WATER, ICE, METEOROLOGICAL, AND SPEED MEASUREMENTS AT SOUTH CASCADE GLACIER, WASHINGTON, 1998 BALANCE YEAR

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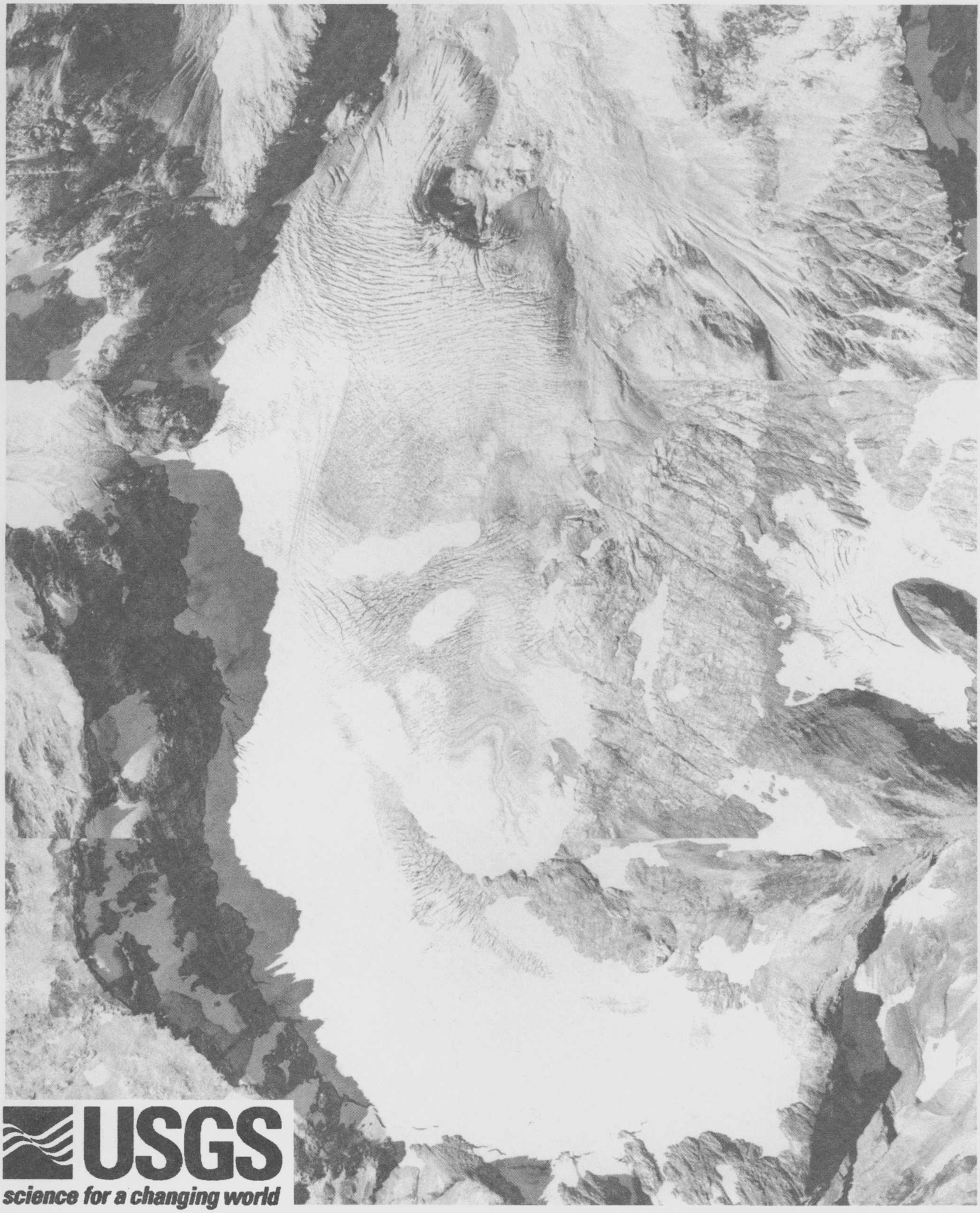

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Cover - South Cascade Glacier, September 14, 1998.

