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U.S. GEOLOGICAL SURVEY STRONG-MOTION RECORDS FROM THE CHALFANT VALLEY, CALIFORNIA, EARTHQUAKE OF JULY 21, 1986

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INTRODUCTION

On July 21, 1986, 1442 GMT, a moderate earthquake, magnitude 6.0, occurred approximately 20 km north of Bishop, California, triggering four strong-motion accelerographs operated by the U.S. Geological Survey (USGS) between 24 and 49 km of the epicenter. The coordinates of the epicenter are 37.544°N and 118.443°W, which is located in Chalfant Valley, a northern extension of Owens Valley near the western front of the north-south trending White Mountains. The event occurred at a depth of 11.6 km and was preceded by a magnitude 5.6 foreshock 24 hours earlier.

The purpose of this report is to provide information on the acceleration records obtained from the main event and to document the site/structure environment at each station.

NEAR-FIELD STRONG-MOTION RECORDINGS

Figure 1 shows the location of USGS Strong-motion instrumentation within 50 km of the Chalfant Valley earthquake epicenter. At each station, the sensors are installed in small structures at ground level or at three depths in drill holes at McGee Creek.

Table 1 provides a summary of peak accelerations, epicentral distances and other descriptive information. The most significant recording obtained from the USGS network was at Long Valley dam abutment, 24 km from the earthquake, where a high frequency spike reached a maximum acceleration of 0.36 *g*. The following paragraphs summarize the documentation of individual station environments with a brief commentary on the characteristics of the acceleration records.

Long Valley Dam Left Abutment

The Long Valley Dam accelerogram was recorded by a Teledyne RFT-250* accelerograph co-located with a California Division of Mines and Geology (CDMG) Kinemetrics SMA-1* accelerograph on the upper left abutment of the dam. The instruments are installed on a 1.5 x 1.5 m concrete slab resting on a 0.5 m thick layer of alluvium (Porcella, 1983). A 1.2 x 1.2 x 1.8 m lightweight steel, prefabricated building covers the instrumentation (fig. 2). The station is situated on a locally flat part of the highly fractured and jointed Bishop tuff (Rinehart and Ross, 1957) approximately 8 m from the edge of a cliff that drops off 58 m at an average angle of 45° to the Owens River bed (figs. 3 and 4).

Copies of the USGS record and that from the co-located CDMG accelerograph (Shakal, 1986) are shown in Figure 5. Note the high frequency spikes on the 185° component (USGS) and the N component (CDMG) at approximately 5.9 and 7.3 seconds after triggering. The directions of motion shown on the two records are reversed due to the different accelerometers installed on each instrument. The pulses at the 5.9 second point are the peak accelerations

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measured on each record, respectively 0.36 and 0.34 g. The maximum acceleration, other than these spikes, is 0.17 g while the duration of amplitudes exceeding 0.10 g is 4.5 seconds.

Similar high-frequency pulses were recorded at this station by the CDMG accelerograph during earthquakes in 1978, 1980, 1981, and 1984 (McJunkin, 1978; Turpen, 1980; McJunkin and Kaliakin, 1981; Porcella, 1983; and Shakal, Sherburne, and Parke, 1984). These high-frequency pulses are not unique and have been recorded at several other strong-motion stations including Bonds Corner, California (Porcella & Matthiesen, 1979), Cerro Prieto, Mexico (Anderson and others, 1982), and the Hawaii Volcano Observatory. In each instance the earthquake was recorded by a Kinemetrics SMA-1 accelerograph using 25-Hz gate-type pendulums. To evaluate the SMA-1 response, the USGS installed Teledyne RFT-250 accelerographs equipped with 21-Hz torsion-type accelerometers at two stations where high-frequency pulses had previously been recorded by SMA-1's. Torsion accelerometers have been extensively studied under laboratory conditions and were the only strong-motion accelerometers used in the USGS network until 1970 (Cloud, 1964; and Halverson, 1971).

This earthquake provided the first comparative data showing similar high-frequency pulses on both instruments. Although response spectra have yet to be calculated, preliminary comparisons indicate the amplitude and frequency of the pulses as recorded by each instrument are nearly identical. No common site/structure factor has yet been isolated to account for the occurrence of these spikes except that they are associated with S-wave arrivals. It is of interest that CDMG has a triaxial accelerometer located on the left abutment at the dam level (fig. 4) that has not recorded high-frequency spikes during this or previous earthquakes.

