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Documentation of changes in fault parameters for the 2002 National Seismic Hazard Maps—Conterminous United States except California

by

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DOCUMENTATION OF CHANGES IN FAULT PARAMETERS FOR THE 2002 NATIONAL SEISMIC-HAZARD MAPS— CONTERMINOUS UNITED STATES EXCEPT CALIFORNIA

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1. INTRODUCTION

This document defines the changes in fault parameters between the 1996 and 2002 versions of the national seismic hazard maps. We note faults that have been added or deleted for the 2002 maps, name changes, and changes in assigned slip rate. We do not describe here faults where the slip rates for the 2002 maps are essentially the same as those used in 1996. The fault parameters used in 2002 were derived from descriptions in the Quaternary fault and fold database for the U.S., a digital compilation of available information documenting Quaternary surface deformation nationwide. The compilation and database is being organized and overseen by M.N. Machette, K.M. Haller, and numerous colleagues including personnel of state geological surveys. Published parts of the database (Collins and others, 1996; Machette and others, 1998; Pearthree, 1998; Widmann and others, 1998; Black and others, 2000; Crone and Wheeler, 2000; Haller and others, 2000; Machette and others, 2001) and similar products in progress for Oregon, Washington, and Idaho were used as the primary input for revising slip rates for 2002.

We frequently refer to the Web-based documentation of faults and their parameters that were used in 1996. That documentation is at http://geohazards.cr.usgs.gov/eq/index.html (as of 10/22/02). Parameters for California faults were calculated in cooperation with the California Geological Survey and are documented separately.

2. OVERVIEW OF CHANGES

2.1. Slip rates

All slip rates given for normal or reverse faults are vertical rates, because the most common paleoseismological data available to calculate rates for dip-slip faults are uplift rates, scarp heights, or vertical surface offsets. For dip-slip faults, the vertical rates are converted to fault parallel rates by using the assigned dip (generally 60 degrees) prior to recurrence computation.

Most of the slip rates in the 1996 and 2002 maps are based on sparse data of variable quality and poorly known uncertainties. Commonly, rates change with the addition of new data. Many of the faults depicted here are characterized by sparse old information that is not up to modern standards. Few faults have been trenched at more than two sites, or have trenches deep enough to reveal the records of more than two or three surface faulting events. Results from these few well-studied faults demonstrate that slip rates can vary widely through time at a site and between sites along a single fault.

2.2. Fault names

Some 1996 fault names have been modified in 2002 to correspond to names regarded to be in common usage in the Quaternary fault and fold database for the United States. To facilitate comparisons between fault parameters used in 1996 and 2002, we provide the following list of name changes. A few name changes occurred because new data shows that a fault as portrayed in 1996 is actually two or that two or more 1996 faults are actually one. However, most name changes occurred because many of the 1996 names were taken from informally published contract reports. In contrast, all the 2002 names are based on exhaustive literature searches that are summarized in the Quaternary fault and fold database for the United States. We judge that the database uses fault names that are most likely to conform to local and long-standing usage. Accordingly, if a 1996 name differs from the name used in the database, we use the latter.

Table 1. Changes in fault name listed by State.

STATE	1996 FAULT NAME	2002 FAULT NAME
Colorado	Sangre de Cristo fault	Northern Sangre de Cristo fault
	Sawatch Range fault	Southern Sawatch fault
Nevada	Bettles Well fault	Bettles Well-Petrified Springs fault
	Clan Alpine Mountains fault	Middlegate fault zone
	Coal Valley fault	Golden Gate fault
	Cortez Mountains fault 1, Cortez Mountains fault 2	Cortez Mountain fault zone
	Crystal Springs fault	Hiko fault zone
	Dry Valley fault	Dry Valley-Smoke Creek Ranch fault zone
	Eastern Edwards Creek Valley fault 1	Buffalo Creek fault zone
	Eastern Edwards Creek Valley fault 2	Eastern Edwards Creek Valley fault zone
	Eastern Osgood Mountains fault 1	Eastern Osgood Mountains fault zone
	Eastern Osgood Mountains fault 2	Eastern Osgood Mountains piedmont fault
	Fairview Peak fault	Fairview fault zone
	Huntoon Valley fault 1 and 3	faults in Excelsior Mountains (#1316)
	Huntoon Valley fault 2	unnamed faults (#1303)
	Huntoon Valley fault 4	unnamed faults (#1302)
	Independence Valley fault 1, Independence Valley fault 2	Independence Valley fault zone
	Indian Valley fault	Southwest Reese River Valley fault (part of)
	Jackson Mountains fault 1, Jackson Mountains fault 2	Jackson Mountains fault zone

Table 1 (cont). Changes in fault name listed by State.

STATE	1996 FAULT NAME	2002 FAULT NAME
Nevada (cont.)	Jersey Valley fault 1, Jersey Valley fault 2	Jersey Valley fault zone
	Liberty fault	Crescent Dunes fault
	Montana Mountains fault	Montana Mountains/Desert Valley fault zone
	Mount Rose fault 2	Little Valley fault
	Northeast Long Valley fault	Warner Valley faults (east)
	Northern Pine Forest Range fault	Eastern Pine Forest Range fault zone
	North Pahranagat Range fault	Mount Irish Range fault
	Peterson Mountain fault 1, Peterson Mountain fault 2	Petersen Mountain fault
	Pueblo Mountains fault	Steens fault zone (part of)
	Pumpernickel Valley fault	Edna Mountain fault
	Rattlesnake Flat fault	faults in southern Garfield Hills
	Ruby Mountains fault 1	Ruby Mountains fault zone, northern section
	Ruby Mountains fault 2	Ruby Mountains fault zone, southern section
	Ruby Mountains fault 3	Northern Huntington Valley fault
	Selenite Range fault	Selenite Range fault zone, and Nightingale Mountains fault zone
	Southeast Sheep Creek Range fault	Sheep Creek Range southeastern fault
	Southwestern Delamar Mountains Fault	Coyote Spring fault
	Stingaree Valley fault	West Gate fault
	Sweetwater Flat fault	Smith Valley fault (part of)
	Unnamed fault	Ione Valley fault (part of)
	Wassuk Range fault 1, Wassuk Range fault 2	Wassuk Range fault zone
	Western Carico Lake Valley fault	Carico Lake Valley fault system (part of)
	Western Edwards Creek Valley fault	Clan Alpine fault zone
	Western Humboldt Range fault 1, Western Humboldt Range fault 2	Western Humboldt Range fault zone
	Whirlwind Valley fault	Beowawe fault
	Western Smoke Creek Desert fault 1, Western Smoke Creek Desert fault 2	Bonham Ranch fault zone

Table 1 (cont). Changes in fault name listed by State.

STATE	1996 FAULT NAME	2002 FAULT NAME
New Mexico	Fault of Black Mesa	Black Mesa fault zone
	Sangre de Cristo fault	Southern Sangre de Cristo fault zone
	West Mesa fault	County Dump fault, Zia fault
Oregon	Brownlee fault	Pine Valley graben fault system (also includes the 1996 Halfway and Posey Valley faults)
	East Chemult graben – Walker Rim fault	Chemult graben fault system (east)
	East Klamath graben fault	Klamath graben fault system (east) (also includes the 1996 South Klamath graben zone)
	East Warner Valley fault, north, and East Warner Valley fault, south	Warner Valley faults (east)
	Eastern Alvord graben fault	Tule Springs Rims faults
	Halfway fault	Pine Valley graben fault system (also includes the 1996 Brownlee and Posey Valley faults)
	Mill Creek fault	Turner and Mill Creek faults
	Netarts Bay fault	Happy Camp fault
	Posey Valley fault	Pine Valley graben fault system (also includes the 1996 Halfway and Brownlee faults)
	Santa Rosa-Owyhee River-Oregon Canyon fault zone	Santa Rosa Range fault system
	South Klamath graben zone	Klamath graben fault system (east) (also includes the 1996 East Klamath graben fault)
	Southeast Newberry, Crack-in-the-Ground fault	Southeast Newberry fault zone
	Tumalo-Black Butte faults	Metolius fault zone
	West Chemult graben – Walker Rim fault	Chemult graben fault system (west)
	West Klamath Lake fault	Klamath graben fault system (west)
	West Warner Valley fault	Warner Valley faults (west)
	Winchester fault	South Slough thrust and reverse faults
	Winter Ridge–Slide Mountain fault	Winter Rim fault system

Table 1 (cont). Changes in fault name listed by State.

STATE	1996 FAULT NAME	2002 FAULT NAME
Texas	East Baylor Mountain fault	East Baylor Mountain-Carrizo Mountain fault
	Sierra Diablo fault	East Sierra Diablo fault (combined in 1996 with the East Flat Top Mountain and North Sierra Diablo faults)
Utah	East Great Salt Lake fault 1	East Great Salt Lake fault zone, Promontory section
	East Great Salt Lake fault 2	East Great Salt Lake fault zone, Fremont Island section; and East Great Salt Lake fault zone, Antelope Island section
	East Joes Valley fault	Joes Valley fault zone east fault
	Joes Valley fault	Joes Valley fault zone west fault
Wyoming	East Yellowstone River fault, and West Yellowstone River fault	Upper Yellowstone Valley faults
	Factory Hill fault	East Mount Sheridan faults
	Star Valley fault	Grand Valley fault

2.3. Fault traces

Most traces were simplified from those depicted in the Quaternary fault and fold database for the United States. For the few faults that are not included in that database, we used the 1996 traces with appropriate modifications.