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By Robert M. Krimmel

U.S. GEOLOGICAL SURVEY
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CONVERSION FACTORS, VERTICAL DATUM, SYMBOLS, AND MACHINE-READABLE FILES

Multiply	By	To obtain
degree Celsius (°C)	1.8, then add 32	degree Fahrenheit
kilogram	2.205	pound
kilogram per cubic meter (kg/m^3)	0.06243	pound per cubic foot
kilometer (km)	0.6214	mile
meter (m)	3.281	foot
millimeter (mm)	0.03937	inch
square kilometer (km^2)	0.3861	square mile

Vertical datum:
In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Symbols used in this report:

$\bar{b}_0$	The change in balance between the minimum balance near the beginning of the water year and October 1.
$\bar{b}_1$	The change in balance between the minimum balance near the end of the water year and September 30.
$\bar{b}_a$	The change in snow, firn, and ice storage between the beginning and end of some fixed period, which here is the water year.
$\bar{b}_m(s)$	The snow above the previously formed summer surface as measured directly by field work in late spring as near as possible to the time of greatest glacier mass.
$\bar{b}_n$	The change in snow, firn, and ice storage between times of minimum mass.
q	River discharge.
S	River stage.
X	Approximate east/west position in the local survey net.
Y	Approximate north/south position in the local survey net.
Z	Altitude above NGVD of 1929.

Machine-readable files:
Most of the data contained in this report have been recorded on easily copied computer media. This machine-readable material is available from the World Data Center, Campus Box 449, University of Colorado, Boulder, CO 80309 <URL: http://www-nsidc.colorado.edu/NOAA/>.

WATER, ICE, METEOROLOGICAL, AND SPEED MEASUREMENTS AT SOUTH CASCADE GLACIER, WASHINGTON, 1998 BALANCE YEAR

Robert M. Krimmel

ABSTRACT

Winter snow accumulation and summer snow, firn, and ice melt were measured at South Cascade Glacier, Washington, to determine the winter and net balances for the 1998 balance year. The 1998 winter snow balance, averaged over the glacier, was 2.76 meters, and the net balance was -1.86 meters. Since the winter balance record began in 1959, 22 winters have had a smaller winter snow balance and 17 winters have had a larger winter snow balance. Since the net balance record began in 1953, only 3 years have had a more negative net balance than 1998. Runoff was measured from the glacier and an adjacent non-glacierized basin. Air temperature, precipitation, and humidity were measured nearby, and ice speed was measured. This report makes these data available to the glaciological and climatological community.

INTRODUCTION

The mass balance program at South Cascade Glacier is part of a larger U.S. Geological Survey (USGS) effort to monitor glacier mass balance throughout the Western States. Mass balance at two other glaciers, Gulkana Glacier and Wolverine Glacier, both in Alaska, is also monitored by the USGS (Kennedy, 1995, March, 1998). The broad USGS glacier monitoring program is discussed in a separate document (Fountain and others, 1997), and South Cascade Glacier is considered to be a "benchmark glacier" as described in that document. The collective records from these glaciers have formed the basis for the analysis of glacier-climate relations on a synoptic scale (Hodge and others, 1998).

South Cascade Glacier is a small valley glacier near the crest of the North Cascade Range, Washington State (fig. 1). Numerous variables relating to the glacier regime have been measured on and near South Cascade Glacier since the late 1950's. The long-term goal of this project is to understand the climate-glacier relation. A short-term goal is to document the measurements with sufficient detail so that an internally consistent record of conditions on and around the glacier can be assembled despite personnel changes, discontinuous records, and changing methods of data collection and analysis. Some periods of record at South Cascade Glacier have been documented. Work from 1957-64 is described by Meier and Tangborn (1965), work from 1965-67 is described by Meier and others (1971) and by Tangborn and others (1977). Hydrologic and meteorological data for 1957-67 are presented by Sullivan (1994). Mass balance results for 1958-85 are summarized by Krimmel (1989), and are presented in detail for 1992-97 (Krimmel, 1993, 1994, 1995, 1996a, 1997, 1998). The purpose of this report is to document the measurements of the 1998 balance year that are relevant to the relation between South Cascade Glacier and climate. These measurements include basin runoff, precipitation, air temperature, humidity, snow thickness and density, ice ablation, surface speed, and surface altitude.