Long Valley Fire Station

The Long Valley fire station is a concrete block one-story building, 10.7 m wide by 13.7 m long resting on alluvial slope wash, 75 m northwest of Hilton Creek near the eastern base of the Sierra Nevada range (Rinehart and Ross, 1957). Peak accelerations recorded at this station were only 0.03 *g* horizontal at a 28-km epicentral distance (fig. 6) compared with horizontal accelerations 5 to 12 times larger, 0.15 and 0.36 *g*, observed at Long Valley Dam at 24-km epicentral distance. The accelerations at Long Valley fire station appear to be considerably smaller than expected at this distance for a magnitude 6.0 earthquake.

Montgomery Pass

The Montgomery Pass accelerograph is installed in a one-story reinforced concrete Nevada Department of Transportation garage; horizontal dimensions are 16.8 x 18.9 m. The building rests on shallow alluvium at the top of Montgomery Pass in a narrow valley approximately 0.6 km wide. The peak horizontal acceleration recorded at this station is 0.11 *g* (fig. 6). Note the harmonic character of horizontal motion that has a dominant frequency of approximately 4.5 Hz.

McGee Creek

The McGee Creek instrumentation system consists of three triaxial downhole accelerometer modules located at 35 and 166.5 m depth in metamorphic rock and at 1 m in glacial moraine (Archuleta and others, 1985). The interface between moraine and rock is located at 30.5 m. The accelerometers were lowered into the bedrock and fixed in position with coarse sand. Stainless steel cables are attached to the top of the modules to faciliatate removal should it become necessary in the future. Data is recorded on a Kinemetrics CRA-1 analog film recorder installed in a fiberglass housing resting on a 1.5 x 1.3 m concrete slab at the surface. Three accelerometers are mounted on the pad to provide surface motion input to the CRA-1 recorder. The system is supplemented by a Kinemetrics SMA-1 accelerograph also installed on the floor of the housing. Timing signals from a WWVB radio receiver and a time code generator are impressed on the edge of the CRA recording film. The instrumentation batteries are charged by two solar panels mounted on the roof of the housing.

Surface and near surface accelerations, 0.08 to 0.09 g (fig. 7), recorded on the moraine materials at McGee Creek, were on the order of 4 times those observed in rock, 0.02 g, at depths of 166.5 and 35 m. Similar results were reported for McGee Creek by Archuleta and others (1985) for the November 23, 1985 magnitude 5.7 Bishop earthquake. At another location, surface motions with magnification of up to 4 times that at depth were recorded at the University of California Richmond Field Station vertical array during earthquakes in 1977 (Johnson and Silva, 1981) and in 1986 (Bolt and Uhrhammer, 1986). The Richmond array consists of accelerometer modules located in alluvium at the surface and at 15 m depth, and in shale bedrock at 47 m depth, 12 m below the alluvium-rock interface.

OTHER RECORDINGS

Small main shock accelerograms were recorded at several Corps of Engineers dams, both on and off the structures, located in the foothills on the west side of the Sierra Nevada, 130 to 200 km from the earthquake epicenter (see Appendix).

Outside of the USGS program an extensive data set was obtained from both structural and ground motion stations operated by CDMG in the Owens Valley region (Shakal, 1986). The Los Angeles Department of Water and Power operates a single accelerograph station located at Control Gorge power plant 15 km northwest of Bishop (Holland, personal communication).

Aftershock Stations

Five temporary aftershock accelerographs were installed within 48 hours of the main event, four on a 30 km north-south line through Chalfant Valley and the fifth about 10 km west of Chalfant Valley (fig. 1). Numerous aftershocks were recorded by these instruments; all but one from events less than magnitude 5. If any of these records are deemed significant, they will be presented in a later report (see Appendix).

Acknowledgments

The USGS appreciates the assistance of the following organizations that have allowed use of their facilities for the operation of strong-motion instrumentation: Mammoth Ranger District of the Inyo National Forest, the Long Valley Fire Protection District, the Nevada Department of Transportation, and the California Division of Mines and Geology. The earthquake records were collected by M. Salsman and R. Forshee. R. Porcella and P. Mork provided data for Table 1.