3. CONTACTS FOR QUESTIONS

Questions and comments about the fault parameters should be directed to Kathy Haller (haller@usgs.gov) or Rus Wheeler (wheeler@usgs.gov).

4. CHANGES BY STATE

This section describes changes in assigned slip rate for individual faults. Faults are listed alphabetically by state. Each paragraph explains changes from the 1996 source parameters to produce the 2002 map. We do not report on those faults for which the slip rates for the 2002 maps are essentially the same as those used in 1996.

The first line of each paragraph lists (1) the 2002 fault name in capitals and 1996 name in mixed case if the two names are different, (2) the identification number of the fault in the Quaternary fault and fold database for the United States, (3) the 1996, and (4) 2002 slip rates. If the fault was not included in the 1996 maps but was added for the 2002 maps, “added for 2002 ” appears in the first line instead of a 1996 slip rate. If a fault described in this section crosses a state border, it is described in the listing under the state that contains most of its length and cross-referenced under the other state.

4.1. Arizona

ALGODONES FAULT ZONE, #944, added for 2002, 0.15 mm/yr (2002).
Scarps are 7-15 m high on Upper Mesa deposits, which soil development indicates to be 50-100 k.y. old (Woodward-McNeil & Associates, 1974). The midpoints of the offset and age ranges yield the assigned slip rate.

BIG CHINO FAULT, #951, 0.09 mm/yr (1996), 0.083 mm/yr (2002).
The assigned slip rate is based on upper Pleistocene (estimated 80-100 ka) alluvial deposits that trenching showed to be offset vertically 7-8 m (Euge and others, 1992).

DUTCHMAN DRAW FAULT, #1003, added for 2002, 0.075 mm/yr (2002).
The assigned slip rate is based on an early Quaternary basalt, dated at 1.4 ± 0.3 Ma (Wenrich and others, 1995) that is displaced approximately 100 m. From these data, P.A. Pearthree (written commun., 2002) calculated a slip rate of 0.06-0.09 mm/yr. We assigned the average of this range for 2002.

HURRICANE FAULT ZONE, #998, 0.4 mm/yr (1996); 0.1 mm/yr—northern (#998ab) and southern (#998ef) parts, 0.2 mm/yr—central (#998cd) part (2002).
The assigned 2002 slip rates are based on recent paleoseismologic investigations (Stenner and others, 1999; Lund and others, 2001; Amoroso and others, 2002). None of the new late Quaternary data suggests a rate as high as that used in 1996, which was based on a long term rate from Hamblin and others (1981). The central part of the fault appears to be characterized by a higher slip rate than the ends based on the lateral continuity of scarps on alluvium. The highest value of the late Quaternary single-event rates reported by Lund and others (2001, p. 35) from Cottonwood Canyon is 0.3 mm/yr and considered to be larger than the characteristic late Quaternary rate for the fault.

SEVIER/TOROWEAP FAULT ZONE, #997, 0.36 mm/yr (1996), 0.36 mm/yr—northern (#997a) part, 0.16 mm/yr—southern (#997bcd) part (2002).
The assigned slip rate for the southern part of the fault is the average rate obtained from the data presented by Jackson (1990), who reports that 25-100 ka deposits are offset 6.5 m. The slip rate for the northern part of the fault remains unchanged from 1996 and is from data presented by Anderson and Christenson (1989).

4.2. California

Changes for California faults are described in separate documentation.

4.3. Colorado

PONCHA PASS FAULT, #2312, 0.11 mm/yr (1996), excluded for 2002.
The Quaternary activity attributed to the Poncha Pass fault in 1996 actually occurred on a nearby fault (Colman, 1985). The NW-striking, 34-km-long Poncha Pass fault appears on at least one pre-1996 compilation map. However, the Quaternary offset in question

occurred on a 6-km-long, unnamed fault that parallels the Poncha Pass fault less than 5 km to the northeast. The short fault is the unnamed fault of Missouri Park, of Widmann and others (1998). The 1996 maps included only faults long enough to contain the rupture zone of an earthquake of Mw 6.0 or larger (Frankel and others, 1996 p. 19) and the 6-km-long fault is too short (Wells and Coppersmith, 1994). In addition, the age of the surface that was offset by the short fault is known but the amount of offset is not reported, so no slip rate can be calculated.

SOUTHERN SAWATCH FAULT, Sawatch Range fault (1996), #2308b, 0.12 mm/yr (1996), 0.062 mm/yr (2002).
The 1996 rate was derived from 3 km of suggested offset of Neogene deposits (24 Ma). The 2002 slip rate is based on data from Ostenaa and others (1981) that suggests the presence of scarps 8-10 m high on Bull Lake-equivalent deposits (160-130 ka).

4.4. Idaho

BEAVERHEAD FAULT, #603, 0.3 mm/yr (1996), 0.12 mm/yr (2002).
The slip rate assigned in 1996 was based on the assertion by Scott and others (1985) that the rate for the central part of the Beaverhead fault might be similar to that of the central part of the Lost River fault (i.e., 0.3 mm/yr). More recent, fault specific geomorphic studies suggest that the slip rate for the Beaverhead fault should be slower. Scarp profiles of multiple-earthquake scarps on early Pinedale-equivalent (25-30 ka) surfaces show vertical surface offsets at six sites on two of the central segments of the fault (Haller, 1988) that suggest an average of 0.12 mm/yr.

CENTENNIAL FAULT, #643, 1.3 mm/yr (1996), 0.9 mm/yr (2002).
The slip rate assigned in 1996 is from Pierce and Morgan (1992), who report this maximum slip rate for the eastern and central parts of the fault based on as much as 20 m of offset of 15 ka deposits from data of Witkind (1975). There is considerable uncertainty in the above age assignment, and the actual late Quaternary slip rate may be 10% of the published value. The assigned rate for the 2002 maps is based on long-term slip data reported by Sonderegger and others (1982), in which they indicate that the 2-Ma Huckleberry Ridge Tuff is offset 1.5-1.8 km.

LEMHI FAULT, #602, 0.3 mm/yr (1996), 0.22 mm/yr (2002).
The slip rate assigned in 1996 was based on the assertion by Scott and others (1985) that the rate for the central part of the Lemhi fault might be similar to that of the central part of the Lost River fault (i.e., 0.3 mm/yr). More recent, fault specific trenching and geomorphic studies suggest that the slip rate for the Lemhi fault should be slower. Scarp profiles of multiple-event scarps by Haller (1988) suggest slip rates of 0.18 mm/yr, 0.28 mm/yr, and 0.086 mm/yr. Trenching by Baltzer (1990) suggests a slip rate of 0.17 mm/yr. Trenching at two sites by Hemphill-Haley and others (1992) indicates a slip rate of 0.27 mm/yr and 0.32 mm/yr, respectively. The average of these is represented by the assigned slip rate.

LOST RIVER FAULT, #601, 0.24 mm/yr (1996), 0.15 mm/yr (2002).
The 1996 rate was based largely on 3.5-4.5 m of post-15-ka offset on a single scarp along the central Lost River fault (Scott and others, 1985). The 2002 assigned slip rate is the

average of published slip rates from two of the central sections of the fault. Specifically, trenching on the Thousand Springs section showed that 2.1 m of vertical offset in 1983 released strain that had been accumulating since 10-11 ka, for a slip rate of 0.21 mm/yr (Vincent, 1995). Trenching on the Pass Creek section showed 13.1-18.1 m of vertical offset of a 140- to 220-ka surface, for a slip rate of 0.06-0.13 mm/yr (Olig and others, 1995); their preferred rate is 0.095 mm/yr.

MADISON FAULT, #655, 0.6 mm/yr (1996), 0.4 mm/yr (2002).
The assigned slip rate is based on reconnaissance studies by Lundstrom (1986) and Mathieson (1983); both report a slip rate of 0.4 mm/yr for the late Pleistocene. More recent studies by Ruleman (2002) suggest a range of similar slip rates that average to 0.4 mm/yr.

SQUAW CREEK FAULT, #632, 0.15 mm/yr (1996), 0.1 mm/yr (2002).
The assigned slip rate is from Geomatrix Consultants, Inc. (1995).

4.5. Montana

BLACKTAIL FAULT, #644, 0.042 mm/yr (1996), 0.03 mm/yr (2002).
The assigned rate is based on the average value from data presented by Stickney and Bartholomew (1987) that suggest there is 4-5 m of offset of inferred upper (<150-ka) Quaternary deposits.

CENTENNIAL FAULT, #643, 1.3 mm/yr (1996), 0.9 mm/yr (2002).
The slip rate assigned in 1996 is from Pierce and Morgan (1992), who report this maximum slip rate for the eastern and central parts of the fault based on as much as 20 m of offset of 15 ka deposits from data of Witkind (1975). There is considerable uncertainty in the above age assignment, and the actual late Quaternary slip rate may be 10% of the published value. The assigned rate for the 2002 maps is based on long-term slip data reported by Sonderegger and others (1982), in which they indicate that the 2-Ma Huckleberry Ridge Tuff is offset 1.5-1.8 km.

