SNOW SURVEYS AND MOUNT SAINT HELENS

By

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INTRODUCTION

Mount Saint Helens is the youngest of the Cascade mountain range volcanoes. It and its neighbors are part of the Pacific "Rim of Fire" which also includes Japan's Fujiyama, Alaska's Valley of the Ten Thousand Smokes, Mexico's Popocatepetl, and Ecuador's Cotopaxi (Harris, 1976). The mountain has been the most active and violent volcano in the conterminous United States during recent geologic time.

On March 27, 1980, Mt. St. Helens broke 123 years of silence with an eruption of gas, steam and old tephra.[4/] During the next few days, several eruptions followed, dusting the mountain and surrounding areas with a thin mantle of ash. A near normal snowpack covered the area, ranging up to an estimated 1750 mm (70 inches) of snow water equivalent at higher elevation snow courses. The mountain slopes are headwaters of several rivers flowing west and of numerous south flowing tributaries to the Lewis River. Because of the volcano's location special snow surveys in the vicinity were planned to document snowpack conditions and effects of tephra on the snow.

HISTORY OF SNOW SURVEYS IN THE AREA

The first snow course was established in 1942 approximately 32 kilometers (20 miles) east-southeast of the volcano at Surprise Lakes. In 1944 the Plains of Abraham snow course was placed on the northeast flank of the mountain at the 1320 meter (4400 ft) level. By 1962 five more courses were added, extending the network from Mt. St. Helens east up the headwaters of the Lewis River to the base of Mt. Adams, 56 km (35 miles) to the east (Figure 1).

The network was installed and measured by the U.S. Geological Survey (USGS). The data were used primarily by Pacific Power and Light in the operation of their three hydro-electric projects on the Lewis River. At the conclusion of the 1978 survey season the USGS suspended snow survey operations throughout western Washington, and adopted the HM model for streamflow forecasting which does not use snowpack data (Tangborn, 1977).

In 1975 the Soil Conservation Service (SCS) began installation of SNOTEL project automated sites in the Western United States (Barton and Burke, 1977). Surprise Lakes and Lone Pine Shelter, 19.2 km (12 miles) northeast of the peak, the highest priority sites, became operational in 1977 and were functional at the start of the current volcanic activity. Sensing equipment had been installed at Plains of Abraham; Spencer Meadows, 19.2 km (12 miles) southeast; and Potato Hill, 48 km (30 miles) east, and radio communications gear was scheduled for installation during the summer of 1980.

CURRENT SNOW SURVEY ACTIVITIES

No routinely scheduled snow surveys had been made at any of the courses during the winters of 1978-79 and 1979-80. When eruptive activity began, SCS decided to reestablish snow surveys at these locations. Helicopter transportation was the only alternative, due to restrictions placed on access to the immediate area by the State of Washington and the U.S. Forest Service. A survey team measured 5 courses on April 10, the date of the first available good flying weather. Results of this and other surveys are shown in Table 1.