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TABLE I

STRONG-MOTION DATA FROM THE CHALFANT VALLEY EARTHQUAKE

Station and Coordinates	Epicentral Distance (km)	Azimuth from Epicenter	Peak Amplitudes Direction	Peak Amplitudes Acceleration (g)	Strong Duration[1] (sec)
Long Valley Dam	24	282°			
Left Abutment			275°	.15	3.8
			Up	.11	2.6
37.588N			185°	.36	4.5
118.705W					
Long Valley	28	275°			
Fire Station			037°	.03	-
			Up	.02	-
37.567N			307°	.03	-
118.757W					
McGee Creek	32	271°			
37.550N					
118.811W					
Downhole System					
166.5 m level			*	(1) .02	-
			Up	(2) .01	-
			*	(3) .02	-
35 m level			*	(4) .02	-
			Up	(5) .02	-
			*	(6) .02	-
Surface			360°	(7) .09	-
			Up	(8) .06	-
			270°	(9) .08	-
1 m level			180°	(10) .06	-
			Up	(11) .08	-
			270°	(12) inoperative	
Accelerograph			180°	.09	1 peak
			Up	.06	-
			090°	.08	-
Montgomery Pass	49	013°			
			360°	.11	1.5
37.977N			Up	.06	-
118.319W			270°	.11	1.7

[1]Duration is the time between first and lasts peaks of acceleration greater than 0.10 g.

*Horizontal component. Direction unknown.

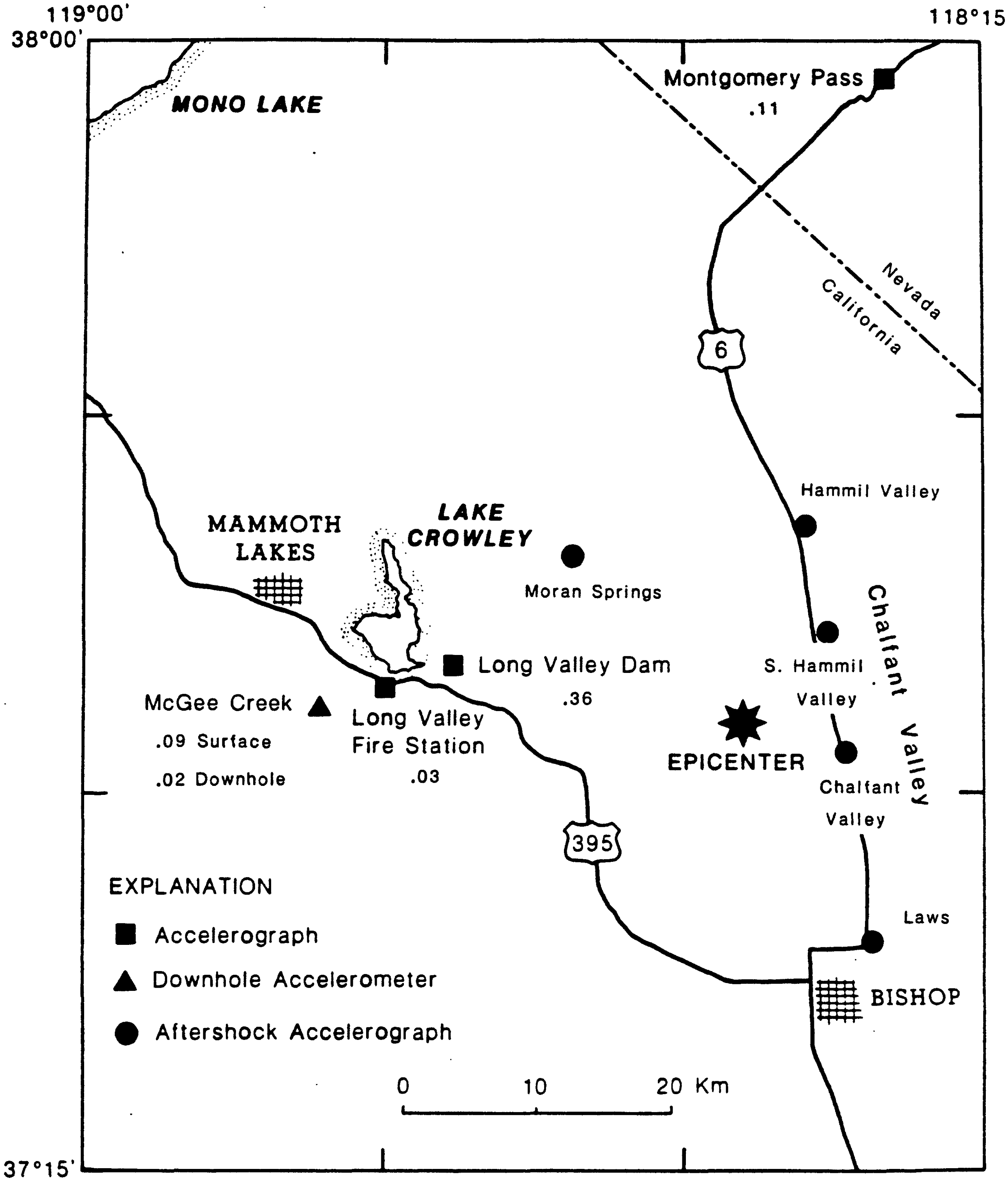

Figure 1.-Location of the USGS near-field permanent and aftershock strong-motion stations for the Chalfant Valley earthquake of July 21, 1986. Maximum accelerations recorded during the main shock are shown in fractions of g at each site.