GEORGIA GULCH FAULT, #667, 0.07 mm/yr (1996), 0.031 mm/yr (2002).
The assigned slip rate is based on 4 m of offset of late Pleistocene deposits (Stickney and Bartholomew, 1987). The assumed age of the offset deposits is 130 k.y.

MADISON FAULT, #655, 0.6 mm/yr (1996), 0.4 mm/yr (2002).
The assigned slip rate is based on reconnaissance studies by Lundstrom (1986) and Mathieson (1983); both report a slip rate of 0.4 mm/yr for the late Pleistocene. More recent studies by Ruleman (2002) suggest a range of similar slip rates that average to 0.4 mm/yr.

MISSION FAULT, #699, 0.75 mm/yr (1996), 0.32 mm/yr (2002).
The assigned slip rate is based on data from the North Crow and Marsh Creek sites of Ostenaa and others (1990). They document 6-7 m of offset at the North Crow site in the past 15-19 k.y. and 4 m of offset at the Marsh Creek site in the same time interval. The slip rate is the average of the four maximum and minimum rates that can be calculated from the presented data.

SWEETWATER FAULT, #645, 0.06 mm/yr (1996), 0.04 mm/yr (2002).
The assigned slip rate is lower than the 1996 rate because the age of the Timber Butte basalt has recently been revised from 4 Ma to 6 Ma (Kreps and others, 1992). Both slip rate calculations use the 250 m of offset documented by Stickney and Bartholomew (1987).

THOMPSON VALLEY FAULT, #696, 0.1 mm/yr (1996), 0.08 mm/yr (2002).
The assigned slip rate is based on data presented by Ostenaa and others (1990). They report that early to mid-Wisconsinan surfaces are offset 6.4 m. The assumed age of the surface is 60-130 ka, and the assigned rate is the average of the maximum and minimum rates calculated from these data.

4.6. Nevada

There are several hundred known or suspected Quaternary faults in the State of Nevada; however, there are few data on most of them. The highest quality data are from detailed studies that provide the fault-specific information necessary to capture reasonable slip-rate values; however, few of the faults in the state have been studied in this detail. Some of the other faults are characterized in a regional assessment by dePolo (1998). He developed a reconnaissance methodology that estimates the maximum slip rate based on empirical relations between slip rate and the height of basal fault facets found along the range front. For use in separate sensitivity studies that are planned to follow publication of the 2002 maps, we have incorporated his assigned value as a maximum slip rate because his assigned slip rate is based on the highest basal facet found along the fault. Most of the faults in the 1996 maps were included according to the preliminary work of dePolo (1996, written commun.). We compared the rates assigned in 1996 with the later definitive work (dePolo, 1998) and made appropriate adjustments to assign the 2002 slip rates.

ANTELOPE RANGE-KINGSLEY MOUNTAINS FAULT ZONE, #1261, 0.1 mm/yr (1996), 0.01 mm/yr (2002).
This fault was assigned a slip rate of 0.1 mm/yr in 1996 based on preliminary data from dePolo (1996, written commun.). However, the slip rate subsequently assigned by dePolo (1998) was 0.01 mm/yr based on the presence of scarps on alluvium but the absence of basal fault facets. The published value will be used herein.

BARE MOUNTAIN FAULT, #1079, added in 2002, 0.008 mm/yr (2002).
Anderson and Klinger (1996) cite the above slip rate based on trenching at one site and reconnaissance of the rest of the fault.

BENTON SPRING FAULT, #1320, 0.1 mm/yr (1996), 0.26 mm/yr (2002).
Bell (1995) indicates the slip rate on this fault is 0.13-0.4 mm/yr. The average of these values is assigned here.

BLACK ROCK FAULT ZONE, #1485, 0.1 mm/yr (1996), 0.19 mm/yr (2002).
The assigned slip rate is based on 4 m of offset of a tephra bed thought to be 18-25 ka (Dodge, 1982).

BLOODY RUN HILLS FAULT, #1509, 0.1 mm/yr (1996), 0.01 mm/yr (2002).
This fault was assigned a slip rate of 0.1 mm/yr in 1996 based on preliminary data from dePolo (1996, written commun.). However, the slip rate subsequently assigned by dePolo (1998) was 0.01 mm/yr based on the presence of scarps on alluvium but the absence of basal fault facets. The published value will be used herein.

BONHAM RANCH FAULT ZONE, Western Smoke Creek Desert fault 1 (1996), #1601, 0.1 mm/yr (1996), 0.2 mm/yr (2002).
The Quaternary fault and fold database for the United States shows that this fault was assigned to the 0.2-1.0 mm/yr slip-rate category based on the published slip rate of Weick (1990), who estimated a maximum Holocene vertical slip rate of about 0.7 mm/yr from 3.5 m (multiple events) of vertical separation of sediment estimated to be about 5 ka. However, the maximum age of the deposits is not convincingly demonstrated and may be as old as 12 ka. The assigned slip rate reflects the uncertainty in the data quality.

BUTTE MOUNTAINS FAULT ZONE, #1277, 0.1 mm/yr (1996), 0.01 mm/yr (2002).
This fault was assigned a slip rate of 0.1 mm/yr in 1996 based on preliminary data from dePolo (1996, written commun.). However, the slip rate subsequently assigned by dePolo (1998) was 0.01 mm/yr based on the presence of scarps on alluvium but the absence of basal fault facets. The published value will be used herein.

CALIFORNIA WASH FAULT, #1118, 0.1 mm/yr (1996), 0.28 mm/yr (2002).
dePolo (1998) assigned a preferred vertical slip rate of 0.28 mm/yr based on "known" data, and dePolo and Anderson (2000) repeated the value. However, the data that constrain this slip rate is not documented, as are similar data for other faults used as calibration points in this model.

CARSON RANGE FAULT (also known as the Genoa fault), #1285, 1 mm/yr (1996), 2 mm/yr (2002).
The assigned slip rate is consistent with trenching data presented by Ramelli and others (1994). They determined that the recurrence interval between the last events was 0.6-1.72 k.y. The multiple-event scarp is 5-6 m high; thus, a slip rate of 2 mm/yr is reasonable.

COYOTE SPRING FAULT, Southwestern Delamar Mountains fault (1996), #1121, 0.1 mm/yr (1996), 0.01 mm/yr (2002).
This fault was assigned a slip rate of 0.1 mm/yr in 1996 based on preliminary data from dePolo (1996, written commun.). However, the slip rate subsequently assigned by dePolo (1998) was 0.01 mm/yr based on the presence of scarps on alluvium but the absence of basal fault facets. The published value will be used herein.

CRESENT DUNES FAULT, Liberty fault (1996), #1340, 0.1 mm/yr (1996), 0.01 mm/yr (2002).
This fault was assigned a slip rate of 0.1 mm/yr in 1996 based on preliminary data from dePolo (1996, written commun.). However, the slip rate subsequently assigned by dePolo (1998) was 0.01 mm/yr based on the presence of scarps on alluvium but the absence of basal fault facets. The published value will be used herein.

DRY LAKE FAULT, #1124, added for 2002, 0.008 (2002)
This fault was added in 2002 based on dePolo (1998 #2845) who calculated a preferred vertical slip rate of 0.008 mm/yr based on offset of 4.4 m across a graben north of Seven Oaks Spring. The age of the offset deposit is assumed to be 550 k.y.

EASTERN BILK CREEK MOUNTAINS FAULT ZONE, #1496, 0.1 mm/yr (1996), 0.01 mm/yr (2002).
This fault was assigned a slip rate of 0.1 mm/yr in 1996 based on preliminary data from dePolo (1996, written commun.). However, the slip rate subsequently assigned by dePolo (1998) was 0.01 mm/yr based on the presence of scarps on alluvium but the absence of basal fault facets. The published value will be used herein.

EASTERN OSGOOD MOUNTAINS FAULT ZONE, Eastern Osgood Mountains fault 1 (1996), #1523, 0.1 mm/yr (1996), 0.01 mm/yr (2002).
This fault was assigned a slip rate of 0.1 mm/yr in 1996 based on preliminary data from dePolo (1996, written commun.). However, the slip rate subsequently assigned by dePolo (1998) was 0.01 mm/yr based on the presence of scarps on alluvium but the absence of basal fault facets. The published value will be used herein.

EASTERN OSGOOD MOUNTAINS PIEDMONT FAULT, Eastern Osgood Mountains fault 2 (1996), #1531, 0.1 mm/yr (1996), 0.01 mm/yr (2002).
This fault was assigned a slip rate of 0.1 mm/yr in 1996 based on preliminary data from dePolo (1996, written commun.). However, the slip rate subsequently assigned by dePolo (1998) was 0.01 mm/yr based on the presence of scarps on alluvium but the absence of basal fault facets. The published value will be used herein.

EASTERN TUSCARORA MOUNTAINS FAULT ZONE, #1554, 0.1 mm/yr (1996), 0.01 mm/yr (2002).
This fault was assigned a slip rate of 0.1 mm/yr in 1996 based on preliminary data from dePolo (1996, written commun.). However, the slip rate subsequently assigned by dePolo (1998) was 0.01 mm/yr based on the presence of scarps on alluvium but the absence of basal fault facets. The published value will be used herein.

