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Hydrologic Changes Associated with the October 28, 1983, Idaho Earthquake

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Abstract – Significant hydrologic changes were observed after the magnitude 7.3 earthquake that occurred on October 28, 1983, in central Idaho. Groundwater levels rose by as much as 3 meters near the epicenter. Discharge in many streams and springs increased, in some instances by more than 100%. One warm spring ceased flowing for several days; the flow then resumed and peaked at about nine times its original rate. Available data show no significant changes in water quality following the earthquake.

Key words: Groundwater; Runoff; Water level; Earthquakes; Springs.

Introduction

On October 28, 1983, one of the strongest earthquakes in the continental United States in 24 years, registering 7.3 on the Richter scale, shook Idaho at 8:06 A.M.. The epicenter was in a sparsely populated area about 24 kilometers northwest of Mackay in central Idaho.

In this article we present some preliminary data recorded by the U.S. Geological Survey on post-earthquake hydrologic changes in wells, springs, streams, and other surface-water bodies in central and southern Idaho.

Physical effects

A prominent 37-kilometer-long fault scarp formed along the western flank of the Lost River Range at the base of Borah Peak, Idaho's highest mountain (Fig. 1). In places, vertical displacement along the fault was as much as 3 meters. Mudflows and landslides were extensive.

Craters formed in the valley near the northern part of Chilly Buttes (Fig. 1) after sand and water under high hydraulic head erupted from the ground. Fissures as much as 35 meters above the valley floor formed on the east side of the northernmost part of Chilly Buttes as groundwater was forced out.

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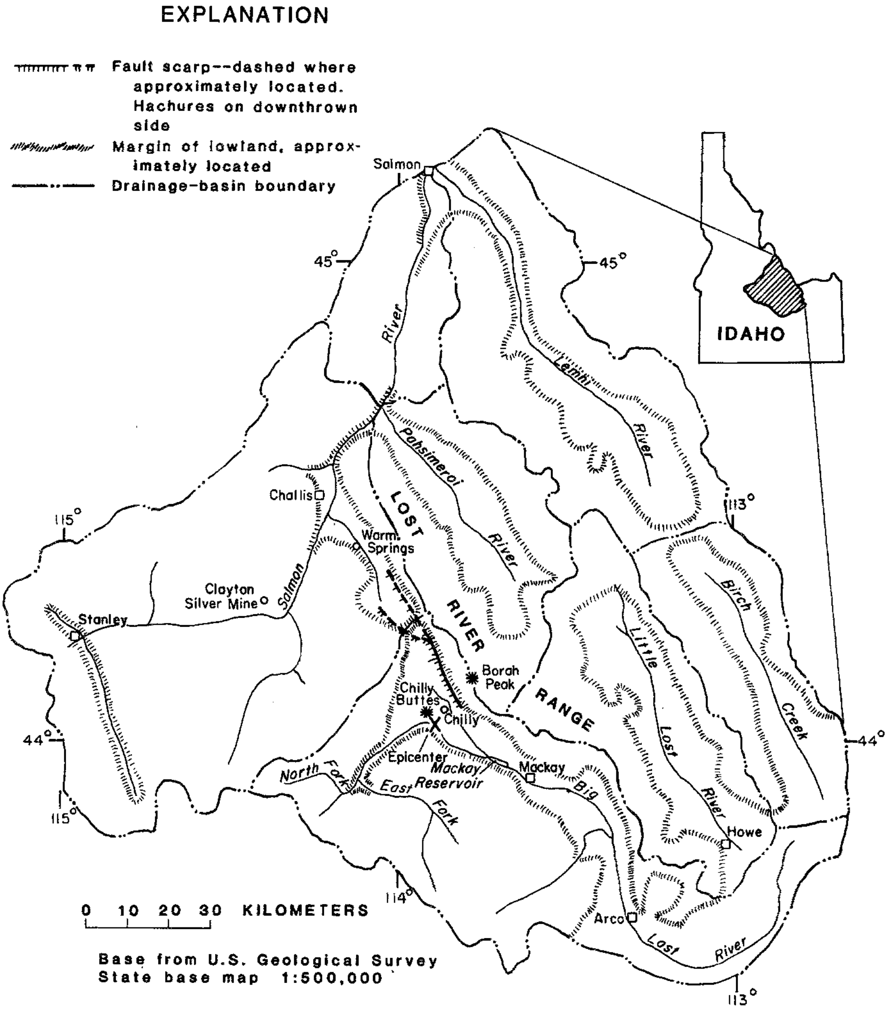

Figure 1
Geographic features in vicinity of earthquake epicenter.

Hydrologic monitoring

The U.S. Geological Survey's statewide hydrologic monitoring network provided the basis for post-earthquake data collection (Fig. 2). However, coverage was expanded in certain areas by inventorying a few new wells and by reactivating sites with historic data so that changes could be detected (Fig. 2). CROSTHWAITE *et al.* (1970) provided additional hydrologic data from which effects of the earthquake in the Big Lost River basin could be gaged.