Figure 2.--Housing at Long Valley Dam.

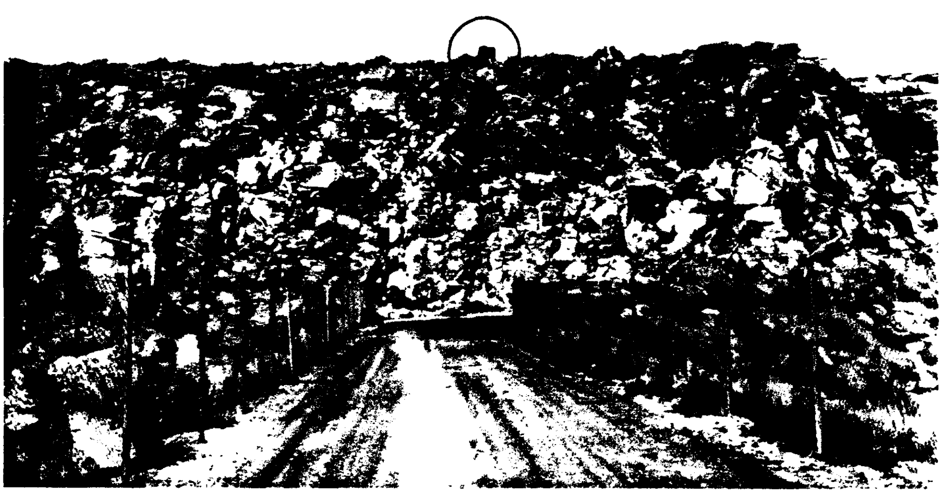

Figure 3.--Bishop tuff at abutment. Instrumentation housing on top of cliff.

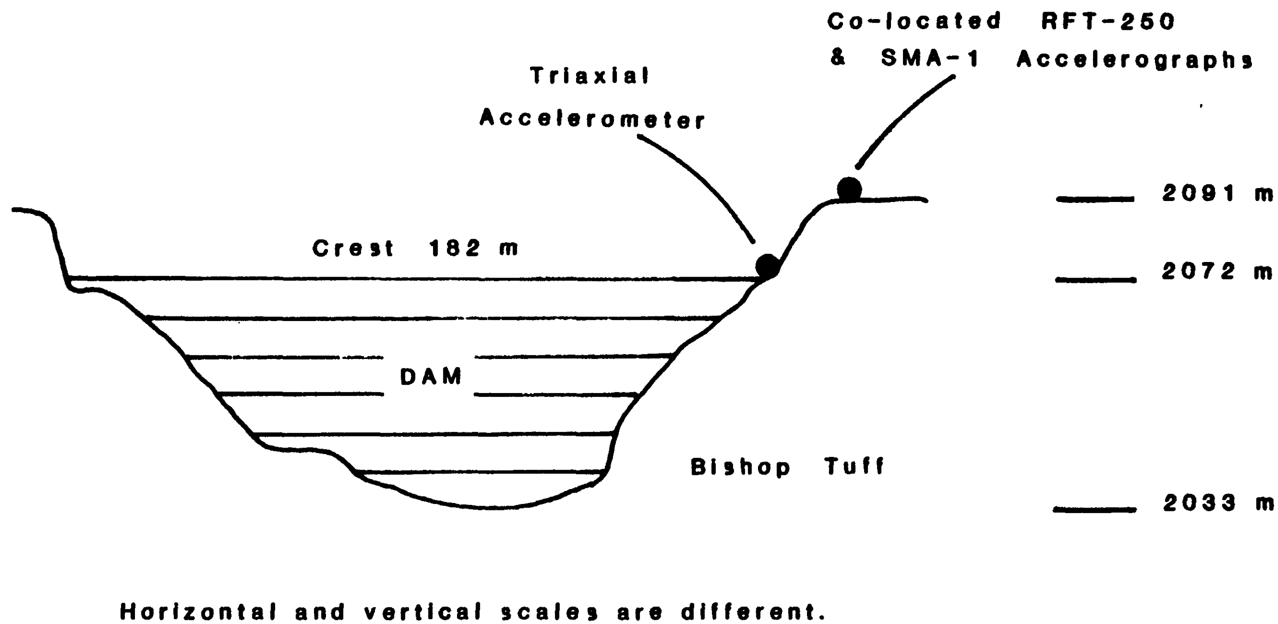

Figure 4.--Elevation view of Long Valley Dam showing location of the strong-motion instrumentation on the left abutment.