EMIGRANT PEAK FAULT ZONE, #1329, 1 mm/yr (1996), 0.76 mm/yr (2002).
The slip rate used in 1996 was based on dePolo (1996, written commun.). The assigned slip rate used here is from dePolo (1998) and dePolo and Anderson (2000) and is based on the observed offset reported by Reheis (1991) of 38 m and the inferred age of the offset deposit of 50 ka.

FRENCHMAN MOUNTAIN FAULT, #1117, added for 2002, 0.015 mm/yr (2002).
This fault was added in 2002 based on dePolo (1998 #2845), who calculated a vertical slip rate of 0.015 mm/yr for the fault based on 7.5 m of offset of a deposit estimated to be 500 ka.

GOLDEN GATE FAULT, Coal Valley fault (1996), #1393, 0.1 mm/yr (1996), 0.01 mm/yr (2002).
This fault was assigned a slip rate of 0.1 mm/yr in 1996 based on preliminary data from dePolo (1996, written commun.). However, the slip rate subsequently assigned by

dePolo (1998) was 0.01 mm/yr based on the presence of scarps on alluvium but the absence of basal fault facets. The published value will be used herein.

GRANITE SPRINGS VALLEY FAULT ZONE, #1622, 0.5 mm/yr (1996), 0.2 mm/yr (2002).
The Quaternary fault and fold database for the U.S. shows that this fault was assigned to the 0.2-1.0 mm/yr slip-rate category, based on the magnitude of the slip rate assigned by dePolo (1998) of 0.506 mm/yr. Thus the slip rate used here is appropriately reassigned.

HIKO FAULT ZONE, Crystal Springs fault (1996), #1130, 0.1 mm/yr (1996), 0.01 mm/yr (2002).
This fault was included in 1996 based on preliminary data from dePolo (1996, written commun.). However, the slip rate subsequently assigned by dePolo (1998) was 0.01 mm/yr based on the presence of scarps on alluvium but the absence of basal fault facets. The published value will be used herein.

INDIAN HILLS.FAULT, #1652, added in 2002, 0.1 mm/yr (2002).
We added this fault in 2002 based on slip rate assigned by dePolo (1998).

JAKES VALLEY FAULT ZONE, #1223, 0.1 mm/yr (1996), 0.01 mm/yr (2002).
This fault was assigned a slip rate of 0.1 mm/yr in 1996 based on preliminary data from dePolo (1996, written commun.). However, the slip rate subsequently assigned by dePolo (1998) was 0.01 mm/yr based on the presence of scarps on alluvium but the absence of basal fault facets. The published value will be used herein.

KANE SPRING WASH FAULT, #1123, 0.1 mm/yr (1996), 0.01 mm/yr (2002).
This fault was assigned a slip rate of 0.1 mm/yr in 1996 based on preliminary data from dePolo (1996, written commun.). However, the slip rate subsequently assigned by dePolo (1998) was 0.01 mm/yr based on the presence of scarps on alluvium but the absence of basal fault facets. The published value will be used herein.

KAWICH-HOT CREEK RANGES FAULT ZONE, #1355, 0.3 mm/yr (1996), 0.2 mm/yr (2002).
The Quaternary fault and fold database for the U.S. shows that this fault was assigned to the 0.2-1.0 mm/yr slip-rate category, based on the magnitude of the slip rate assigned by dePolo (1998) of 0.525 mm/yr. Thus the slip rate used here is appropriately reassigned.

KINGS CANYON FAULT ZONE (northern part of the Carson Range fault in 1996), #1654, 0.2 mm/yr (2002)
In 1996, this fault was depicted as part of the Carson Range fault and was assigned a slip rate of 1 mm/yr. dePolo (1998), however, depicts it as a separate fault with a lower slip rate; thus the reduction in slip rate here.

LITTLE VALLEY FAULT, Mount Rose fault 2 (1996), #1648, 0.1 mm/yr (1996), 0.2 mm/yr (2002).
The Quaternary fault and fold database for the U.S. shows that this fault was assigned to the 0.2-1.0 mm/yr slip-rate category, based on the magnitude of the slip rate assigned by dePolo (1998) of 0.488 mm/yr. Thus the slip rate used here is appropriately increased.

LONE MOUNTAIN FAULT ZONE, #1338, 0.1 mm/yr (1996), 0.13 mm/yr (2002).
The assigned slip rate was calculated by dePolo (1998) based on field data from Yount (1997, written comm., as reported in dePolo, 1998). The slip rate is derived from offset across a 3.2-m-high scarp (presumably a multiple-event scarp) on a latest Pleistocene (15 to 30 ka) fluvial terrace along the fault west of Lone Mountain. DePolo (1998) and dePolo and Anderson (2000) calculated a preferred vertical slip rate of 0.13 mm/yr (using a preferred vertical offset of 2.9 m from Yount's original data) and preferred age of the deposit of 22.5 k.y.

MARYS MOUNTAIN FAULT, #1154, 0.1 mm/yr (1996), 0.001 mm/yr (2002).
This fault was included in 1996 based on preliminary data from dePolo (1996, written commun.). However, the slip rate subsequently assigned by dePolo (1998) was 0.001 mm/yr based on the absence of scarps on alluvium and basal fault facets. The published value is used herein.

MCGEE MOUNTAIN FAULT ZONE, #1488, 0.1 mm/yr (1996), 0.01 mm/yr (2002).
This fault was included in 1996 based on preliminary data from dePolo (1996, written commun.). However, the slip rate subsequently assigned by dePolo (1998) was 0.01 mm/yr based on the presence of scarps on alluvium but the absence of basal fault facets. The published vaulue is used herein.

MOUNT IRISH RANGE FAULT, North Pahranagat Range fault (1996), #1738, 0.1 mm/yr (1996), 0.01 mm/yr (2002).
This fault was included in 1996 based on preliminary data from dePolo (1996, written commun.). However, the slip rate subsequently assigned by dePolo (1998) was 0.01 mm/yr based on the presence of scarps on alluvium but the absence of basal fault facets. The published vaulue is used herein.

MOUNT ROSE FAULT ZONE, #1647, 0.1 mm/yr (1996), 1.5 mm/yr (2002).
The assigned slip rate is provided by Ramelli and dePolo (1997) who estimated a range of late Holocene slip rates of 1.1-3.8 mm/yr and tentatively preferred a slip rate of about 1.5 mm/yr, based on trench results from near Ophir Creek.

PENOYER FAULT, #1132, added for 2002, 0.016 mm/yr (2002).
This fault was added in 2002 based on dePolo (1998) and dePolo and Anderson (2000). Their preferred vertical slip rate of 0.016 mm/yr was based on vertical offset of 5.9 m of an uplifted alluvial fan estimated to be 375 ka.

PETERSEN MOUNTAIN FAULT 2 part of #1640, 0.1 mm/yr (1996), 0.05 mm/yr (2002).
This fault was assigned a slip rate of 0.1 mm/yr in 1996 based on preliminary data from dePolo (1996, written commun.). The 2002 slip rate is reduced based on the relative values for this and the adjacent Petersen Mountain fault assigned by dePolo (1998).

PYRAMID LAKE FAULT ZONE, #1669, 0.5 mm/yr (1996), 2 mm/yr (2002).
Briggs (2002) indicates that post-Lahonton (13 ka) channels and ridges are offset 27-33 m by the Pyramid Lake fault zone.

RAILROAD VALLEY FAULT ZONE, #1380, 0.1 mm/yr (1996), 0.07 mm/yr (2002). This fault was assigned a slip rate of 0.1 mm/yr in 1996 based on preliminary data from dePolo (1996, written commun.). The 2002 slip rate is from dePolo (1998) and dePolo and Anderson (2000) and is based on the preferred value of an observed offset of 14 m and inferred age of the offset deposit of 200 ka. These data yield a slip rate substantially higher than the 0.01 mm/yr that is reported in Appendix E of dePolo (1998), based on slip rate-basal facet relations. The higher rate is retained here.

RAINBOW MOUNTAIN FAULT ZONE, #1679, 0.1 mm/yr (1996), 0.15 mm/yr (2002). The assigned slip rate is based on the amount of slip reported for the last two events (1.3-1.8 m) and the length of the appropriate time interval (between 11.8-14.5 ka and the present) as reported by Bell and others (2001). These data yield slip rates of 0.09-0.15 mm/yr. The maximum of these rates is assigned for 2002 because neither includes a component of lateral slip that is known to have occurred at least in the historical event.

RUBY MOUNTAINS FAULT ZONE, NORTHERN SECTION, Ruby Mountains fault 1 (1996), #1573a, 0.5 mm/yr (1996), 0.28 mm/yr (2002).
The slip rate used in 1996 was based on dePolo (1996, written commun.). The slip rate used here is from dePolo (1998) and dePolo and Anderson (2000) and is based on the observed offset of 20.8 m and inferred age of the offset deposit of 74 ka (Willoughby, 1997).

RUBY MOUNTAINS FAULT ZONE, SOUTHERN SECTION, Ruby Mountains fault 2 (1996), #1573b, 0.5 mm/yr (1996), 0.28 mm/yr (2002).
The slip rate used in 1996 was based on dePolo (1996, written commun.). The slip rate used here is from dePolo (1998) and dePolo and Anderson (2000) and is based on the observed offset of 20.8 m and inferred age of the offset deposit of 74 ka (Willoughby, 1997).