Description and Climate of the Area

South Cascade Glacier is located at the head of the South Fork of the Cascade River, a tributary to the Skagit River, which flows into Puget Sound about 100 km to the west. The region is dominated by steep terrain, with local relief of more than 1,000 m. Areas within the basin not covered by glacier ice or water are thinly veneered bedrock. The bedrock either is mantled by a thin layer of soil and, in places, by scrub conifer, heather, or other vegetation typical of the high North Cascade Range, or is covered by glacial moraine or outwash material.

South Cascade Lake Basin has an area[1] of 6.14 km^2, and spans from 1,615 to 2,518 m altitude. A subbasin of the South Cascade Lake Basin is the 4.46-km^2 Middle Tarn Basin[2], which constitutes the southern two-thirds of the South Cascade Lake Basin. Virtually all icemelt[3] within the South Cascade Lake Basin takes place in the Middle Tarn Basin.

Salix Creek Basin (fig. 1) is an unglacierized basin adjacent to the South Cascade Lake Basin. It has an area[4] of 0.22 km^2, spans from 1,587 to 2,140 m altitude, and is predominantly south facing.

The climate of the region is maritime. Near the glacier, typical winter low temperatures are about -10°C, and typical summer high temperatures are about 20°C. Most of the precipitation, which commonly amounts to 4.5 m annually (Meier and others, 1971), falls as snow in the period October to May.

Measurement Systems

Glacier mass balance definitions (Mayo and others, 1972) are adhered to in this report, and the stratigraphic system, which is more field compatible than the fixed date system, is usually used. The specific terms are defined where first used. Other mass balance nomenclatures are in use, notably those described by Østrem and Brugman (1991), which could as well be used to report these results. The definitions by Mayo and others (1972) are used to maintain consistency with earlier reports on South Cascade Glacier work.

The balance year, defined by Mayo and others (1972) as the interval between the minimum glacier mass in one year and the minimum glacier mass the following year, is used in this report because most of the field measurements reference the surface formed at the end of the previous balance year. This report contains recorded data for the 1998 water year (WY), October 1, 1997, through September 30, 1998. The WY is identical to the hydrologic year which was used in earlier mass balance reports (Mayo and others, 1972, Meier and others, 1971). When information concerning these variables is required, but is outside of the WY, the required data are discussed.

---

[1] The area of this basin has been previously reported as 6.02 and 6.11 km^2. These differences are due to different interpretations of the drainage divide.

[2] "Middle Tarn" is an unofficial name.

[3] A small, debris-covered area of perennial ice lies outside of the Middle Tarn Basin.

[4] Salix Creek Basin drainage divides are poorly defined.

All local geodetic coordinates are in meters, in which the local +Y axis is approximately true north. Vertical locations are in meters above the National Geodetic Vertical Datum of 1929. Horizontal locations are defined by a local system that can be converted to Universal Transverse Mercator (UTM) zone 10 coordinates by:

UTM easting = local X (0.99985) + 642,000
UTM northing = local Y (0.99985) + 5,355,000.

Densities are given as a decimal fraction of the density of water, the density of which is considered to be 1,000 kilograms per cubic meter. All balance measurements are given as water equivalents unless otherwise stated.

1998 BALANCE YEAR DATA COLLECTION

Recorded Variables

Air temperature was measured at the Salix Creek gaging station, the South Fork gaging station, the Middle Tarn gaging station, and the Hut (fig. 1). These records are shown graphically (fig. 2). Air temperature was measured instantaneously once per hour at each station. Temperature is estimated to be accurate to ±1°C. Daily maximum (highest of the 24 hourly readings), minimum (lowest of the 24 hourly readings), and average temperatures are given in tables 1-4. Humidity was measured at the South Fork gaging station (fig. 2).

Precipitation was measured at the Salix Creek gaging station (fig. 3). The tipping bucket gage catch was accumulated for 1 hour and recorded digitally. The gage orifice was 200 mm in diameter and had no wind screen. The precipitation gage was sensitive to 0.024 mm of precipitation. The gage operated in October and from early June through October, thus the problems associated with measuring snow precipitation were not encountered.