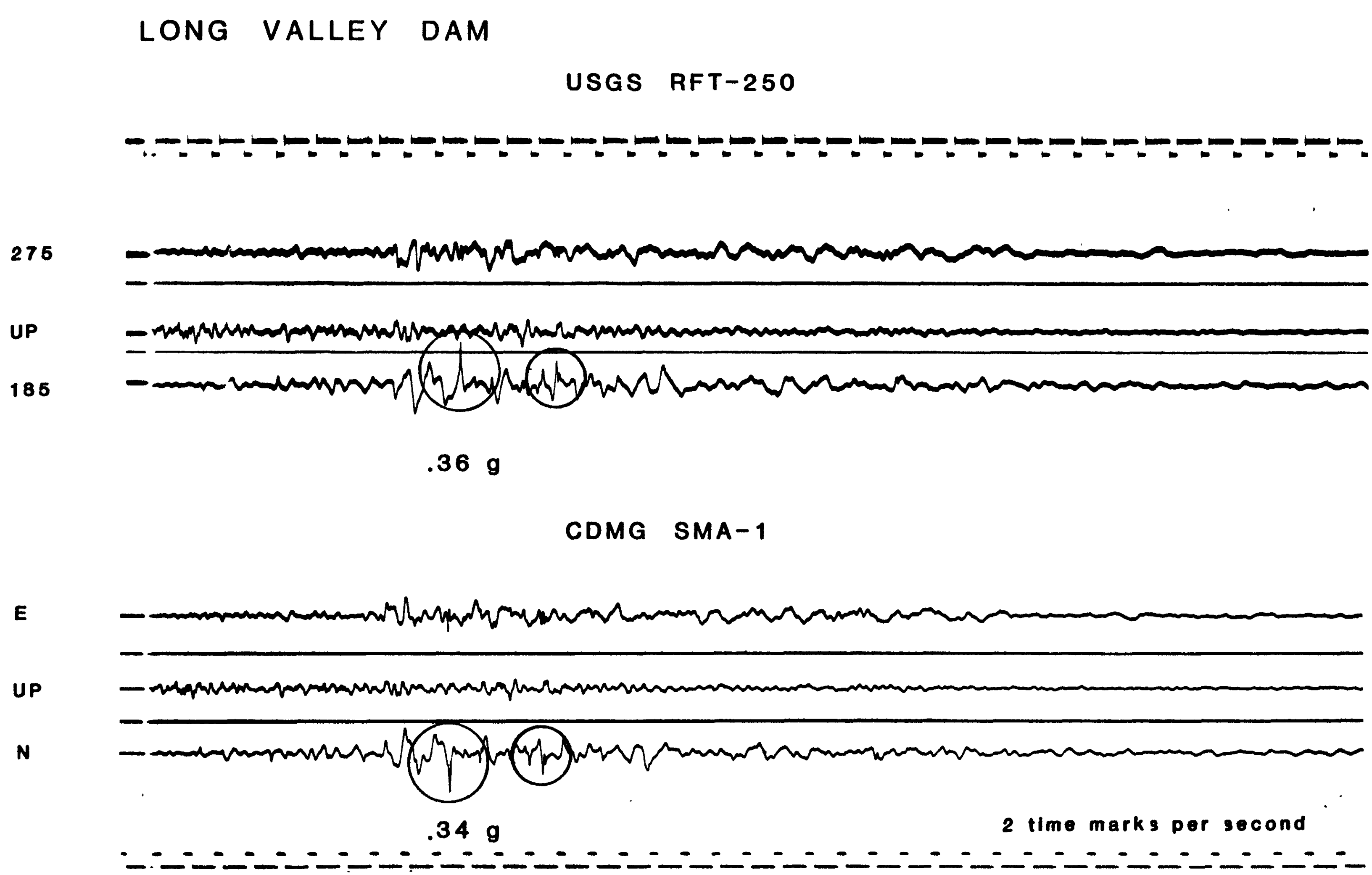

Figure 5.--Co-located accelerograph records from Long Valley Dam upper abutment.