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1/ Soil Conservation Service, Portland, Oregon
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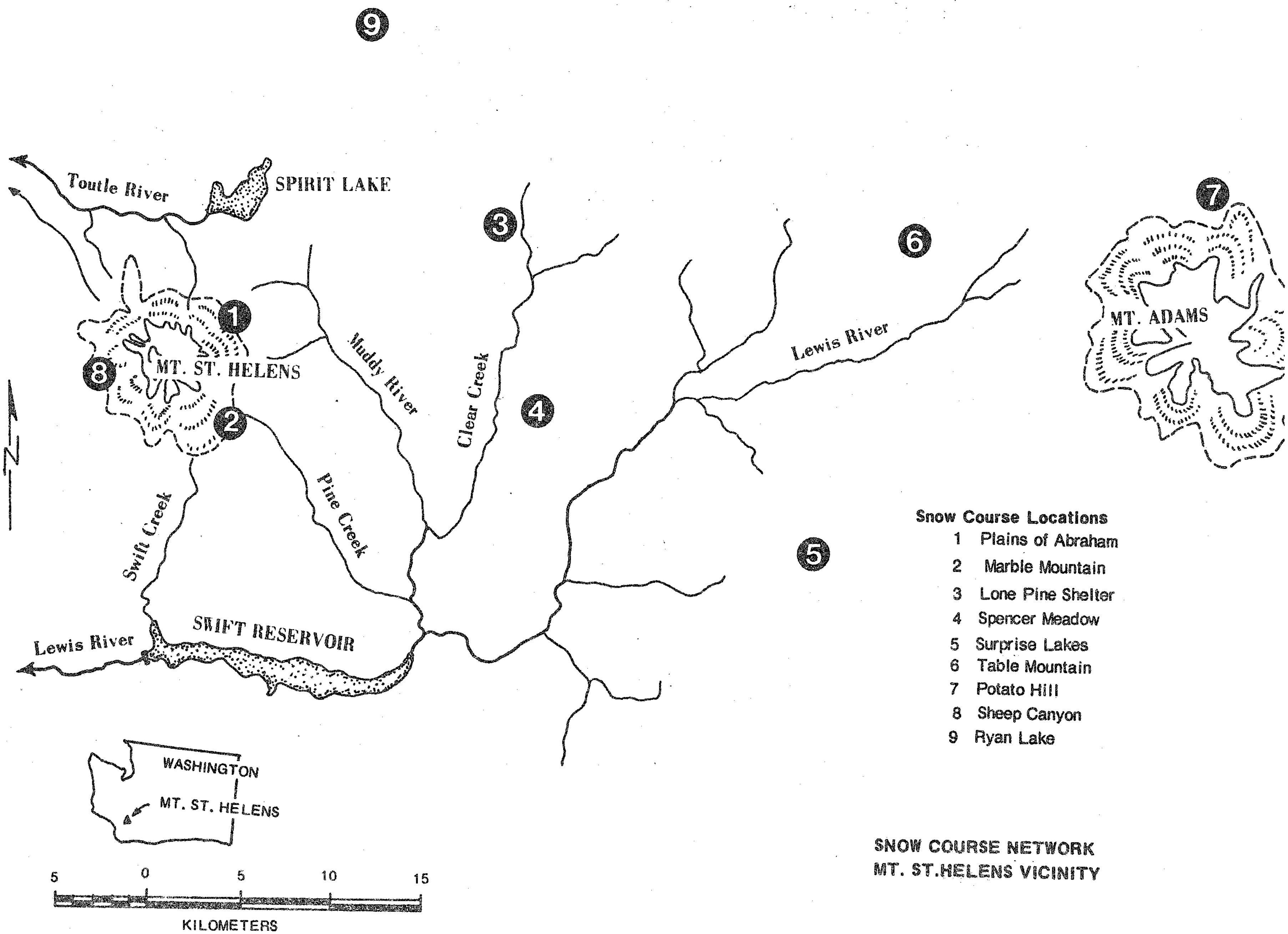
3/ Soil Conservation Service, Reno, Nevada
4/ Tephra = Molten or solid rock of any size erupted into the air above a volcano



SNOW COURSE NETWORK
MT. ST.HELENS VICINITY

FIGURE 1

A survey scheduled for May 19 was postponed by the massive eruption which began at 8:30 a.m. on May 18. Geologists reports indicated that some of the snow courses were probably destroyed, and tephra had been deposited over a large part of the survey zone.