RUBY VALLEY FAULT ZONE, #1718, 0.4 mm/yr (1996), 0.1 mm/yr (2002).
The assigned slip rate is reduced to 0.1 mm/yr based on the lack of evidence pointing to multiple latest Pleistocene surface-rupturing events. Mapping by Dohrenwend and others (1991) indicates that the youngest scarps formed in the late Pleistocene (<130 ka).

SAN EMIDIO FAULT ZONE, #1613, 0.1 mm/yr (1996), 0.2 mm/yr (2002).
The Quaternary fault and fold database for the U.S. shows that this fault was assigned to the 0.2-1.0 mm/yr slip-rate category, based on the magnitude of the slip rate assigned by dePolo (1998) of 0.419 mm/yr. Thus, the slip rate used here is appropriately increased.

SANTA ROSA RANGE FAULT SYSTEM, Santa Rosa-Owyhee River-Oregon Canyon fault zone (1996), #1508, 0.75 mm/yr (1996), 0.13 mm/yr (2002).
The assigned 2002 slip rate is based on the reported minimum rate of 0.01-0.13 mm/yr reflecting the most recent interval of faulting (Narwold, 1999; 2000). These slip rates are based on field measurements of surface offset at several locations along the northern Santa Rosa Range fault system and estimated ages for the faulted deposits based on calcic soil development. We assigned the upper limit of the range of minimum rates.

SCHELL CREEK RANGE FAULT SYSTEM, #1241, 0.1 mm/yr (1996), 0.01 mm/yr (2002).
This fault was included in 1996 based on preliminary data from dePolo (1996, written commun.). However, the slip rate subsequently assigned by dePolo (1998) was 0.010 mm/yr based on the presence of scarps on alluvium but the absence of basal fault facets. The published value will be used herein.

SHEEP BASIN FAULT, #1115, added for 2002, 0.044 mm/yr (2002).
This fault was added in 2002 based on dePolo's (1998) reevaluation of field data presented by Longwell (1930). Longwell (1930) reported the presence of a 34-m-high scarp, from which dePolo (1998) determines a preferred vertical offset of 22 m. The scarp is on a deposit assumed to be 500 ka.

SHOSHONE RANGE FAULT ZONE, #1148, 0.5 mm/yr (1996), 0.1 mm/yr (2002).
This fault was included in 1996 based on preliminary data from dePolo (1996, written commun.). The slip rate subsequently assigned by dePolo (1998) was 0.335 mm/yr based on an empirical relationship between height of basal fault facets and slip rate. For consistency with the way other 1996 slip rates were treated, this fault is assigned a slip rate of 0.1 mm/yr in the absence of any other data.

SIMPSON PARK MOUNTAINS FAULT ZONE, #1178, 0.3 mm/yr (1996), 0.22 mm/yr (2002).
dePolo (1998) assigned a preferred vertical slip rate of 0.22 mm/yr based on "known" data, and dePolo and Anderson (2000) repeated the value. However, the data that constrain this slip rate is not documented, as are similar data for other faults used as calibration points in his model.

SMITH VALLEY FAULT ZONE, Smith Valley fault and Sweetwater fault (1996), #1291, 0.49 mm/yr (1996), 0.38 mm/yr (2002).
The assigned slip rate is based on work by Hayes (1985). He reported an estimated slip rate of 0.36-0.41 mm/yr for the Smith Valley fault zone in the vicinity of Nevada Hot Springs for the past 18 k.y.

STEENS FAULT ZONE, Pueblo Mountains fault (1996), #856, 0.1 mm/yr (1996), 0.3 mm/yr (2002).
The Pueblo Mountains fault of dePolo (1998) was merged with its appropriate extension to the north (the Steens fault zone). The 2002 slip rate is the value that was assigned to the Steens fault zone in 1996.

TOIYABE RANGE FAULT ZONE, #1337, 0.8 mm/yr (1996), 0.22 mm/yr (2002).
The slip rate used in 1996 was based on dePolo (1996, written commun.). The slip rate used here is from dePolo (1998) and dePolo and Anderson (2000) and is based on observed offset of 43.4 m and inferred age of an offset deposit of 200 ka.

WEST SPRING MOUNTAINS FAULT, #1073, added in 2002, 0.045 mm/yr (2002).
This fault was added in 2002 based on slip rates reported by Anderson and others (1995). They indicate this fault is characterized by rates on the order of 0.02 and 0.07 mm/yr

(average 0.045 mm/yr). Subsequently, dePolo (1998) reported a preferred slip rate of 0.07 mm/yr, which was based on field data of Anderson and others (1995).

WESTERN GRANITE RANGE FAULT, #1610, 0.1 mm/yr (1996), 0.2 mm/yr (2002).
The Quaternary fault and fold database for the U.S. shows that this fault was assigned to the 0.2-1.0 mm/yr slip-rate category, based on the magnitude of the slip rate assigned by dePolo (1998) of 1.503 mm/yr. Thus the assigned slip rate used here is appropriately increased.

WESTERN TOIYABE RANGE FAULT ZONE, #1336, 0.1 mm/yr (1996), 0.2 mm/yr (2002).
The Quaternary fault and fold database for the U.S. shows that this fault was assigned to the 0.2-1.0 mm/yr slip-rate category, based on the magnitude of the slip rate assigned by dePolo (1998) of 0.488 mm/yr. Thus the assigned slip rate used here is appropriately increased.

WHITE RIVER VALLEY FAULT ZONE, #1398, 0.1 mm/yr (1996), 0.045 (2002).
This fault was included in 1996 based on preliminary data from dePolo (1996, written commun.). However, dePolo (1998) and dePolo and Anderson (2000) calculated the "known" slip rate of 0.02-0.07 mm/yr based on the offset of a single-event scarp at Sawmill Canyon that is on a surface estimated to be Sangamon in age (74-200 ka) as estimated by J. Yount. These values have little meaning and may not represent even an approximation of the true slip rate. However, we use the average of possible maximums here.

4.7. New Mexico

CABALLO FAULT, #2088, 0.04 mm/yr (1996), 0.025 mm/yr (2002).
The Caballo fault was assigned a lower slip rate and a shorter length in 2002 than in 1996. Machette (1987b) and Foley and others (1988) used scarp profiles and trenches to calculate slip rates of 0.02-0.03 mm/yr for the Caballo fault, and we used the center of this range. New mapping shortened the recognized trace length of the fault from 79 km in 1996 to 22 km in 2002 – the northern half and southern quarter of the 1996 Caballo fault are now recognized as separate faults with much slower slip rates.

COUNTY DUMP FAULT, part of West Mesa fault (1996), #2038, 0.03mm/yr (1996), 0.038 mm/yr (2002).
New mapping resulted in the 1996 West Mesa fault being split into a northern part, the Zia fault, and a southern part, the County Dump fault. Mapping of an exposure by McCalpin (1997) shows multiple faulting events resulting in 20 m of offset since 527 ka.

HUBBELL SPRINGS FAULT, #2120, added in 2002, 0.07 mm/yr (2002).
This fault was added in 2002 based on recent trenching studies that found that four earthquakes, each producing about 1.5 m of vertical displacement, occurred at 11-13 ka, 20-30 ka, 50-60 ka, and either 90 ka or 245 ka (Personius and others, 2000). The oldest earthquake is of highly uncertain age, but the other three bracket two complete, well-constrained recurrence intervals. Accordingly, using the midpoints of age ranges, 3.0 m of displacement occurred between 12 ka and 55 ka for a slip rate of 0.07 mm/yr.

JEMEZ-SAN YSIDRO FAULT, #2029, 0.06 mm/yr (1996), 0.020 mm/yr (2002).
The 1996 Jemez fault was assigned a greater length and a smaller slip rate for 2002 than in 1996. The trace used in 2002 is from Machette and others (1998). They grouped the Jemez fault with the San Ysidro fault to the south, because they are laterally continuous and dip in the same direction. The 1996 slip rate came from Wong and others (1995), who assigned slip rates by analogy to this and similar faults. Existing data at the time suggested 12 m and 50 m of offset of the 1.2 Ma Bandelier Tuff along the fault. More recent work reports offsets of 6-11 m of the 620-ka Lava Creek B ash (Izett and Wilcox, 1982; Sarna-Wojcicki and others, 1987). We used the average offsets, and averaged the younger and older slip rates to derive 0.020 mm/yr.

LA CAÑADA DEL AMAGRE FAULT ZONE, #2005, 0.1 mm/yr (1996), 0.06 mm/yr (2002).
The 1996 slip rate of 0.1 mm/yr is from a 10.6 Ma dike that was offset 530 m, probably since 5 Ma (Wong and others, 1995). However, Machette and others (1998) cite 15 m of offset of the 1.2 Ma Bandelier Tuff. This younger surface and its younger offset indicate a slip rate of 0.012 mm/yr. We averaged the older and younger slip rates to derive 0.06 mm/yr.

LA JENCIA FAULT, #2109, 0.2 mm/yr (1996), 0.021 mm/yr (2002).
The 2002 rate was calculated from heights of two multi-event scarps on surfaces of known ages, and from the height of a single-event scarp that ended a recurrence interval of known duration (Machette and others, 1998).