Discharge was measured at 25 streams and 4 springs in the Big Lost River basin

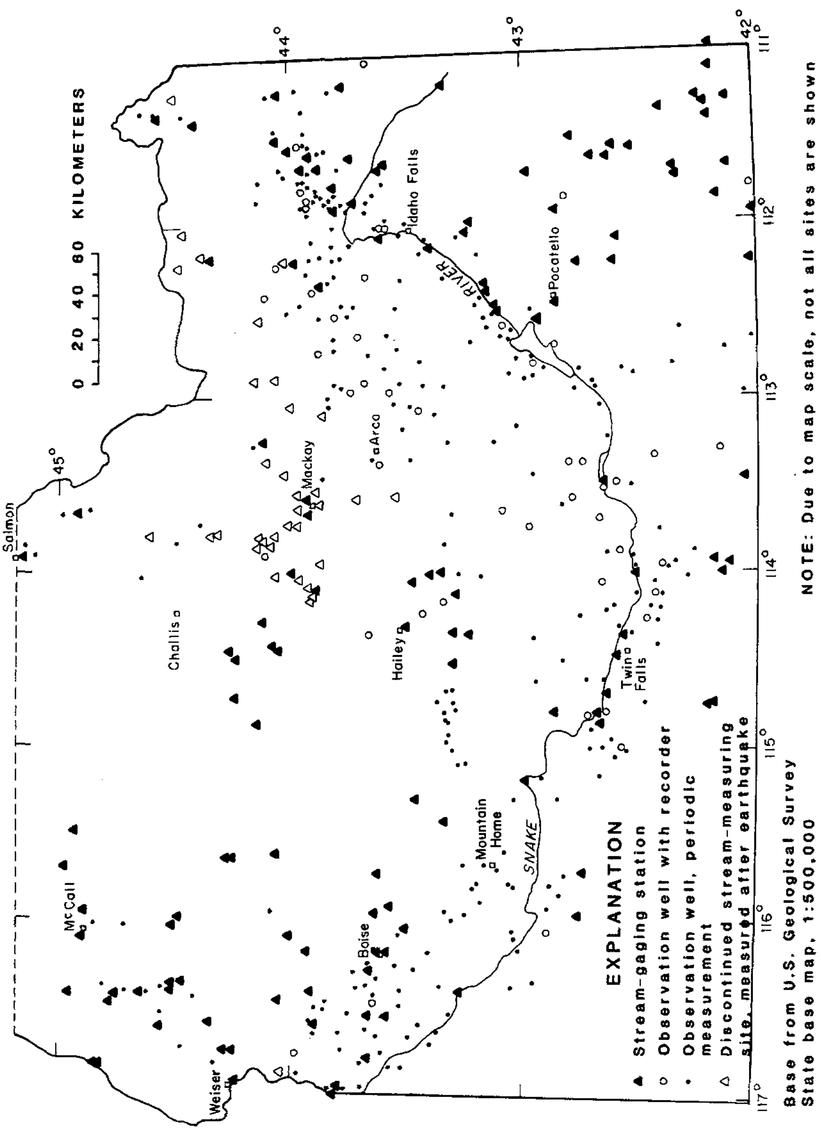

Fig. 2
Post-earthquake hydrologic monitoring sites in southern Idaho.

and at 23 streams and 6 springs in basins north and east of the Big Lost River basin. Areas to the west and south were adequately monitored by the existing network.

Water levels were measured in 69 wells, which included 41 wells added to the existing network for this study. Some sites were dropped after the initial post-earthquake measurements; others will be continued until trends are established.

Water samples were collected from 40 sites for chemical analysis and from 15 sites for suspended-sediment concentrations.

Hydrologic changes

The most prominent changes in the hydrologic system occurred near the epicenter. Some changes were noted in wells in other parts of Idaho, and also in Montana and Wyoming as far away as 700 kilometers (Fig. 3). Table 1 summarizes hydrologic changes compiled from well and spring recorder charts, observations, and unconfirmed reports; locations of these changes are cross-referenced by number, to Fig. 3.