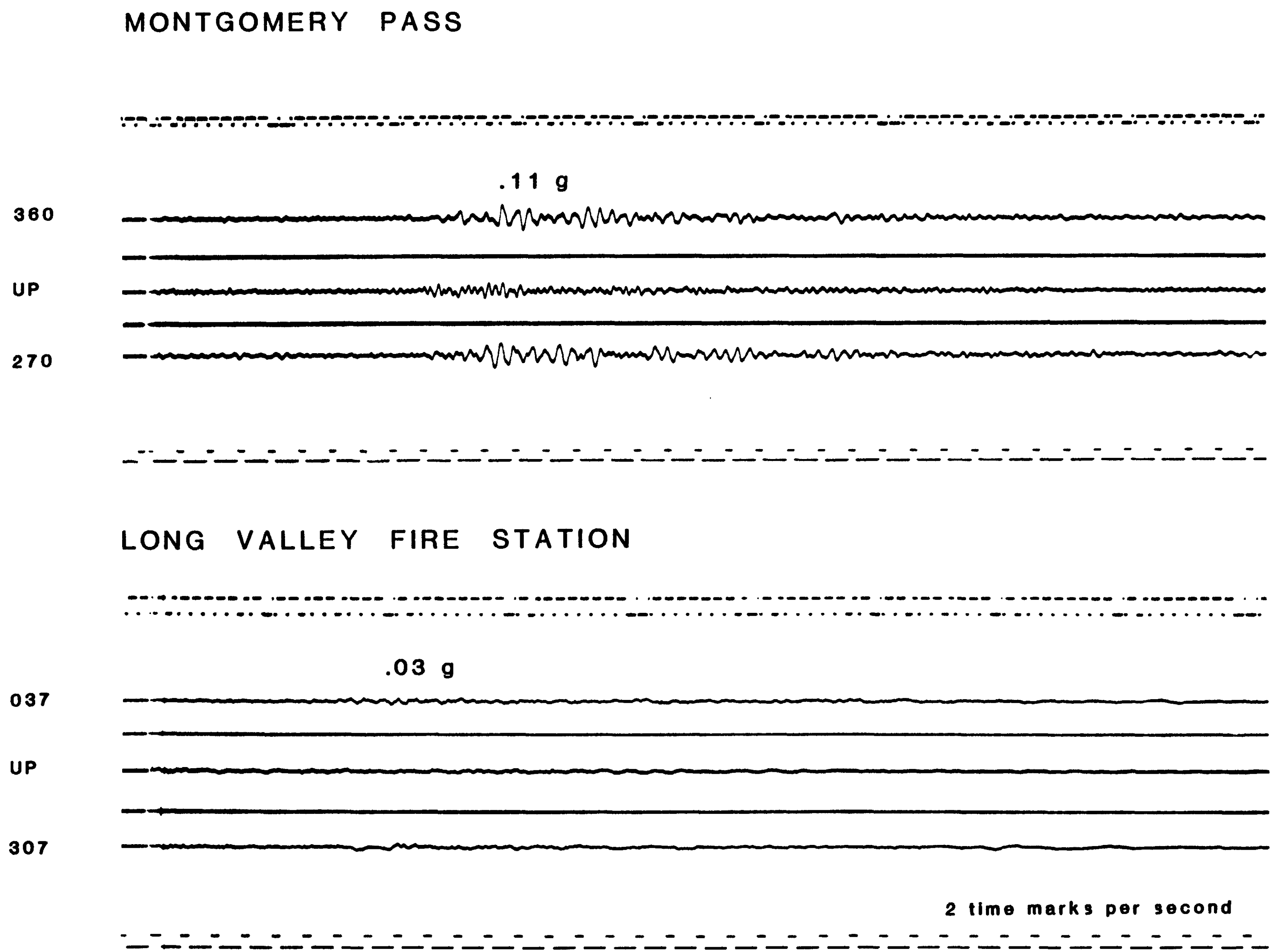

Figure 6.--Accelerograph records from Long Valley fire station and Montgomery Pass.