TABLE 1

SNOW SURVEY DATA
MT. ST. HELENS VICINITY - 1980

DATE	LOCATION	SNOW DEPTH(cm)	SNOW WATER EQUIVALENT(cm)	DENSITY %	TEPHRA THICKNESS SURFACE(mm)
April 10, 1980	Lone Pine Shelter	232	91.25	39	Trace
	Surprise Lakes	272	102.5	38	Trace
	Plains of Abraham	370	182.5	49	2 mm
	Spencer Meadow	76	31.25	41	Trace
	Table Mountain	270	107.5	40	0
April 30, 1980	Lone Pine Shelter	142	60.5	43	Trace to 10 mm, variable
	Surprise Lakes	116	56.25	48	Trace
	Plains of Abraham	181	102.5	57	15 mm
	Spencer Meadow	0	0	0	0
	Table Mountain	122.5	58.75	48	Trace
	Marble Mountain	0	0	0	0
June 17, 1980	Lone Pine Shelter	59	30	51	120-150 mm variable
July 1, 1980	Lone Pine Shelter	42	23	55	120-150 mm
July 29, 1980	Lone Pine Shelter	0	0	0	120-150 mm

The Lone Pine Shelter SNOTEL site, almost directly downwind from the volcano, functioned throughout the entire period. Figure 2 shows the response of the snow pressure pillow to the deposition of tephra. The snowpack at Surprise Lakes had melted bare coincidentally to the May 18 eruption, and being crosswind to the volcano, received no deposition.

The next survey was conducted on June 17-as soon as helicopter availability and adequate visibility permitted. This trip was limited to aerial reconnaissance except at Lone Pine Shelter where ground measurements were made and was followed by several more trips to the site while snow remained.

In October an SCS SNOTEL team installed sensor equipment at four sites. The Plains of Abraham site, obliterated by explosive blast, mud flows and/or pyroclastic flows, was reestablished and new locations developed at Sheep Canyon, Ryan Lake, and near the Marble Mountain aerial marker. In December the radio communications equipment was delivered and installed. By the end of January 1981 all SNOTEL sites had been activated.

Each site currently reports snow water equivalent of the snowpack, precipitation accumulated in a storage gage, and air temperature. By the beginning of the 1981-82 snow season, special event actuated and data integration equipment at seven SNOTEL sites will analyze snow and precipitation gage data and activate a polling sequence. During a significant storm or snow melt event the site will report whenever a pre-defined magnitude of change has occurred. Temperature extrémes and accumulated degree hours will also be transmitted. These data will complement information from other sources in assessing potential hazards such as pyroclastic flows, mud flows, etc., and predicting floods.