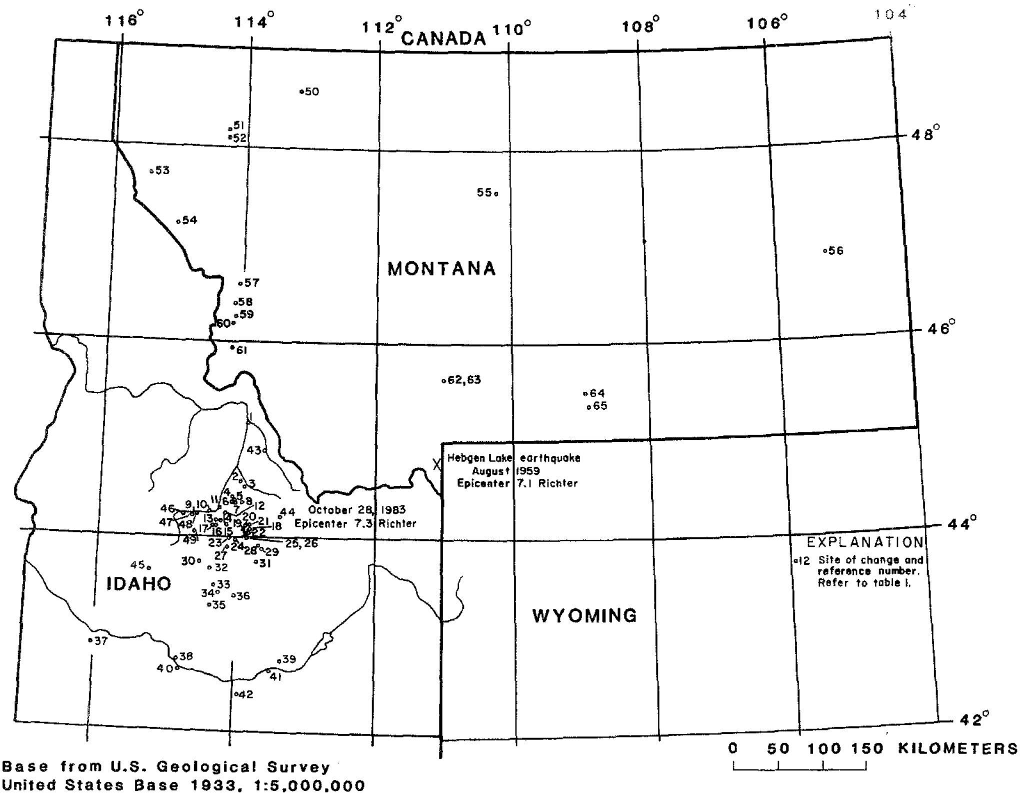

Fig. 3
Locations of observed and reported hydrologic changes in Idaho and Montana after earthquake.

Table 1

*Summary of Post-earthquake Hydrologic Changes** [*Modified from S. H. Wood, Boise State University, written commun., 1984*]

Ref. number: see Fig. 3	Site	Change
Idaho sites**		
1	U.S. Geological Survey gaging station, Salmon River at Salmon	Increased discharge (refer to Fig. 8).
2	Lawson Creek	Increased discharge reported. Measured 845 liters per second.
3	Sulphur Creek	Increased discharge reported. Measured 440 liters per second at springs in 1971. Measured 753 liters per second after earthquake.
4	Hole in the Rock Creek	Increased discharge reported.
5	Lime Creek	Increased discharge reported.
6	Warm Springs south of Challis	Spring discharge of 170 liters per second ceased but began again November 4 (refer to Fig. 7).
7	Devils Canyon	Increased discharge reported.
8	Grouse Creek drainage	Formed new 8,000-square-meter lake about 3 meters deep, reported by U.S. Forest Service
9	Clayton Silver Mine	Increased discharge. Pumping rate of 62 liters per second, doubled to maintain pre-earthquake water level.
10	Spring near Clayton Silver Mine	Discharge diminished, then increased; reported.
11	Unnamed spring	Increased discharge reported.
12	Tub Spring area	Increased discharge reported.
13	Unnamed spring	New spring reported.
14	Road Creek	Increased discharge reported.
15	Bear Creek	Increased discharge reported.
16	U.S. Geological Survey gaging station, Herd Creek below Trail Creek Gulch near Clayton	Increased discharge (refer to Fig. 8).
17	Pine Creek	Increased discharge reported.
18	U.S. Geological Survey observation well	Higher water level (refer to Figs. 4 and 5).
19	Whiskey Spring	Discharge diminished, then recovered; reported.
20	Chilly Buttes	Water under high hydraulic head gushed out of fissures on side of butte (head estimated at about 35 meters); discharge exceeded 2,800 liters per second. Sand and water issued from craters in valley floor. A temporary lake formed but drained within 2 weeks.
21	Birch Springs	Springs along fault saturated hillside and caused landslide. Discharge estimated to equal pre-earthquake discharge.
22	Elkhorn Creek Canyon	New springs reported to discharge about 60 liters per second.
23	Bartlett Creek	Increased discharge reported.
24	U.S. Geological Survey gaging station, Big Lost River at Howell Ranch near Chilly	Increased discharge (refer to Fig. 8).