PAJARITO FAULT, #2008, 0.09 mm/yr (1996), 0.068 mm/yr (2002).
The assigned slip rate is based on 81 m offset of the 1.2 Ma Bandelier Tuff.

SAN ANDRES MOUNTAINS FAULT, added for 2002, #2053, 0.10 mm/yr (2002).
The fault was added for 2002 based on 6- to 15-m-high scarps, which offset surfaces on the Picacho alluvium that are 70-130 ka (Machette, 1987a). The average offset divided by the average age yields the assigned slip rate.

SAN FELIPE FAULT ZONE, #2030a, 0.05 mm/yr (1996), 0.043 mm/yr (2002).
Personius and others (1999) calculated the minimum and maximum slip rates implied by 90-120 m scarp heights on the 2.2-2.8 Ma San Felipe basalts. We averaged these rates to obtain 0.043 mm/yr.

ZIA FAULT, part of West Mesa fault (1996), #2046, 0.03 mm/yr (1996), 0.038 mm/yr (2002).
New mapping resulted in the 1996 West Mesa fault being split into a northern part, the Zia fault, and a southern part, the County Dump fault. The Zia fault was assigned a slower slip rate in 2002 than in 1996. The assigned slip rate is based on Kelley (1977), who reports that the 1.6 Ma Santa Fe Group is offset as much as 200 ft (61 m).

4.8. Oregon

CAPE BLANCO ANTICLINE, #894, 2.0 mm/yr (1996), 1.4 mm/yr (2002).
Kelsey (1990) measured uplifts of marine terraces that are arched over the anticline. The preferred ages for the terraces are 80 ka and 105 ka. Kelsey (1990) calculated a maximum

uplift rate of 1.4 mm/yr for the 105-ka terrace. Geomatrix Consultants, Inc. (1995) attributed the arching and growth of the anticline to an underlying blind thrust fault.

CHEMULT GRABEN FAULT SYSTEM (EAST), East Chemult graben—Walker Rim fault (1996), #839b, 0.4 mm/yr (1996), 0.052 mm/yr (2002).
The fault system forms the eastern side of the Chemult graben. Two slip rate estimates are available for the graben, 0.05 mm/yr from 300 m of offset in 4.5-7 Ma volcanic rocks, and 0.4 mm/yr from 5- to 6-m-high scarps on latest Pleistocene (15 ka) deposits (Geomatrix Consultants, Inc., 1995). Geomatrix Consultants, Inc. (1995) notes geomorphic expressions indicating that the eastern side of the graben probably has slower slip rates than the western side. The Quaternary fault and fold database for Oregon (Personius and others, in review) explains why 0.4 mm/yr probably applies only to the western side of the graben. Thus, in 2002, 0.052 mm/yr was used for the eastern side.

COTTONWOOD MOUNTAIN FAULT, #806, 0.02 mm/yr (1996), 0.09 mm/yr (2002).
Knudsen and others (1994) used numerous fault scarp profiles and estimated ages of late Quaternary deposits to determine long-term slip rates of 0.03-0.15 mm/yr for the Cottonwood Mountain fault. The assigned slip rate for 2002 is the average of the extremes.

HAPPY CAMP FAULT, Netarts Bay fault (1996), #882, 0.04 mm/yr (1996), 0.025 mm/yr (2002).
The Happy Camp fault was misidentified as the Netarts Bay fault in 1996. We follow the established usage of the name as summarized in the Quaternary fault and fold database for Oregon (Personius and others, in review). The Happy Camp fault was assigned a smaller slip rate in 2002 than in 1996. The fault is known only from its 3-km-long exposure in coastal sea cliffs. The observed offset of Quaternary sediments on the fault is inconsistent with its being as short as 3 km. Accordingly, we followed Geomatrix Consultants, Inc. (1995) in assigning a length of 20 km. The 1996 rate is based on 9-m offset of Pleistocene channel deposits that are probably 200 ka to 1.6 Ma (Geomatrix Consultants, Inc., 1995). The maximum rate from these data was used in 1996. Averaging the range of slip rates yields the assigned value.

HELVETIA FAULT, #OR2, 0.01 mm/yr (1996), 0.014 mm/yr (2002).
Geomatrix Consultants, Inc. (1995) reported 20 m of vertical separation of the upper part of late Miocene-early Pleistocene sediments (11 Ma-750 ka). Geomatrix Consultants, Inc. (1995) assumed, without explanation, an age of 2 Ma for the surface that is offset 20 m, and calculated the slip rate used in 1996. Averaging the resulting slip rates yields the assigned 2002 value.

HORSE HAVEN (SIC) HILLS ANTICLINE: see Horse Heaven Hills structure (NW trend) under Washington.

JUNIPER MOUNTAIN FAULT, #805, 0.02 mm/yr (1996), 0.01 mm/yr (2002).
The fault has Quaternary scarps but no data from which to calculate a slip rate. However, Geomatrix Consultants, Inc. (1995) proposed a three-point distribution of possible slip rates, and used geomorphic expression of the fault and possibly some preliminary estimates of scarp heights to suggest a probability for each rate: 0.01 mm/yr (probability

0.5), 0.05 mm/yr (0.4), and 0.1 mm/yr (0.1). In 2002, the highest-probability slip rate (0.01 mm/yr) is used here.

KLAMATH GRABEN FAULT SYSTEM (EAST), East Klamath graben fault and South Klamath graben zone (1996), #843bc, 1.5 mm/yr (1996), 0.2 mm/yr (2002).
The 1996 East Klamath graben fault and, on strike to the south, the 1996 South Klamath graben zone form the eastern edge of the Klamath graben. For 2002 the two faults were combined into the Klamath graben fault system (east), following the Quaternary fault and fold database for Oregon (Personius and others, in review). Geomatrix Consultants, Inc. (1995) provides a three-point probability distribution of slip rate: 0.15 mm/yr (probability 0.4), 0.2 mm/yr (0.5), and 0.5 mm/yr (0.1). The age-offset data cited by Geomatrix Consultants, Inc. (1995) and reported in the Quaternary fault and fold database for Oregon (Personius and others, in review) are either from pre-Quaternary surfaces, which provide very slow slip rates, or from a potentially single-rupture scarp on a mid-Holocene ash, which provides no constraint. The highest probability rate (0.2 mm/yr) in the three-point distribution of Geomatrix Consultants, Inc. (1995) falls between these extremes and we used it.

PINE VALLEY GRABEN FAULT SYSTEM, BROWNLEE SECTION, Brownlee fault (1996), #809a, 0.08 mm/yr (1996), 0.0075 mm/yr (2002).
Geomatrix Consultants, Inc. (1995) estimated three possible slip rates and assigned probabilities to each: 0.005 mm/yr (probability of 0.4), 0.01 mm/yr (probability of 0.4), and 0.05 mm/yr (probability of 0.2). We assigned the average of the two higher probability rates.

PINE VALLEY GRABEN FAULT SYSTEM, HALFWAY-POSEY VALLEY SECTION, Halfway fault and Posey Valley fault (1996), #809b, 0.03 and 0.02 mm/yr (1996), 0.0075 mm/yr (2002).
Geomatrix Consultants, Inc. (1995) estimated three possible slip rates and assigned probabilities to each: 0.005 mm/yr (probability of 0.4), 0.01 mm/yr (probability of 0.4), and 0.05 mm/yr (probability of 0.2). We assigned the average of the two higher probability rates.

RATTLESNAKE-WALLULA FAULT SYSTEM, #WA1, 0.2 mm/yr (1996), 0.043 mm/yr (2002).
This zone of northwest-striking faults is assigned a lower slip rate in 2002 than in 1996. The zone of faults is mostly strike slip in its southeastern half and reverse in its northwestern half. Geomatrix Consultants, Inc. (1995) estimated a 0.8 probability that the entire system is reverse, dipping southwest, and a 0.2 probability that it is strike slip, dipping vertically. For each alternative, they published three fault-parallel slip rates and estimated the probability of each. For each of the six slip rates, we multiplied its probability by the probability of the associated faulting style, to obtain the probability of that combination of slip rate and faulting style. A fault-parallel slip rate of 0.05 mm/yr on a reverse fault is by far the most likely, having a probability of 0.48. The other five combinations ranged between 0.04 and 0.16. Geomatrix Consultants, Inc. (1995) estimated that fault dips of 45 and 60 degrees are equally probable. We chose 60 degrees. These values produce the assigned vertical slip rate of 0.043 mm/yr.

SANTA ROSA RANGE FAULT SYSTEM, Santa Rosa-Owyhee River-Oregon Canyon fault zone (1996), #1508, 0.75 mm/yr (1996), 0.13 mm/yr (2002).
The assigned 2002 slip rate is based on the reported minimum rate of 0.01-0.13 mm/yr reflecting the most recent interval of faulting (Narwold, 1999; 2000). These slip rates are based on field measurements of surface offset at several locations along the northern Santa Rosa Range fault system and estimated ages for the faulted deposits based on calcic soil development. We assigned the upper limit of the range of minimum rates.