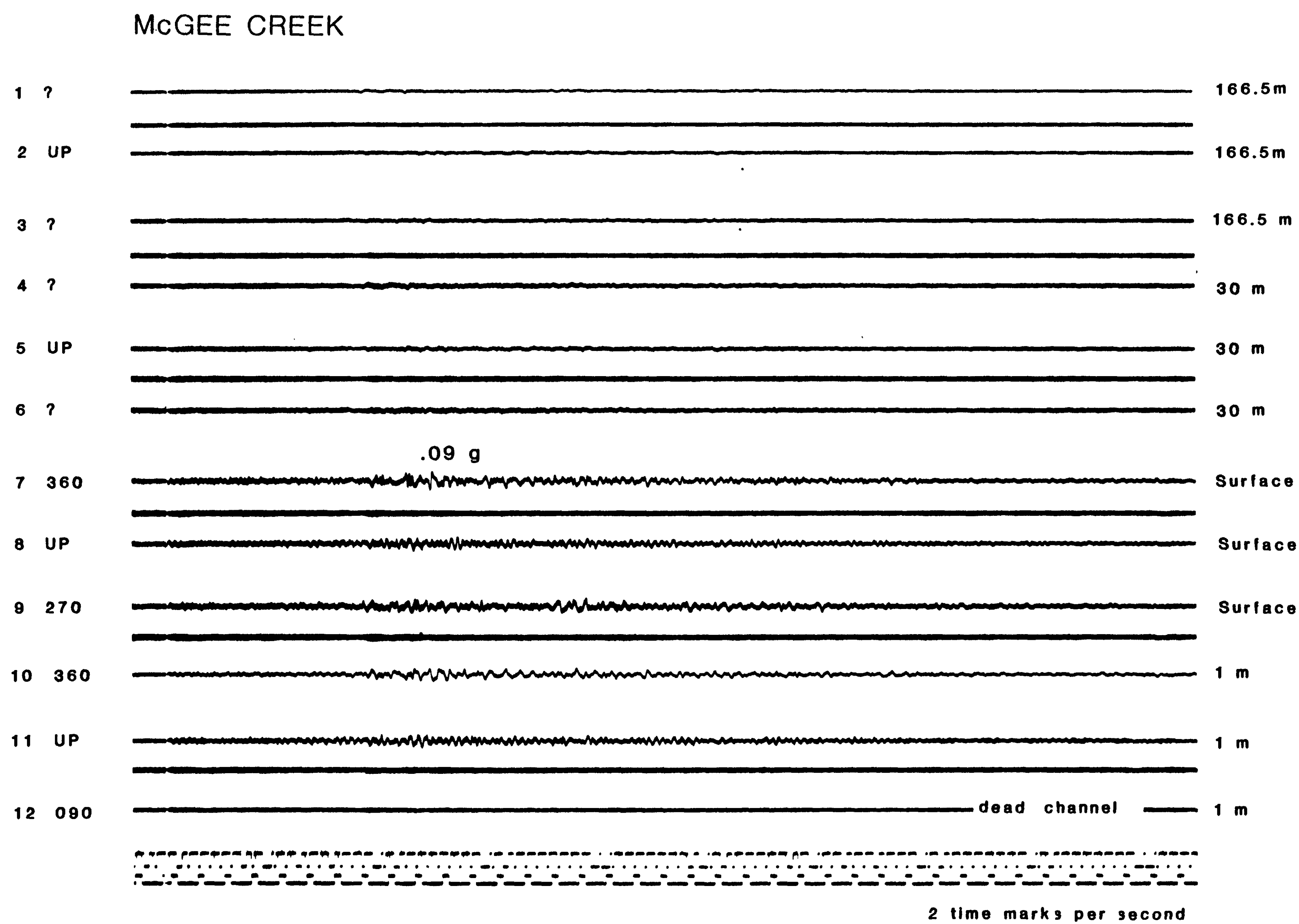

Figure 7a.--Accelerometer traces from the downhole/surface system at McGee Creek. The question marks are horizontal traces of unknown direction.