Table 1.—*continued.*

Ref. number; see Fig. 3	Site	Change
Idaho sites—*continued*		
25	Hamilton Spring	Surge of water (about 2,800 liters per second). Discharge doubled pre-earthquake discharge of 850 liters per second.
26	Mackay State Fish Hatchery	Surge of water (about 2,000 liters per second). Discharge increased from 620 to 850 liters per second.
27	U.S. Geological Survey gaging station, North Fork Big Lost River at Wildhorse near Chilly	Increased discharge (refer to Fig. 8).
28	Mackay Reservoir	Stage fluctuated about 0.03 meter.
29	Mackay City Spring	Increased discharge reported.
30	Easley Warm Spring	Increased discharge reported.
31	Cherry Creek area	New springs and landslide reported.
32	U.S. Geological Survey observation well	Higher water level after earthquake (refer to Fig. 4).
33	U.S. Geological Survey gaging station, Big Wood River at Hailey	Increased discharge (refer to Fig. 8).
34	U.S. Geological Survey observation well	Higher water level after earthquake (refer to Fig. 4).
35	U.S. Geological Survey gaging station, Big Wood River near Bellevue	Increased discharge (refer to Fig. 8).
36	U.S. Geological Survey gaging station, Little Wood River above High Five Creek near Carey	Increased discharge (refer to Fig. 8).
37	U.S. Geological Survey observation well	Higher water level after earthquake (refer to Fig. 4).
38	U.S. National Fish Hatchery spring	Large spring fluctuated about 85 liters per second above and below normal discharge of about 740 liters per second for several days.
39	U.S. Geological Survey observation well	Water level lower, then returned to normal following large aftershock (refer to Fig. 4).
40	U.S. Geological Survey observation well	Increased discharge from artesian well (refer to Fig. 4).
41	U.S. Geological Survey observation well	Water level higher, then declined (refer to Fig. 4).
42	U.S. Geological Survey observation well	Water level lower, then returned to normal (refer to Fig. 4).
43	U.S. Geological Survey gaging station, Lemhi River near Lemhi	Increased discharge (based on estimates).
44	U.S. Geological Survey gaging station, Little Lost River below Wet Creek near Howe	Increased discharge.
45	U.S. Geological Survey gaging station, South Fork Boise River near Featherville	Increased discharge.
46	U.S. Geological Survey gaging station, Salmon River below Yankee Fork near Clayton	Increased discharge.
47	U.S. Geological Survey gaging station, Thompson Creek near Clayton	Increased discharge.

Table 1.—*continued.*

Ref. number; see Fig. 3	Site	Change
48	U.S. Geological Survey gaging station, Squaw Creek below Bruno Creek near Clayton	Increased discharge.
49	U.S. Geological Survey gaging station, East Fork Salmon River Above Big Boulder Creek near Clayton	Increased discharge.
Montana sites†		
50	Well in Browning area	Well went dry after earthquake, was good producer previously.
51	Well in Kalispell area	Well yielded brown water 3 hours after earthquake.
52	Spring in Kalispell area	Spring went dry after earthquake; as of December 14, 1983, still dry.
53	Well in Thompson Falls area	Pump set 1.2 meters above bottom pumped dry quickly after earthquake.
54	Well in Superior area	Well yielded muddy, iron-stained water for several hours.
55	Well in Geraldene area	Well developed odor and iron problems after earthquake.
56	Well in Glendive area	Well yielded muddy water.
57	Several wells in Florence area	Wells yielded iron-enriched water after earthquake; stains badly.
58	Springs in Victor area	Discharge increased after earthquake.
59	Well in Corvallis area	Water developed "musty" taste.
60	Wells in Hamilton area	One well yielded red water after earthquake. Seven other wells went dry.
61	Well in Darby area	Well always yielded iron-enriched water, but much worse after earthquake; changed a filter every 2–3 months before earthquake; changed daily after earthquake.
62	Well in Bozeman area	Well now loses prime; was a good producer since 1930.
63	Well in Bozeman area	Well yielded iron-enriched water after earthquake.
64	Well in Joliet area	Well went dry within 2 days after earthquake.
65	Well in Joliet area	Well developed hydrogen sulfide odor. No apparent changes in quality, quantity, temperature, or appearance.

* Modified from S. H. Wood, Boise State University, written communication, 1984.

** Additional changes probably occurred which have not yet been reported.

† J. A. Moreland, U.S. Geological Survey, written communication, 1984.