Salix Creek stage, South Fork Cascade River stage, and Middle Tarn stage were recorded digitally. The sensors are floats with a steel tape driving a potentiometer. Stage records are shown in figure 3. The stage recorders are sensitive to ±3 mm and are estimated to be accurate to ±3 mm.

The well at the Middle Tarn gaging station was frozen from early December until early May, resulting in lost record. The stage record from Salix was unusable in most of October and from November through early June.

Intermittent Measurements

Snow depth and density; snow, firn, and ice ablation; and river discharge measurements are made during site visits several times each the year. Instruments and facilities are serviced during these visits as well.

Snow depth was measured by probing at numerous locations on May 5-6, 1998 (fig. 4, table 5). Snow density was measured in a snow pit near P1 (fig. 1) on May 5, 1998 (table 6). The level of snow on eight, 33-mm-diameter aluminum stakes (fig. 1) with wood bottom plugs was measured several times during the ablation season (table 7, fig. 5).

Aerial photography recorded the condition of the glacier on September 14, 1998 (fig 6). Measurements of the size and shape of the glacier are made from stereo aerial photography. This photography was taken at a scale of 1:12,000 with a cartographic camera on 230-mm-wide color film and is suitable for creating stereo models, four of which cover nearly all the basin. Other aerial or terrestrial photography or satellite imagery may exist in 1998, but no attempt was made to catalogue other sources. An altitude grid (a digital elevation model, DEM) of the glacier was formed by photogrammetric measurement of altitude at a regular 100-m spacing over the area of the glacier. Photogrammetrically determined altitudes are estimated to be accurate to ±2 m, and are shown in figure 7 and table 8. Even though nearly all 1998 snow was melted from the glacier by September 14, 1998, and the surface was firn and ice, it was difficult to measure the altitude in some of the firn areas. The firn was that formed in 1997, 1996, and possibly 1995, had little stereo definition in the photography. As a result the altitude at some of the DEM points could not be measured. At these points the 1997 DEM was substituted. Figure 7 and table 8 indicate which points were used from the 1997 DEM.

The terminus of the glacier (fig. 8) was digitized from the photographs by measuring the locations of numerous points along the edge of the glacier. The location of the points is estimated to be accurate to ±1 m. The area of the glacier near the end of the 1997 balance year was 1.995 km^2 (Krimmel, 1998). Assuming that the area of the glacier south of Y=2,900 m is unchanged since 1997, the area of the glacier near the end of the 1998 balance year was 1.966 km^2. The glacier terminus retreated from its 1997 position almost everywhere. The retreat from 1997-98 was subjectively averaged to be 20 m (fig. 8).

Nearly all 1998 snow had melted from the glacier by September 14, 1998. Most of the bright material visible on the September 14 photographs is snow that fell in 1997 or 1996, and is technically firn. This firn was very difficult to distinguish from the remaining 1998 snow on the photography, so the snow/firn distinction was made on the glacier on September 15. Ablation continued after September 15, and by the end of the ablation season there was no snow on the glacier. The 1998 equilibrium line altitude was above the highest part of the glacier, so the accumulation area ratio was zero.

DATA REDUCTION

Precipitation

A precipitation gage at the Salix Creek gaging station operated from October 1 to early November and from early June to the end of the 1998 WY (fig. 3). Incremental precipitation gage catch was accumulated for each day, and the daily total precipitation is shown graphically in figure 9 and table 9.

The Salix Creek precipitation measurement site is not representative of either basin because of local variations in precipitation, the difficulty of measuring precipitation when the weather is windy, and the difficulty of measuring precipitation that falls as snow. The importance of the record is to compare it with records from other years, to indicate the time of precipitation events, and to indicate general precipitation conditions.