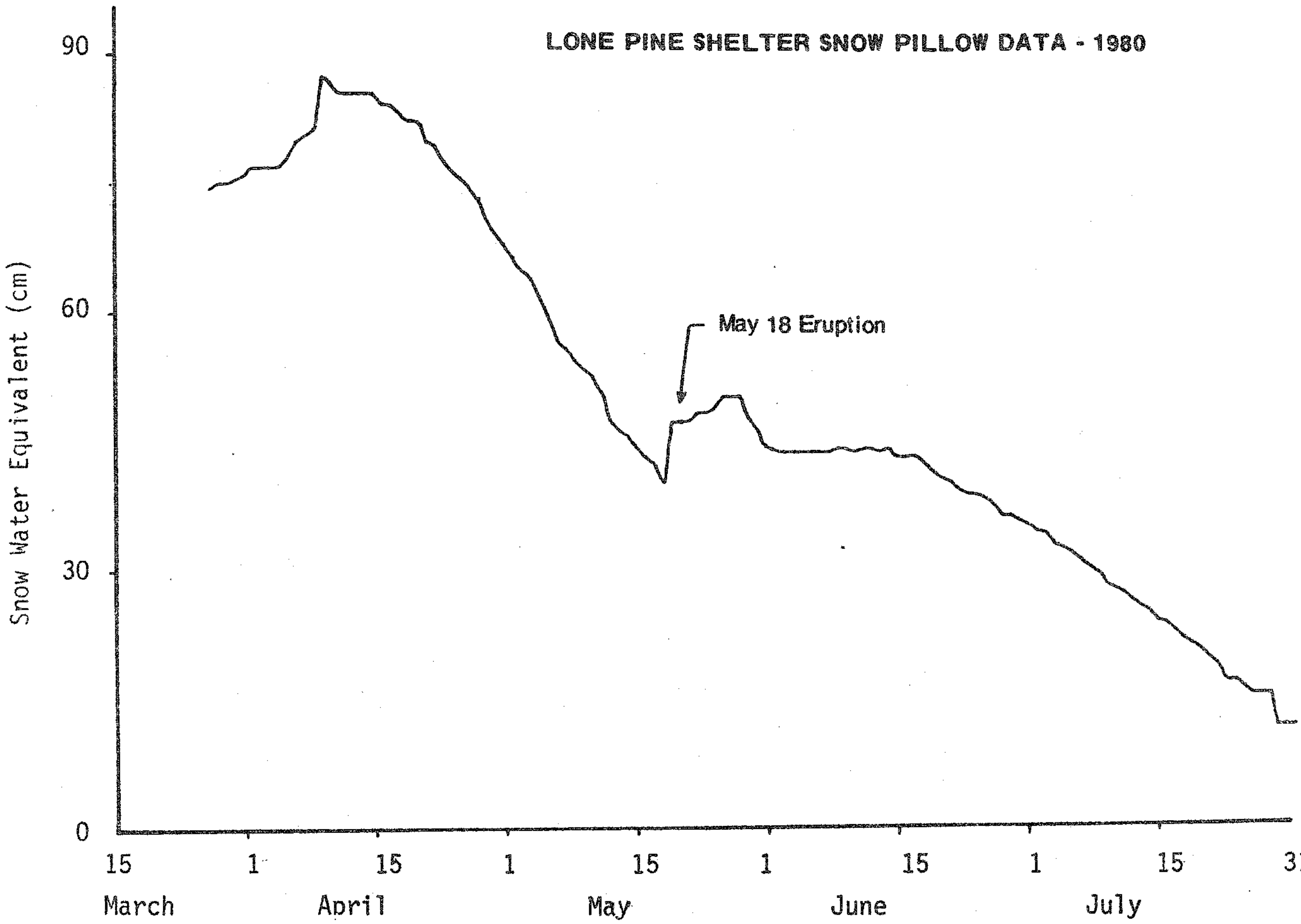


FIGURE 2

OBSERVATIONS

Between March 27 and April 10, the date of the first survey, the area received several major storms. On April 10, the snowpack at Plains of Abraham had layers of tephra at the surface and three other layers, all in the top 80 cm (32 inches) of a 375 cm (150 inch) snowpack. (Note; Table 1 and Figure 3 differences between survey depths at the same location on the same date were from the destructive process of pit sampling, requiring federal sampling some distance from the pits.) See Figure 3 for profiles at Plains of Abraham, Surprise Lakes, and Lone Pine Shelter. The other sites had similar horizons of tephra in the upper part of the profile. The total amount of tephra in and upon the snowpack decreased rapidly with distance from the mountain. Equipment to measure albedo was not available, so a quantitative measure of the effect of tephra on the snow surface could not be made. However, melting was observed by the survey team. The weather was partly cloudy with temperatures slightly above freezing.

Unusually warm sunny weather prevailed during the period from April 10 to April 30, when the next survey was made. By April 30, melting of the upper part of the snowpack had consolidated all the tephra layers at the surface. At the Plains of Abraham the tephra was thick enough to give the appearance of solid ground. Surface humps up to 50 cm (20 inches) had developed (see Figure 4).

The tephra layer on these humps generally exceeded 25 mm (1 inch) in thickness, whereas in the surrounding area it was only about 15 mm (0.6 inch). These humps might have been formed when slight depressions in the snowpack surface collected air and water borne tephra. The thicker blanket of material would have then effectively insulated the snow, causing a much slower melt rate than in the surrounding area.

FIGURE 4 - HUMPS ON SNOWPACK SURFACE

The snow surface at Lone Pine Shelter was very irregular. Although the site is almost completely shaded by a mature Douglas fir stand, the snow appeared somewhat as if sun cupped. Most of the tephra had collected in the low spots. Melt was obviously accelerated at Table Mountain and Surprise Lakes, where there was a light dusting of tephra on the surface and exposure open to solar radiation.