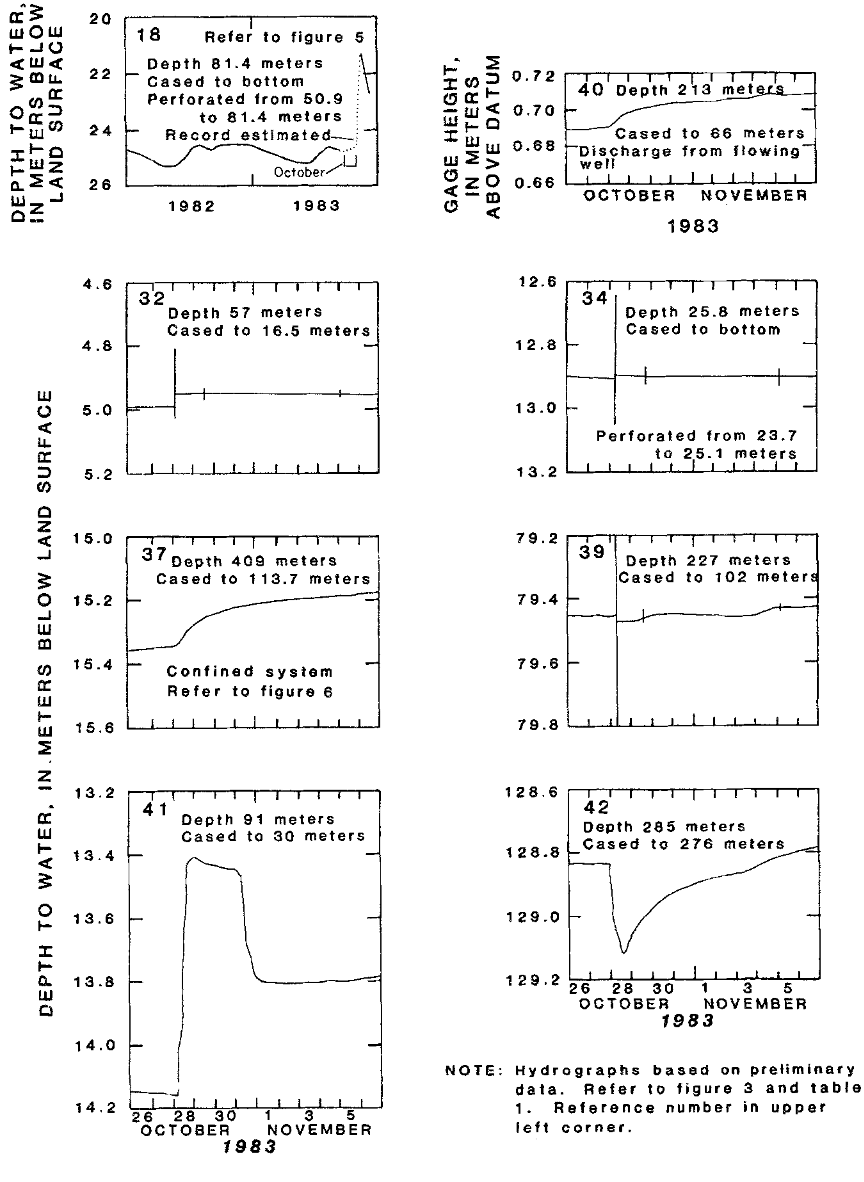

Figure 4
Hydrographs of selected wells showing water-level changes after earthquake.

Groundwater

Water levels in wells near the epicenter generally rose rapidly after the earthquake; some overtopped their casings. Water issuing from many of these wells was muddy and clogged some pumps.