TULE SPRINGS RIMS FAULT, Eastern Alvord graben fault (1996), #858, 0.3 mm/yr (1996), 0.1 mm/yr (2002).
The assigned slip rate is from a three-point distribution of slip rates reported by Geomatrix Consultants, Inc. (1995). We chose the highest-probability rate for 2002.

TURNER AND MILL CREEK FAULTS, Mill Creek fault (1996), #871, 0.01 mm/yr (1996), 0.0066 mm/yr (2002).
The assigned slip rate is based on 100 m of vertical offset (Graven, 1990; Yeats and others, 1996) of the Miocene Columbia River Basalts (14-16.5 Ma).

WALDPORT FAULT, #886, 0.10 mm/yr (1996), 0.14 mm/yr (2002).
Scarps 15-20 m high mark the offset of an approximately 125 k.y. marine terrace across the Waldport fault (Ticknor, 1993; Kelsey and others, 1996). The middle of the range of scarp heights divided by the estimated terrace age gives the 2002 slip rate of 0.14 mm/yr.

WARNER VALLEY FAULTS (EAST), East Warner Valley fault North, East Warner Valley fault South, and Northeast Long Valley fault in Nevada (1996), #827ac, 0.2 mm/yr (1996), 0.11 mm/yr (2002).
The assigned slip rate is based on the highest probability (0.4) slip rate (0.1 mm/yr) estimated by Geomatrix Consultants, Inc. (1995).

WARNER VALLEY FAULTS (WEST), Warner Valley fault (1996), #827b, 0.2 mm/yr (1996), 0.11 mm/yr (2002).
This fault was renamed following the Quaternary fault and fold database for Oregon (Personius and others, in review). The fault forms the west side of the north-trending Warner Valley graben. The Warner Valley faults (west) were assigned a smaller slip rate in 2002 than in 1996. Slip rates are from vertical offsets of 5-8 Ma volcanic rocks that are exposed outside the graben. There, the volcanic rocks crop out 0.6-0.8 km higher than the elevation of the valley floor of the graben. Presumably the volcanics underlie the valley floor as well, so 0.6-0.8 km is the minimum offset. Thus, using the average age and the average offset, the 2002 rate is 700 m / 6.5 Ma = 0.11 mm/yr. The reference used in 1996 (Geomatrix Consultants, Inc., 1995) estimated a maximum slip rate of 0.2 mm/yr, but assigned it a low probability of 0.01; this maximum rate was used in 1996.

WINTER RIM FAULT SYSTEM, Winter ridge-Slide Mountain fault (1996), #831, 0.6 mm/yr (1996), 0.43 mm/yr (2002).
The 1996 Winter Ridge–Slide Mountain fault was renamed the Winter Rim fault system for 2002, following the Quaternary fault and fold database for Oregon (Personius and others, in review). The 1996 assigned slip rate was based on the slip rates and probabilities of 0.3 mm/yr (probability P = 0.3), 0.5 mm/yr (P = 0.5), and 0.6 mm/yr (P =

0.2) by Geomatrix Consultants, Inc.(1995); the maximum value was used in 1996. The assigned slip rate for 2002 is based on the average offset and the average age from field data that suggest 6.0-6.8 m of vertical offset of a 12- to 18-ka surface.

4.9. Texas

For most Texas faults the 1996 slip rate exceeds the assigned 2002 rate. This occurred because the 1996 maps used slip rate values as stated by Collins and others (1996), which was based on slip rates calculated for a critical-facility assessment (Collins and Raney, 1993). For conservatism in the critical-facility analysis, the youngest possible age for the faulted middle Pleistocene surfaces was used (130 ka) to calculate slip rates. However, Collins and others (1996) report that more likely age of the surfaces is 250-500 ka along some faults and 400-500 ka along others. The conservative age assignment resulted in comparatively high rates in 1996. In 2002, we assigned an age range of 130-500 ka to the middle Pleistocene surfaces.

ACALA FAULT, #903, 0.14 mm/yr (1996), 0.088 mm/yr (2002).
The assigned slip rate is calculated from 18 m of offset on middle Pleistocene deposits that are 130-500 ka (Collins and others, 1996). The 2002 assigned slip rate is based on the average of the resulting slip rates.

AMARGOSA FAULT, #905, 0.18 mm/yr (1996), 0.11 mm/yr (2002).
The assigned slip rate is calculated from 24 m of offset on middle Pleistocene deposits that are 130-500 ka (Collins and others, 1996). The 2002 assigned slip rate is based on the average of the resulting slip rates.

ARROYO DIABLO FAULT, #904, 0.02 mm/yr (1996), 0.013 mm/yr (2002).
The assigned slip rate is calculated from 1.6-3 m of offset from two or more earthquakes (Collins and Raney, 1993) on middle Pleistocene deposits that are 130-500 ka (Collins and others, 1996). The 2002 assigned slip rate is based on the average of the resulting slip rates.

CABALLO FAULT, #906, 0.18 mm/yr (1996), 0.11 mm/yr (2002).
The assigned slip rate is calculated from 24 m of offset on middle Pleistocene deposits that are 130-500 ka (Collins and others, 1996). The 2002 assigned slip rate is based on the average of the resulting slip rates.

CAMPO GRANDE FAULT, #902, 0.1 mm/yr (1996), 0.048 mm/yr (2002).
The assigned slip rate is calculated from 10 m of offset on middle Pleistocene deposits that are 130-500 ka (Collins and others, 1996). The 2002 assigned slip rate is based on the average of the resulting slip rates.

EAST BAYLOR MOUNTAIN–CARIZZO MOUNTAIN FAULT, East Baylor Mountain fault (1996), #912, 0.01 mm/yr (1996), 0.0076 mm/yr (2002).
The assigned slip rate is calculated from 1.6 m of offset on middle Pleistocene deposits that are 130-500 ka (Collins and others, 1996). The 2002 assigned slip rate is based on the average of the resulting slip rates.

EAST SIERRA DIABLO FAULT, Sierra Diablo fault (1996), #910, 0.1 mm/yr (1996), 0.020 mm/yr (2002).
The 1996 Sierra Diablo fault included the 2002 East Sierra Diablo, East Flat Top Mountain, and North Sierra Diablo faults. Data with which to calculate a slip rate is available only from the East Sierra Diablo fault (Collins and others, 1996). The assigned slip rate is based on 4 m of offset on middle Pleistocene deposits that are 130-500 ka (Collins and others, 1996). The 2002 assigned slip rate is based on the average of the resulting slip rates.

WEST DELAWARE MOUNTAINS FAULT ZONE, #911, 0.1 mm/yr (1996), 0.024 mm/yr (2002).
The assigned slip rate is based on 1.6 m of offset of an upper Quaternary surface. Offsets are 0.9 m, 1.2 m, and 1.6 m on successively older deposits, so the 1.6 m offset could be the result of two or more surface ruptures. An unfaulted deposit buries the fault and was dated at 5.7 ka (uncalibrated) (Collins and Raney, 1993). Thus, the 1.6 m of offset occurred during the past 5.7-130 ka. The 1996 slip rate, as well as the average of the resulting slip rates (0.15 mm/yr), are inconsistent with the subdued geomorphic expressions of the scarps. Accordingly, to obtain the 2002 assigned rate we divided 1.6 m by the average of the age range.

WEST EAGLE MOUNTAINS–RED HILLS FAULT, #913, 0.02 mm/yr (1996), 0.013 mm/yr (2002).
The 1996 fault of this name was split into a shorter West Eagle Mountains–Red Hills fault and the West Indio Mountains fault, following Collins and others (1996). The 2002 slip rate is based on 2.7 m of offset on middle Pleistocene deposits that are 130-500 ka (Collins and others, 1996). The 2002 assigned slip rate is based on the average of the resulting slip rates.

WEST INDIO MOUNTAINS FAULT, #915, 0.02 mm/yr (1996), 0.044 mm/yr (2002).
In 1996 this fault was part of the West Eagle Mountains–Red Hills fault. The two are regarded as independent sources here following Collins and others (1996). The assigned slip rate for the West Indio Mountains fault is calculated from 9 m offset of middle Pleistocene deposits that are 130-500 ka (Collins and others, 1996). The 2002 assigned rate is the average of the resulting slip rates.

WEST LOBO VALLEY FAULT ZONE, #918, 0.01 mm/yr (1996), 0.034 mm/yr (2002).
The fault zone has four sections, and the section lengths and vertical offsets appear to increase from north to south. Along all sections, the faulted deposits are middle Pleistocene that are 130-500 ka (Collins and others, 1996). The 1996 rate used the highest slip rate quoted by Collins and others (1996) for either of the two middle sections of the fault. The 2002 assigned slip rate is the average of the maximum and minimum slip rates from the two middle sections; the maximum rate comes from the south-central section and the minimum comes from the north-central section.

4.10. Utah

HOUSE RANGE FAULT, #2430, 0.1 mm/yr (1996), excluded for 2002.
The slip rate assigned in 1996 (0.1 mm/yr) was based on the slip rate calculated by Hecker (1993). It was based on the amount of slip during the last event and the time since; Hecker defines it as a maximum. In actuality, such a slip rate has little meaning and is unlikely to represent even an approximation of the true slip. Absent other data from which to calculate a slip rate for the fault, we exclude it from consideration.