On May 18, the remaining snowpack in the area was destroyed, as it was at Plains of Abraham, or covered with tephra, like that at Lone Pine Shelter. Further observations traced the progress of snowmelt at Lone Pine, with onsite measurements on June 17, July 1 and July 29. The May 18 eruption deposited from 12 to 15 cm (5-6 inches) of mostly coarse grained tephra over the snow pillows. The initial response of the pillow system indicated a weight change of 7.2 cm (2.9 inches) equivalent in water. On May 21, 23, and 25 rainy periods added some moisture to the tephra, and the weight increased another 1 cm (0.4 inch). Snowmelt resumed on May 27 and proceeded very slowly due to the insulating effects of the tephra blanket until about June 16; it then accelerated, and was complete on July 26. (Figure 2).

SNOW PROFILES, MT ST HELENS AREA -1980

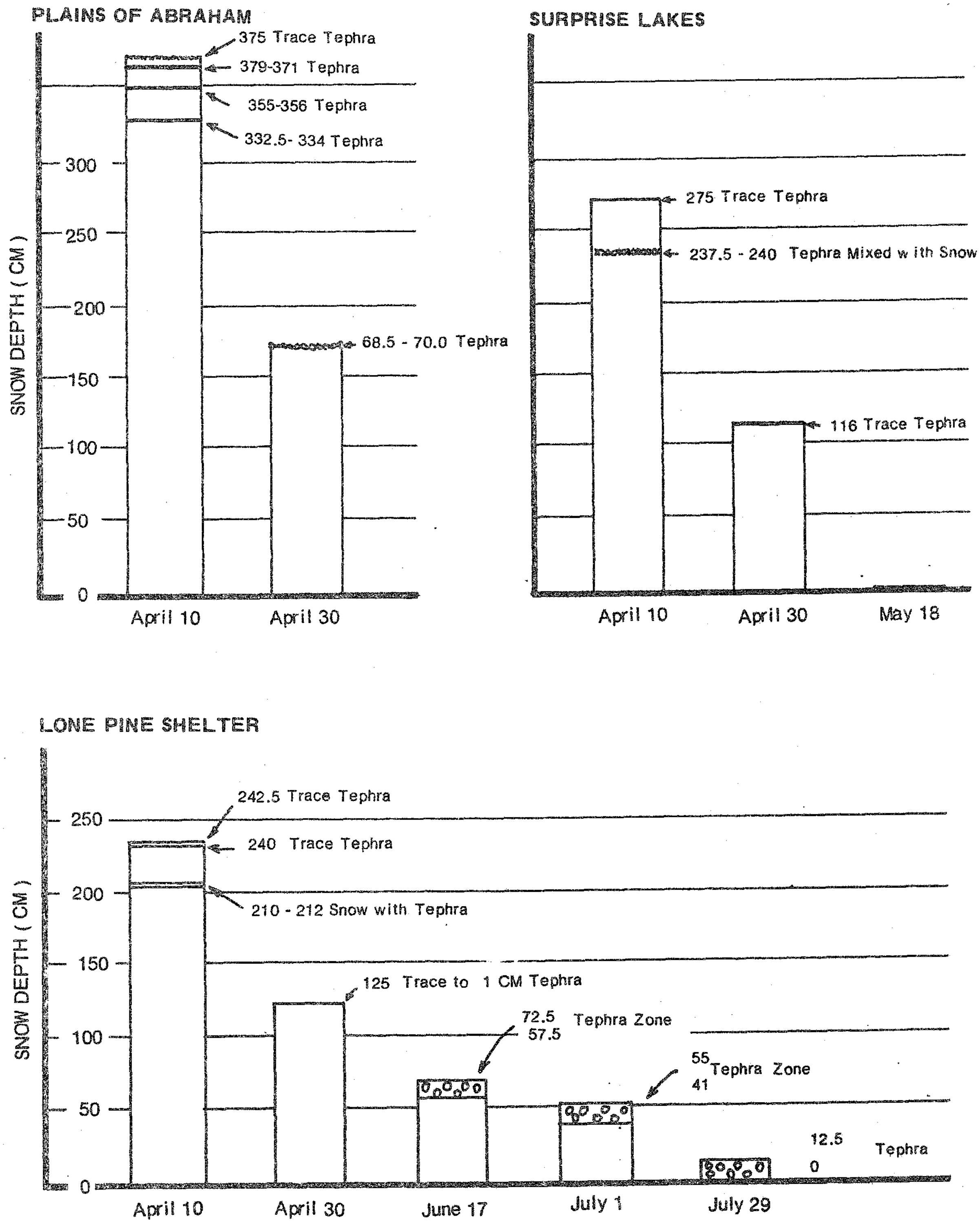


FIGURE 3

Examination of daily snow pillow values shows a nominal melt rate of 15 mm (0.6 inches) per day during the period from April 20 to May 18. From June 16 to July 26 the melt rate was approximately 7 mm (0.28 inches) per day. On July 29 a survey team visiting the site found the snow had totally melted. In an attempt to verify the weight of the tephra one of the four snow pillows was excavated. Whereas the snow sensor registered 8.2 cm (3.3 inches) immediately following the deposition, when the snow had melted the weight was 15 cm (6 inches). With one-fourth of the pillow surface cleaned off, the weight was reduced to 11.25 cm (4.5 inches) or 75 percent of the total weight. The difference in weight may be partially explained by retention of rainfall in the tephra, which was deposited essentially dry.

The 1980-81 winter season was very unusual. Precipitation throughout the fall and winter was below normal. National Weather Service statistics indicate about 85 percent of normal precipitation in the Lewis River Watershed during the October 1, 1980-March 31, 1981 period. The few storms which hit the area were relatively warm. Only small accumulations of snow have collected at the SNOTEL sites, and the pack has been melted by rain and warm