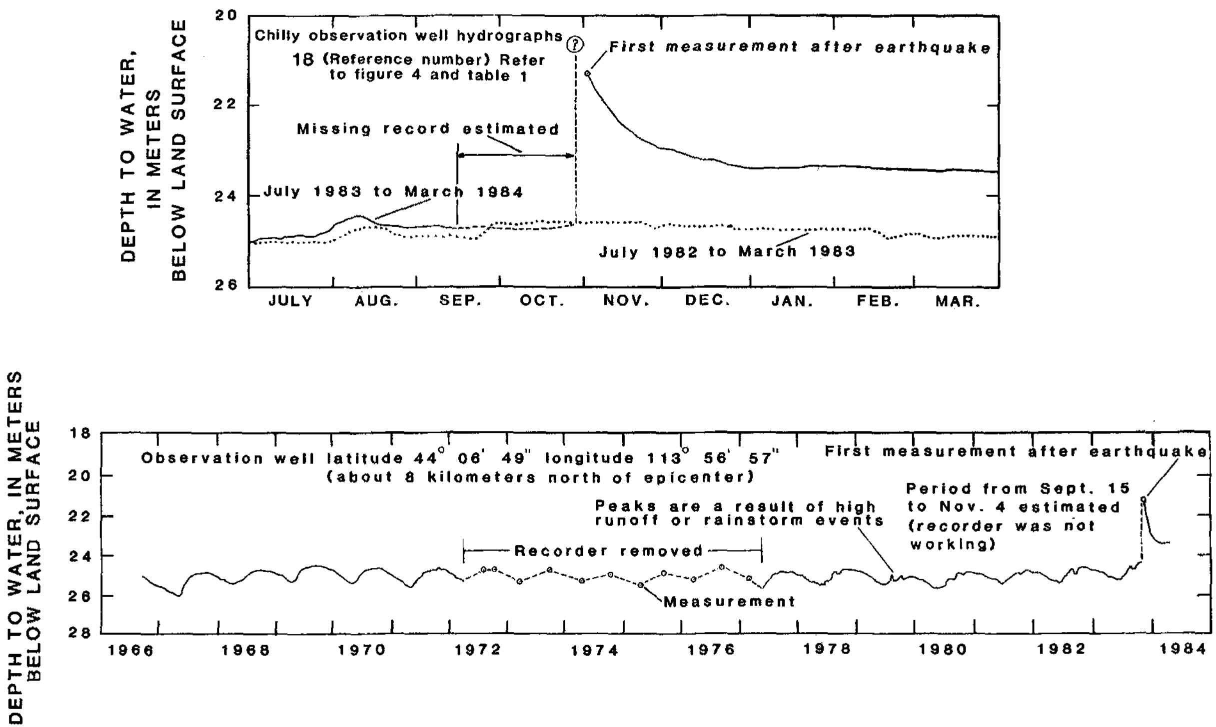

Figure 5
Hydrographs of observation well near Chilly 8 kilometers north of epicenter, showing short-term and long-term water-level changes.

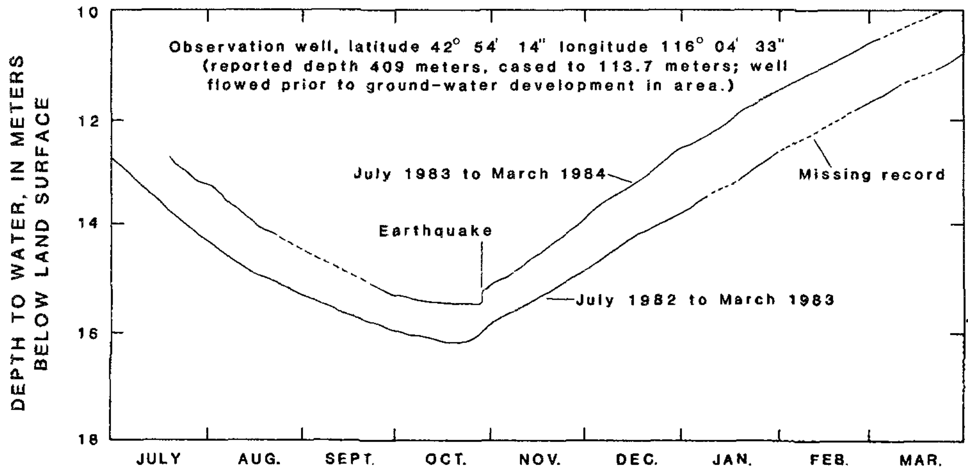

Figure 6
Hydrographs of observation well 210 kilometers southwest of epicenter, showing comparison of water-level changes after earthquake with previous year's record.

Changes in water levels during the earthquake were noted in numerous wells throughout southern Idaho (Fig. 4). Water levels in some wells north of the epicenter in Montana declined after the earthquake. The declines were accompanied by muddy water and, occasionally, an odor of hydrogen sulfide gas (MORELAND, 1984).

The most prominent water-level change was recorded in an observation well near Chilly (Fig. 5). The recorder malfunctioned on September 15, 1983, and when it was restarted on November 4, the water level in the well had risen nearly 4 meters. Subsequently the water level declined steadily until January, when it leveled off about 1.5 meters above its pre-earthquake level. An observation well 210 kilometers southwest of the epicenter also experienced water-level changes (Fig. 6). The well is 409 meters deep in a confined system. The well flowed prior to groundwater development in the area. Withdrawals of groundwater for irrigation near the well lowered the potentiometric head.

The Clayton Silver Mine near Challis, Idaho (Fig. 1), which routinely pumped about 62 liters per second from the lower level of one of the workings, to keep water from the mining operations, had to pump 126 liters per second after the earthquake to maintain the pre-earthquake water level (ROVETTO, 1984). As of February 1984 a pumping of 96 liters per second was adequate to maintain the working level. A similar increase in flow was observed in the mine following the 1959 Hebgen Lake earthquake in Montana (ROVETTO, 1984; SWENSEN, 1964, p. 162). The flow returned to its pre-earthquake volume after about 8 months.

