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Greenville fault zone, Marsh Creek-Greenville section (Class A) No. 53b

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Compiled in cooperation with the California Geological Survey

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Synopsis	**General:** Historically active dextral strike-slip faults located in the Diablo Range. Minor surface fault rupturing was associated with the January 1980 Livermore Valley earthquakes (Bonilla and others, 1980 #5366; Hart and others, 1980 #5376; Bolt and others, 1981 #5365). Most of the fault trace is based on geologic and geomorphic evidence from detailed reconnaissance-level mapping by Herd (1977 #5364), Dibblee (1980 #5335, 1980 #5370, 1980 #5371, 1980 #5372), Hart (1981 #5375), and Earth Sciences Associates (1982 #5374) as reported in Wright and others (1982 #5357). Trench investigations along the Marsh Creek-Greenville

	section [53b] document latest Pleistocene and Holocene displacement. Partial late Quaternary slip rates of 0.1–0.7 mm/yr have been reported by Wright and others (1982 #5357) and Sweeney (1982 #5361). Unruh and Sawyer (1995 #5339, 1998 #5360) suggested that the late Quaternary slip rate might be as high as 3 mm/yr on the basis of structural modeling. Sawyer and Unruh (2002 #5362) calculated a Holocene dextral slip rate of 4.1±1.8 mm/yr at the Laughlin Road site. **Sections:** This fault has 4 sections. Wright and others (1982 #5357) defined three segments based on differences in geomorphic expression of the fault zone and different apparent ages of activity. From north to south these segments include the Clayton, Marsh Creek-Greenville, and Arroyo Mocho segments. Unruh and Sawyer (1998 #5360) defined four sections based on differences in geomorphic expression and structural character of the fault zone. From north to south their sections are named Livermore, Arroyo Mocho, San Antonio Valley, and Coyote Creek. The Livermore section of Unruh and Sawyer (1998 #5360) mostly corresponds with the southern Marsh Creek-Greenville segment of Wright and others; the Arroyo Mocho section of Unruh and Sawyer (1998 #5360) generally corresponds with the Arroyo Mocho segment of Wright and others (1982 #5357). The Coyote Creek section of Unruh and Sawyer (1998 #5360) is not considered here because Quaternary displacement has not been demonstrated.
Name comments	**General:** The fault was first mapped by Vickery (1925 #5359), who named it the Riggs Canyon fault. Huey (1948 #5363) was the first to use the name Greenville fault for traces along the eastern side of the Livermore Valley. The Greenville fault zone includes traces of the Marsh Creek and Clayton faults, which were first mapped by Colburn (1961 #5369) and named by Brabb and others (1971 #5368). Colburn (1961 #5369) named the structure along the northeastern side of Mount Diablo the Mount Diablo fault.
County(s) and State(s)	CONTRA COSTA COUNTY, CALIFORNIA ALAMEDA COUNTY, CALIFORNIA
Physiographic province(s)	PACIFIC BORDER
Reliability of location	Good Compiled at 1:62,500 scale. *Comments:* Location is based on digital revisions to Jennings

	(1994 #2878) using original mapping by Dibblee (1980 #5370; 1980 #5371; 1980 #5372; 1980 #5373), Earth Sciences Associates (1982 #5374), Hart (1981 #5375), and Unruh and Sawyer (1998 #5360) at 1:24,000 scale. Marsh Creek fault also was mapped by Brabb and others (1971 #5368) at 1:62,500 scale.
Geologic setting	This dextral strike-slip fault zone borders the eastern side of Livermore Valley and is considered to be part of the larger San Andreas fault system in the central Coast Ranges. The fault zone extends from northwest of Livermore Valley along the Marsh Creek and Clayton faults towards Clayton Valley. Unruh and Sawyer (1995 #5339, 1998 #5360) suggested that slip from the Greenville fault is transferred to the Concord fault [38] along the Mt. Diablo fold and thrust belt and that only minimal slip continues to the Clayton fault [53a]. The fault zone extends southeastward into San Antonio Valley, offsets late Mesozoic rocks of the Franciscan Complex. Southeast of Livermore Valley the fault is located within the uplifted Diablo Range and controls the generally linear drainage course of Arroyo Mocho, Colorado, and Sweetwater Creeks. Maximum dextral displacement along the Greenville fault zone is about 8.5–9 km, based on 9 km of dextral offset of a late Mesozoic serpentinite body and about 8.5 km dextral offset of the Tesla fault (Cotton, 1972 #5348; Sweeney, 1982 #5361).
Length (km)	This section is 35 km of a total fault length of 91 km.
Average strike	N35°W (for section) versus N30°W (for whole fault)
Sense of movement	Right lateral *Comments:* Predominantly dextral strike-slip displacement characterizes this section of the Greenville fault zone. The sense of movement is based on the geomorphic expression of surface traces of the fault, and the focal plane solutions and observed surface fault rupture associated with the 01/24/1980 and 01/27/1980 Livermore Valley earthquakes (Bonilla and others, 1980 #5366; Bolt and others, 1981 #5365; Hart, 1981 #5375).
Dip	90–75° NE. *Comments:* The southern part of this section is characterized by vertically dipping strike-slip faults as indicated by linear geomorphic expression. The northern part of this section includes

