front population centers. Remaining faults in table are in alphabetical order.
[2]Rupture models include: AF = antithetic fault; G = graben; I = independent, unsegmented; L = linked; MS = multisegment rupture; S = segmented.
[3]Fault activity class suffixes are: ka thousands of years ago, and ma = millions of years ago. Fault activity classes are <15 ka = latest Quaternary, <130 ka = late Quaternary, <750 ka = late and middle Quaternary, and <1.6 Ma = Quaternary. The activity class of a fault is the youngest class based on the age of the known or estimated most recent surface faulting or deformation. Activity classes were adopted from the QFFDUS. No activity class is reported for the WGUEP14 multisegment ruptures because such events, while considered possible, have not been individually documented in the paleoseismic record.
[4]Fault type includes: N = normal slip; a fault characterized by predominantly vertical displacement in which one side of the fault moves downward (hanging wall) with respect to the other side of the fault (footwall). Generally, this type of fault is a sign of tectonic extension.
[5] M_{CHAR} is the characteristic mean magnitude for a rupture source, which assumes full rupture of the source and is computed from magnitude relations relating length, area, or average displacement to magnitude. M_{CHAR} earthquake magnitude relations and relation weights used to determine M_{CHAR} for this table follow conventions established by WGUEP14 (see Wong and others, in preparation, table 3.5-2).
[6]Fault lengths measured straight line end to end as reported in the QFFDUS unless noted otherwise.
[7]Fault dip angle as recommended by the Basin and Range Province Earthquake Working Group II (Lund, 2012) to the USGS for the 2014 update of the NSHM, and as subsequently adopted by WGUEP14.
[8]Seismogenic depth estimate for normal-slip faults and coseismic fault pairs as adopted by WGUEP14.
[9]Fault end coordinates obtained from the QFFDUS (Kathy Haller, USGS, written communication, 2014; WGS84) unless noted otherwise.
[10]Fault/fault segment located across the Utah/Idaho border in Idaho.
[11]Segment lengths from WGUEP14.
[12]Plausable multi-segment rupture scenario as determined by WGUEP14; activity class not assigned to potential ruptures.
[13]Data not available; lack a map of sufficient accuracy from which to determine fault end point coordinates.
[14]Oquirrh fault zone segments defined as per WGUEP14.
[15]Dinter and Pechmann (2005) first identified the Carrington fault based on displacements observed in high-resolution seismic reflection profiles in Great Salt Lake. Based on apparent similarities of their lakebed scarps, WGUEP14 assigned the Carrington fault an activity class similar to the Antelope Island segment of the Great Salt Lake fault zone, and that convention is adopted here. The Carrington fault has not yet been incorporated into the QFFDUS. Because the fault is submerged beneath Great Salt Lake, end point latitude and longitudes are not available.
[16]Following the recommendation of the Utah Quaternary Fault Parameters Working Group (http://geology.utah.gov/ghp/workgroups/uqfpwg.htm), the Southern segment of the East Cache Valley fault zone includes the James Peak and Broadmouth Canyon faults.
[17]The Hansel Valley/Hansel Mountain faults are antithetic to the North Promontory fault.
[18]Fault end coordinates estimated from Google Earth (WGS84).
[19]Seismic data (Coogan, 2008) show that the east and west bounding faults of the Joes Valley graben dip more steeply than is typical for most normal faults in Utah. It is unclear from the seismic data whether the Joes Valley faults sole into a geologically weak layer at shallow depth (3-5 km) or penetrate to seismogenic depth (GEO-HAZ Consulting, Inc., 2013). Length of the Joes Valley fault is reported only for the Latest Quaternary (< 15 ka) active portion of the fault zone.
[20]The Main Canyon fault bounds the east side of East Canyon Valley. An investigation by Piety and others (2010) showed that stratigraphic and structural relations, and radiocarbon and luminescence ages provide evidence for two surface-faulting earthquakes during the past 30 to 38 kyr on the fault. The most recent event likely occurred shortly before 5 to 6 ka, but could be as old as 12 to 15 ka. The Main Canyon fault has not yet been incorporated into the QFFDUS as redefined based on Piety and others' (2010) new paleoseismic data. The Main Canyon fault is currently listed in the QFFDUS as the East Canyon (east side) fault (Class B).
[21]The Sevier and Northern Toroweap segments of the Sevier/Toroweap fault are both reported as greater than 80 km long (USGS, 2014), and resulting M_{CHAR} magnitudes are M 7.4. Lund and others (2008) found compelling, but not conclusive, evidence for two additional segment boundaries on the Sevier segment, indicating that the Sevier segment may consist of multiple shorter segments that would generate correspondingly smaller earthquakes. Although not studied in detail, it may be possible that the Northern Toroweap segment also includes unrecognized additional segment boundaries. Therefore, the M_{CHAR} magnitudes reported for the Sevier and Northern Toroweap segments are considered poorly constrained maximum values.
[22] Due to structural similarities, the Snow Valley graben is assigned the same rupture model, fault-dip, and seismogenic-depth distributions as the Joes Valley fault zone.

[23]The Stansbury fault zone is subdivided into three sections as per WGUEP14 and Helm (1994, 1995); individual sections have not yet been included in the QFFDUS.
[24]The Utah Lake faults are antithetic to the Provo segment of the WFZ.
[25]Fault length reported only for the Late Quaternary active (< 130 ka) portion of the fault.
[26]Knudsen (in press) recently defined a new northernmost segment of the Washington fault zone termed the Washington Hollow segment. The Washington Hollow segment has not yet been incorporated into the QFFDUS.
[27]End points from Knudsen (in press).
[28]The Ft. Pearce segment of the Washington fault zone consists of the previously defined Northern segment (Pearthree, 1998), which Knudsen (in press) renamed to accommodate the fact that the Washington Hollow segment is now the northernmost segment of the Washington fault zone. Additionally, Knudsen (in press) redefined the previously identified Mokaac section of the Washington fault zone (Pearthree, 1998) and the independently mapped Dutchman Draw fault (Billingsley, 1992a, 1992b) as strands of the Ft. Pearce segment. The Ft. Pearce segment has not yet been incorporated into the QFFDUS.
[29]The Western Bear Lake fault is antithetic to the Eastern Bear Lake fault.
[30]The West Valley fault zone is antithetic to the Salt Lake City segment of the WFZ.



Faults included in the revised (through 2013) Hazus Loss Estimation Software Earthquake Model fault database for Utah.