Groundwater gushed from fissures opened in the Chilly Buttes area and in the vicinity of another butte about 8 kilometers to the south, near the epicenter, for several

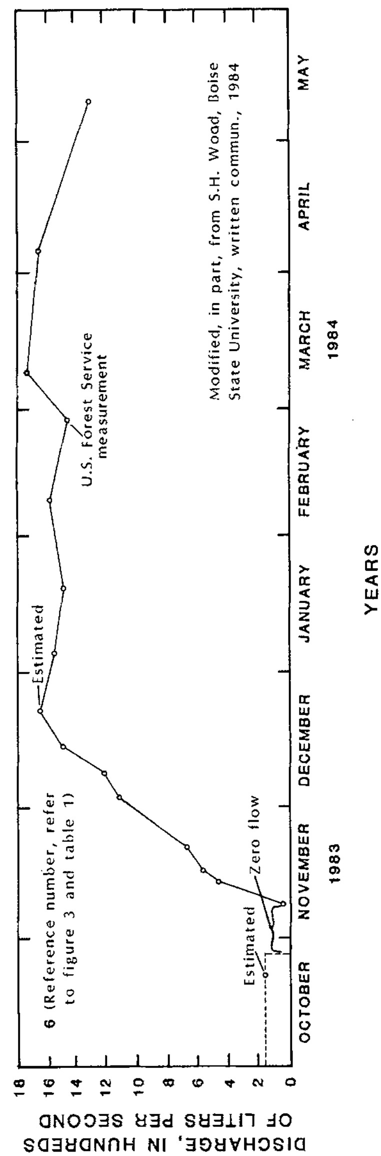

Figure 7

Hydrograph of Warm Springs, south of Challis, showing changes in discharge after earthquake.

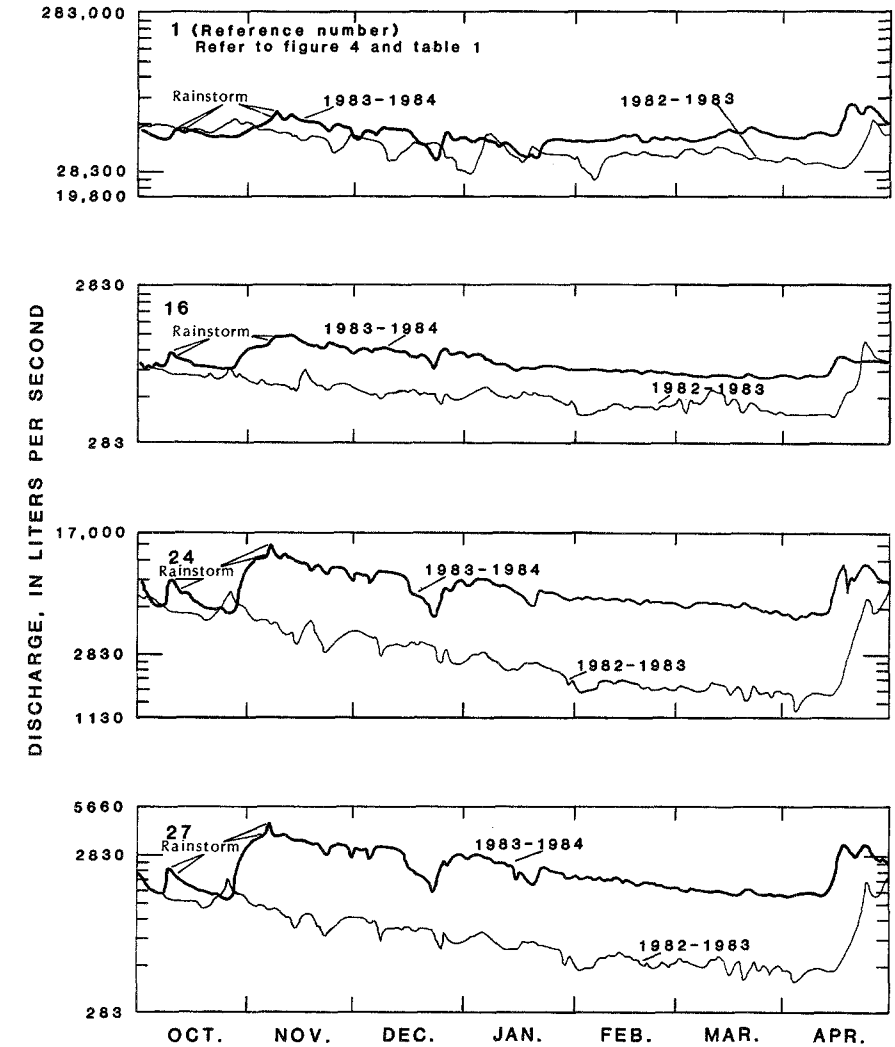

Figure 8
Hydrographs of selected streams for October 1982 to April 1983 and October 1983 to April 1984, showing comparison of changes after earthquake with previous year's record.

hours after the earthquake and caused local flooding. Rising groundwater levels resulted in saturation of the valley alluvium, which compounded the flooding and formed a temporary lake near Chilly Buttes.