HURRICANE FAULT ZONE, #998, 0.4 mm/yr (1996); 0.1 mm/yr—northern (#998ab) and southern (#998ef) parts, 0.2 mm/yr—central (#998cd) part (2002).
The assigned 2002 slip rates are based on recent paleoseismologic investigations (Stenner and others, 1999; Lund and others, 2001; Amoroso and others, 2002). None of the new late Quaternary data suggests a rate as high as that used in 1996, which was based on a long term rate from Hamblin and others (1981). The central part of the fault appears to be characterized by a higher slip rate than the ends based on the lateral continuity of scarps on alluvium. The highest value of the late Quaternary single-event rates reported by Lund and others (2001, p. 35) from Cottonwood Canyon is 0.3 mm/yr and considered to be larger than the characteristic late Quaternary rate for the fault.

JOES VALLEY FAULT ZONE WEST FAULT, Joes Valley fault (1996), #2453, 0.2 mm/yr (1996), 0.75 mm/yr (2002).
The assigned slip rate is the average of the slip rate reported in Black and others (2000) of 0.4-1.1 mm/yr and is based on 12 m of offset of 11- to 30-ka deposits.

MORGAN FAULT, #2353, 0.1 mm/yr (1996), 0.09 mm/yr (2002).
The assigned slip rate is the mean of the range given by Hecker (1993) of 0.03-0.15 mm/yr for the past 1-5 m.y.

SEVIER/TOROWEAP FAULT ZONE, #997, 0.36 mm/yr (1996), 0.36 mm/yr—northern (#997a) part, 0.16 mm/yr—southern (#997bcd) part (2002).
The assigned slip rate for the southern part of the fault is the average rate obtained from the data presented by Jackson (1990), who reports that 25-100 ka deposits are offset 6.5 m. The slip rate for the northern part of the fault remains unchanged from 1996 and is from data presented by Anderson and Christenson (1989).

STANSBURY FAULT ZONE, #2395, added for 2002, 0.4 mm/yr (2002).
The 2002 slip rate is the preferred slip rate reported by Geomatrix Consultants, Inc. (1999).

WEST CACHE FAULT ZONE, WELLSVILLE FAULT, #2521c, added for 2002, 0.17 mm/yr (2002).
This fault was added in 2002 based on a reported late Quaternary (<25 ka) slip rate for this part of the fault of 0.11-0.22 mm/yr (Black and others, 2000). The average of that range is used here.

4.11. Washington

DEVILS MOUNTAIN FAULT, #574, added for 2002, 0.15 mm/yr (2002).
We used the mean Pleistocene vertical slip rate from Johnson and others (2001), derived from onshore subsurface data. The 80 ka top of the Whidbey Formation is offset vertically by 11.9 m across the fault. We stress that this slip rate does not include possible strike-slip motion that cannot be identified from vertical offset data.

HORSE HEAVEN HILLS STRUCTURE (NW TREND), Horse Haven (sic) Hills anticline (1996), #578, 0.06 mm/yr (1996), 0.031 mm/yr (2002).
This feature was listed under Oregon in 1996, although the structure is entirely within Washington. The maximum, but lower-probability slip rate from Geomatrix Consultants, Inc. (1995) was assigned in 1996. The assigned 2002 slip rate is based on 323 m of vertical offset of a 10.5 Ma basalt (Geomatrix Consultants, Inc., 1995; 1996).

MILL CREEK FAULT (also known as Toppenish Ridge fault), #576, added for 2002, 0.038 mm/yr (2002).
Geomatrix Consultants, Inc. (1996) cited 500 m of vertical offset of a 10.5-16.0 Ma basalt, and calculated a fault-parallel slip rate. We used their data and calculated a vertical slip rate of 0.038 mm/yr, from the average of the rates indicated by the range in age of the basalt.

RATTLESNAKE-WALLULA FAULT SYSTEM, #WA1, 0.2 mm/yr (1996), 0.043 mm/yr (2002).
This zone of northwest-striking faults is assigned a lower slip rate in 2002 than in 1996. The zone of faults is mostly strike slip in its southeastern half and reverse in its northwestern half. Geomatrix Consultants, Inc. (1995) estimated a 0.8 probability that the entire system is reverse, dipping southwest, and a 0.2 probability that it is strike slip, dipping vertically. For each alternative, they published three fault-parallel slip rates and estimated the probability of each. For each of the six slip rates, we multiplied its probability by the probability of the associated faulting style, to obtain the probability of that combination of slip rate and faulting style. A fault-parallel slip rate of 0.05 mm/yr on a reverse fault is by far the most likely, having a probability of 0.48. The other five combinations ranged between 0.04 and 0.16. Geomatrix Consultants, Inc. (1995) estimated that fault dips of 45 and 60 degrees are equally probable. We chose 60 degrees. These values produce the assigned vertical slip rate of 0.043 mm/yr.

SADDLE MOUNTAINS FAULT, #575, added for 2002, 0.052 mm/yr (2002).
Geomatrix Consultants, Inc. (1996) cited 405 m of vertical offset of a 10.5-14.0 Ma basalt on the fault, and calculated a fault-parallel slip rate that would apply along the entire length of the fault. This vertical offset developed by slip along a ramp, on which the fault dips 60 degrees southward, and on which the fault cut through the thick, stiff Columbia River basalts. As the 405 m of vertical uplift accumulated, it grew an anticline atop the dipping fault ramp. However, Geomatrix Consultants, Inc. (1996) also reported an additional 640 m of horizontal slip measured along the flat part of the fault within the thick, soft sedimentary rocks and sediments that overlie the basalts. This 640 m of slip also took place on the ramp, where it would have been expressed as an additional (640 m)(sin 60 deg.) = 554 m of vertical uplift if the ramp had continued to cut upward

through the sediments and sedimentary rocks. Instead, because the fault flattened at the top of the ramp, this 640 m of slip merely moved the front limb of the anticline farther north, widening the anticline instead of making it higher. Nonetheless, this 640 m represents additional slip on the ramp since 10.5-14.0 Ma. However, Geomatrix Consultants, Inc. (1996) was uncertain whether the 640 m of additional slip applied to the entire length of the fault. Accordingly, they assigned a probability of 0.6 to the possibility that the entire fault is best represented by only the 405 m of vertical uplift, and a probability of 0.4 to the alternative that the entire fault underwent both components of slip. We used these probabilities, offsets, and fault dip to replace the fault-parallel slip rate of Geomatrix Consultants, Inc. (1996) with a vertical slip rate of 0.052 mm/yr.

SEATTLE FAULT ZONE: explained separately in the final documentation for the 2002 update of the national seismic hazard maps.

STRAWBERRY POINT FAULT, #571, added for 2002, 0.25 mm/yr (2002).
This slip rate is the minimum vertical uplift rate determined by Johnson and others (2001) from onshore subsurface data. This slip rate does not include possible strike-slip motion that cannot be identified from vertical offset data.

UTSALADY POINT FAULT, #573, added for 2002, 0.15 mm/yr (2002).
This slip rate is the minimum vertical uplift rate determined by Johnson and others (2001) from onshore subsurface data. This slip rate does not include possible strike-slip motion that cannot be identified from vertical offset data.

4.12. Wyoming

BEAR RIVER FAULT, #730, added for 2002, 2.3 k.y. return time (2002).
The assigned recurrence interval is based on the timing of the most recent events on the Bear River fault. West (1992 #826; 1993 #825; 1994 #4412) indicated faulting events at 2.4±1.1 ka and 4.6±0.7 ka.

EAST MOUNT SHERIDAN FAULTS, Factory Hill fault (1996), #766, 0.5 mm/yr (1996), 1.4 mm/yr (2002).
New mapping led to grouping the 1996 Factory Hill fault with other active faults that extend farther south and renaming them the East Mount Sheridan faults (Machette and others, 2001). The assigned 2002 slip rate is based on field data that suggests 9.6 m of vertical offset of a mid-Holocene fan.

GREYS RIVER FAULT, #728, added for 2002, 0.62 mm/yr (2002).
The assigned slip rate is derived from 9.3 m of slip in the past 15 k.y. (Jones and McCalpin, 1992; McCalpin, 1993).

HOBACK FAULT, #772, 1 mm/yr (1996), 0.071 mm/yr (2002).
The 2002 slip rate is based on scarps as high as 10 m that formed on Bull Lake-equivalent glacial terrane (140 ka).

UPPER YELLOWSTONE VALLEY FAULTS, East Yellowstone River fault and West Yellowstone River fault (1996), #761, 0.4 mm/yr (1996), 0.37 mm/yr (2002).
The East Yellowstone River fault and the West Yellowstone River fault of 1996 were combined for 2002. The two faults strike northerly, overlap for much of their lengths, and bound a post-glacial valley 1-2 km wide that is interpreted as a graben. If the interpretation is valid, then the two faults are normal, dip toward each other, and intersect at a depth of 1-2 km. Probably one is antithetic and not likely to be seismogenic. Accordingly, we used only the longer, east-dipping fault, and assigned it a slip rate calculated from scarps as high as 5 m on late glacial deposits (13.5 ka).

5. 2002 FAULT PARAMETERS

Table 2. Assigned and calculated fault parameters for the 2002 maps.
http://pubs.usgs.gov/of/2002/ofr-02-467/ofr-02-467-table2.pdf

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