	the Marsh Creek fault, which has a more westerly strike, suggesting a component of reverse displacement (and NE dip). The 01/24/1980 and 01/27/1980 Livermore Valley earthquakes occurred near the Marsh Creek fault. The focal plane solution for the 01/27/1980 event had a 70° NE. dip (Bolt and others, 1981 #5365).
Paleoseismology studies	The Laughlin Road site [53-3] of Sawyer and Unruh (2002 #5362) involved the excavation of two fault-normal and two fault-parallel trenches in order to determine the Holocene slip rate of the Greenville fault. These trenches exposed a sequence of alluvial-fan deposits offset by high-angle faults, some characterized by sub-horizontal slickensides on clay gouge. Some fractures extended to the modern land surface, consistent with surface rupture observations following the 1980 Livermore earthquakes. Site 53-1. A single trench was excavated across a strand of the Greenville fault at site 53b-2 by the U.S. Geological Survey in 1975 (reported in Hart and others, 1980 #5376). The trench, which crossed an east-facing scarp, exposed a single, steeply (about 75° southwest-dipping fault that places Miocene Cierbo (?) Formation against late Pleistocene alluvium estimated to be about 40 ka (Qoa2 unit of Herd, 1977 #5364) on the basis of the development of an overlying B soil horizon. The fault extends into and may displace the B horizon, indicating a post-40 ka time of offset. Site 53-2. A single trench was excavated across a subtle scarp located along an east-facing bench (Earth Sciences Associates, 1982 #5374) as reported in Wright and others (1982 #5357). Trench G-10 exposed a near vertical, 1.5-m-wide fault zone that displaces a 35–40 ka paleosol. A scarp-derived colluvial wedge, estimated to be 10–12 ka from soil development, is also displaced. Wright and others (1982 #5357) reported that the youngest soil unit (estimated to be 2–4 ka) is also offset, although soil-fault relations are not clear. Wright and others (1982 #5357) estimated about 3:1 horizontal to vertical slip components on the basis of rake of slickenlines observed in trench G-10.
Geomorphic expression	The Marsh Creek-Greenville section is marked by a roughly 1-km-wide zone of discontinuous surface fault traces with geomorphic expression characteristic of dextral strike-slip displacement such as closed depressions, linear scarps, linear

	drainages and ridges, side-hill benches, dextrally deflected drainages, shutter ridges, aligned benches, saddles and troughs, linear tonal contrasts on young (Holocene ?) alluvium (Hart, 1981 #5375; Wright and others, 1982 #5357; Unruh and Sawyer, 1998 #5360). Wright and others (1982 #5357) considered the Marsh Creek-Greenville section generally to be less well developed and youthful than traces delineating the Arroyo Mocho section [53c].
Age of faulted surficial deposits	A trench exposure just north of Highway 580 in the northern Livermore Valley (Herd, 1977 #5364) shows that late Pleistocene alluvium is displaced and the fault extends upward into an overlying B soil horizon. The age of the deposit is not known, but it may be latest Pleistocene (10–30 ka). South of Livermore Valley, the fault offsets a paleosol and colluvium thought to be about 10–12 ka (trench G-10 of Earth Sciences Associates, 1982 #5374), as reported in Wright and others (1982 #5357). Wright and others (1982 #5357) also reported that a 2–4 ka soil is offset, but fault/soil relations are not clear in trench log G-10. It is presumed that the age of the deposits is estimated based on soil profile development.
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* The 01/24/1980 Livermore Valley earthquake occurred along the Marsh Creek-Greenville section and was associated with minor surface-fault rupture. Two trench sites (Wright and others, 1982 #5357) show displaced alluvial deposits estimated to be about 40 ka and colluvial deposits estimated to be about 10-12 ka (age estimates based on soil profile development). Late Holocene soil estimated to be 2-4 ka is possibly offset at site 53b-3 (Wright and others, 1982 #5357).
Recurrence interval	*Comments:* Wright and others (1982 #5357) estimated a recurrence of about 4.2 k.y. based on an assumed ML 6.5 earthquake, the estimated slip rate of 0.1–0.3 mm/yr, and an assumed 0.65 m slip per event.
Slip-rate category	Between 1.0 and 5.0 mm/yr *Comments:* Sawyer and Unruh (2002 #5362) reported a Holocene

	horizontal deformation rate of 4.1±1.8 mm/yr at the Laughlin Road site. The rate is based on 17–25 m of dextral offset of channel-fill unit G and the margin of a large paleochannel. Preliminary age constraints are based on six AMS radiocarbon dates on pedogenic carbonate and suggest a limiting minimum age range of 4.1–8.5 ka for channel-fill unit G. Wright and others (1982 #5357) reported a dextral slip rate of 0.1–0.3 mm/yr for this section of the Greenville fault zone. This rate is based on relations exposed in trench G-10. A vertical separation of about 2.7 m for a colluvial-paleosol unit, along with fault-plane slickensides indicating a 3:1 ratio of H:V slip components, suggests a dextral offset of approximately 8 m. The age of the offset unit is estimated to be about 35–40 ka on the basis of soil development. The reported rates of deformation are a minimum because the displacement is distributed across the total width of the fault zone at site 53-2, which is about 750 m wide (Wright and others, 1982 #5357). Also, the amount of dextral offset is inferred from a locally observed vertical component of displacement and assumptions of the ratio of horizontal to vertical offset.
Date and Compiler(s)	2002 William A. Bryant, California Geological Survey Sereyna E. Cluett, California Geological Survey
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