Increased discharge from many springs was reported. The most significant increase was at Warm Springs south of Challis (Fig. 7). Pre-earthquake discharge from these springs was 170 liters per second. The springs ceased flowing after the earthquake, began flowing again on November 4, then increased steadily, and peaked at 1,640 liters

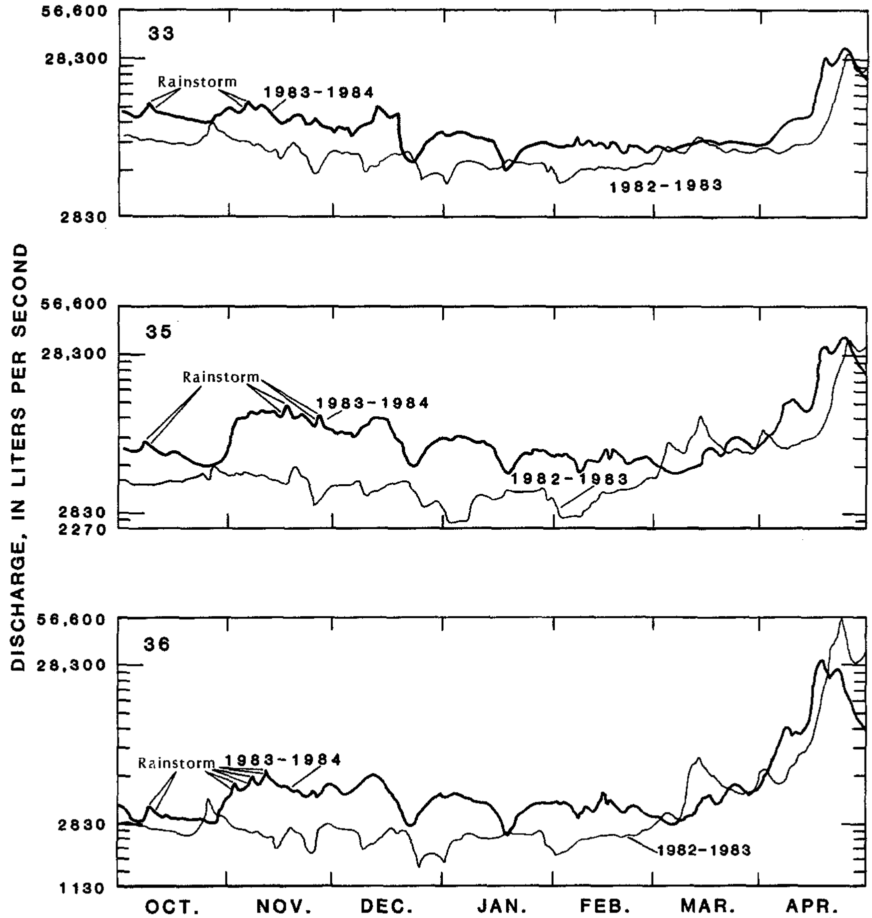

Figure 8.—*continued*

per second on December 20 (WOOD, 1984). Discharge remained reasonably steady during January and February, ranging from 1,470 to 1,560 liters per second. Discharge increased to 1,750 liters per second by March 8, 1984, then decreased to 1,630 and 1,300 liters per second on April 5 and May 9, 1984.

Surface water

Most streams in the epicenter area and surrounding basins were at or above maximum average discharge prior to the earthquake. After the earthquake significant increases were measured at several U.S. Geological Survey gaging stations (Table 1 and Figs. 2 and 8).

Streamflow increased more than 100% in North Fork Big Lost River, about 23 kilometers southwest of the epicenter and, in Big Lost River, about 14 kilometers southwest of the epicenter. Flow in the North Fork increased from 1,420 liters per second prior to the earthquake to 3,400 liters per second. Flow in the Big Lost River increased from 4,960 liters per second prior to the earthquake to 11,300 liters per second. By December the flow in this river had decline slightly, to 9,200 liters per second. According to National Weather Service data, there were no major precipitation events in the area during October to have caused the increased discharge. Precipitation events before and after the earthquake are labeled in Fig. 8.

Two lakes formed as a direct result of the earthquake. One at Chilly Buttes, previously mentioned, drained within 2 weeks after the earthquake. The other is in a remote area in the Pahsimeroi River basin drainage (Fig. 1).

Mackay Reservoir, about 16 kilometers southeast of the epicenter, has a storage capacity of 54.7 cubic hectometers and was about 90% full at the time of the earthquake. The safety of the residents of Mackay, about 6 kilometers downstream from the reservoir, was of great concern. The dam did not fail, but a considerable amount of rock from adjacent cliffs fell into the spillway channel. The earthquake shock was reflected in the reservoir by relatively minor wave action. A vertical motion through an approximately 0.03-meter range that lasted about 30 minutes was recorded.

Water quality and sediment

Comparison of pre-earthquake water-quality analyses with the few post-earthquake analyses available at present (March 1984) showed no significant changes. Sediment samples are currently being analyzed.

Acknowledgment

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