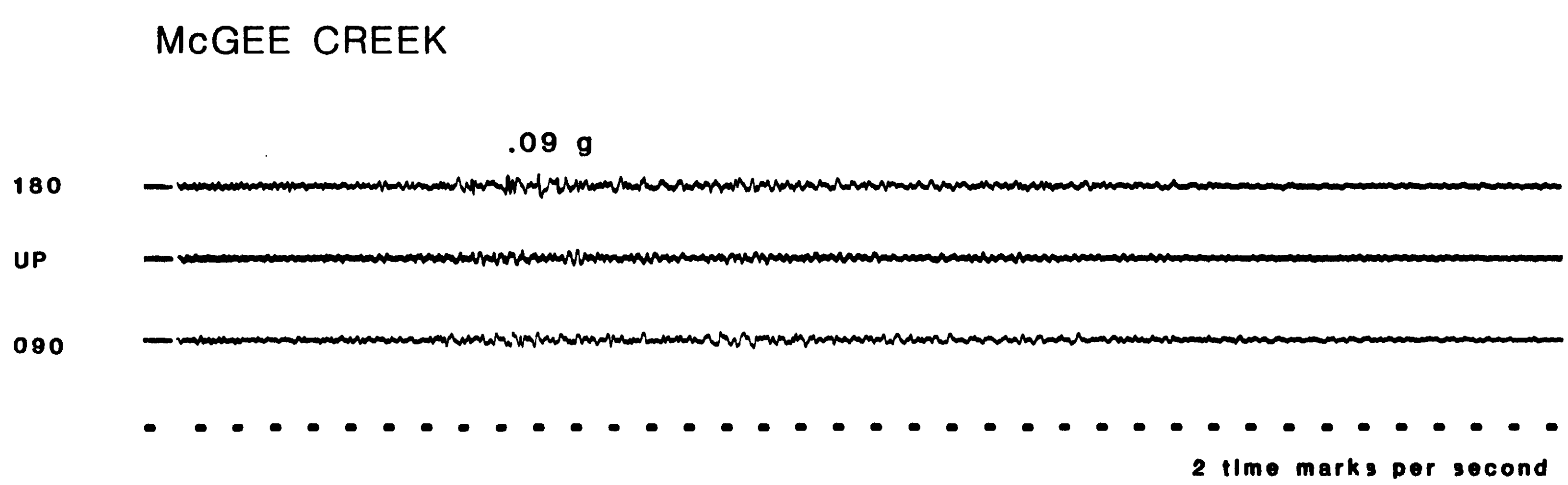

Figure 7b.--McGee Creek surface accelerograph record.

APPENDIX A

FORESHOCK STRONG-MOTION RECORDS

Station	Earthquake	Peak Acceleration (g)
McGee Creek	18 July 0718 GMT M = 3.8	<.05
Long Valley Dam	20 July 1430 GMT M = 5.9	.15
McGee Creek		<.05
Montgomery Pass		<.05
Terminus Dam		
Aux. Dam Crest		<.05
Main Dam Tower*		<.05
Main Dam Crest*		<.05
Lake Success		
Crest*		<.05
Slope*		<.05

*No real time. Believed to be from the July 20 earthquake.

APPENDIX B

MAIN EVENT STRONG-MOTION RECORDS FROM DISTANT CORPS OF ENGINEERS DAMS

Station	Epicentral Distance (km)	Peak Acceleration (g)
Buchanan Dam		
Crest	145	<.05
Hidden Dam		
Crest	135	<.05
Lake Success Dam		
Abutment*	160	<.05
Downstream*		<.05
Slope*		<.05
Crest*		<.05
Pine Flat Dam		
Abutment*	110	<.05
Terminus Dam		
Main Dam Crest*	130	<.05
Main Dam Tower*		<.05
Aux. Dam Crest		.06
Aux. Dam Abutment*		<.05

*No real time. Believed to be from the main shock July 21 earthquake.

APPENDIX C

AFTERSHOCK STRONG-MOTION RECORDS

Permanent Stations

Station	Peak Acceleration (g)
Earthquake of 21 July, 1451 GMT, M = 5.6	
McGee Creek	<.05
Montgomery Pass	<.05
Terminus Aux. Dam Crest	<.05
Earthquake of 21 July, 2207 GMT, M = 5.3	
Long Valley Dam*	.19
McGee Creek	<.05
Montgomery Pass	<.05
Terminus Aux. Dam Crest	<.05
Earthquake of 31 July, 0722 GMT, M = 5.8	
McGee Creek	<.05
Montgomery Pass	<.05
Terminus Dam	
Main Dam Tower**	<.05
Main Dam Crest**	<.05
Aux. Dam Crest	<.05

*Eight other minor earthquakes recorded at Long Valley Dam

**No real time. Believed to be from the July 31 earthquake.

Temporary Stations

Stations	Records to August 15	Earthquake Records with Acceleration >.10 g	
Chalfant Valley	77	23 July 1539 GMT M = 4.1	.24
		24 July 1644 GMT M = 3.6	.18
		24 July 1903 GMT M = 3.6	.19
		1 August 1427 GMT M = 4.3	.25
		1 August 1428 GMT M = 4.7	.40
		12 August 0929 GMT M = 3.5	.11
Hammil Valley	8		
Laws	10	1 August 1428 GMT M = 4.7	.11
Moran Spring	7		
So. Hammil Valley	11		