temperatures on several occasions. On April 1, 1981, the snowpack at the Plains of Abraham SNOTEL sites contained 20 cm (8 inches) of water equivalent, only 11 percent of the old snow course average. At the new Marble Mountain site the total catch in the precipitation storage gage from October 11, 1980 through March 31, 1981 was 313 cm (125 inches). The Marble Mountain data indicate that previous estimates of average annual precipitation in that locality, extrapolated from nearby lower elevation raingage records, may be 30 to 50 percent low.

The snowpack has been intermittent and discontinuous during this past winter at elevation below 1,200 meters (4000 feet). Therefore, the potential hazard of floods caused by pyroclastic flows onto snowpacks has been minimal. Also, the effects of tephra on the snowpack have been small.

SUMMARY AND CONCLUSIONS

Observations made during snow surveys in the Mt. St. Helens vicinity, indicate that light dustings of tephra reduce the albedo of the snowpack and accelerate melt. Tephra thickness of 2.5 cm (1 inch) retarded melt. The critical thickness, at which melt is inhibited rather than enhanced, was unmeasurable, due in most part to the lack of an unaffected control area. When a thick blanket of tephra, 12-15 cm (5-6 inches), covered an estimated 75 cm (30 inches) deep shaded snowpack, melt rates were reduced by over 50 percent, from 15 mm (0.6 inches) per day down to 7 mm (0.28 inches) per day.

Monitoring the snowpack around the volcano has been intensified to help assess potential hazards from pyroclastic flows and resultant floods, as well as from precipitation caused floods. Three new SNOTEL sites have been installed, and the site destroyed by the May 18, 1980, blast has been reestablished, bringing the Mt. St. Helens vicinity number of active SNOTEL sites to eight. A long term monitoring program is foreseen, based on the volcano's historic patterns of activity. The most recent previous eruptive period lasted from 1840 through 1857, so the potential for eruption affecting the snowpack may exist for as many as 10 to 20 years.

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