Salix Creek Runoff

Salix Creek stage measurements (fig. 3) are converted to instantaneous discharge values, averaged for each day, and converted to a basin-averaged daily runoff (fig. 9, table 10). The Salix Creek stage recorder failed in early October, restarted in early November, failed in early December, and restarted in early June, resulting in some lost record. The flow of Salix Creek at the gaging station is controlled by a weir supported by bedrock. No visible changes of the control occurred during the year; thus, the rating used to convert stage to discharge was the same as has been used since measurements began in 1960:

$$q = S^{2.57} * 2.71$$

where q is discharge in cubic feet per second and S is stage in feet. The equation for the rating is in English units for the convenience of the author and reader, because the original stage data are in feet and the machine-readable files are in feet. Except in these two instances, stage has been converted to meters.

South Fork Cascade River Runoff

South Fork Cascade River stage measurements (fig. 3) are similarly converted to instantaneous discharge values, averaged for each day, and converted to a basin-averaged daily runoff (fig. 9, table 11). The controlling weir is built on glacial outwash and moraine, and is known to be unstable. Visual inspection of the weir and surrounding foundation and diversion walls indicated that changes were minor from 1996 to 1997. Three discharge measurements made in 1998 indicated that the 1997 rating could be used, but with a minor change at very low stage. The rating used to convert stage to discharge was:

For stage below 0.60 foot:

$$q = 2.47 * (S + 0.4)^{2.50}$$

For stage above 0.60 foot:

$$q = 17.45 - 43.14 * S + 40.94 * S^2 - 0.90 * S^3$$

Because of suspected changes in the weir during the year, errors in the South Fork Cascade River discharge calculations may be ±20 percent of the determined values.

Middle Tarn Runoff

Stage measurements (fig. 3) were converted to discharge, and subsequently to runoff (fig. 9, table 12), using a rating determined from 14 discharge measurements made between September 8, 1992, and September 16, 1994. The outlet from Middle Tarn is a bedrock channel that does not change; therefore, the rating curve is expected to remain stable at Middle Tarn. For stages above 0.35 foot,

$$q = 2.064 - 3.673 * S + 24.770 * S^2,$$

and for a stage of 0.35 foot and below,

$$q = S^{1.809} * 25.123.$$

The Middle Tarn stage recorder failed in early December and was not restarted until early June, resulting in lost record.

MASS BALANCE

Winter Balance

Winter balance was measured May 5-6, 1998. Snow depth was measured by probing to the 1997 summer horizon at 60 points (fig. 4, table 5). The locations of these points were measured with an encrypted GPS (Global Positioning System). Most of the locations are good to ±10 m in horizontal and vertical. The probed snow depths are ±0.05 m. It was not always certain that the probe penetrated through the 1998 snow, or that it stopped at the 1997 summer surface. Several ice layers made probing difficult, and the thick layer of snow that remained after the 1997 balance year may have been penetrated. A vertical core along the wall of a pit dug through the snowpack at the P-1 index station (fig. 1) gave an unambiguous snow depth and indicated that most of the probed depths were to the 1997 summer horizon. Two points near 1,900 m altitude (fig. 10) were suspected of penetrating into 1997 snow.

Snow density was measured at P-1 in a pit (table 6). Total snowpack thickness was 4.43 m, total water equivalent was 2.40 m, for a bulk density of 0.54. A density measurement was also made near the west outlet of South Cascade Lake at the eight-point snow course (Krimmel, 1997). The average snow depth was 1.72 m, the average water equivalent was 0.79 m, for an average density of 0.46. The 1998 glacier snowpack can be characterized as abnormally thin and abnormally dense.

For the purpose of calculating the winter snow balance, the snow density gradient as a function of altitude must be established. Bulk snowpack density is usually a function of both depth and altitude. A thick snowpack is normally more dense than a thin snowpack because it is compressed at depth, and a low-altitude snowpack is normally more dense than a high-altitude snowpack. This is especially true in the North Cascades where winter rain can saturate the snow and increase the speed of metamorphism into more compact grains. In May of 1998, however, the snowpack density at 1,618 m was 0.46, and at 1,842 m was 0.54. These two measurements were used to form a linear function of density with altitude from 1,618 to 1,842 m. Above 1,842 m the density was assumed to be 0.54. Using this distribution of snow density the water equivalent of each probed depth was calculated, and plotted against altitude in figure 10. A hand-drawn curve was used to smooth these data, and from that curve a table of values (table 13) was formed from which the snow water equivalent at each altitude in the 1997 South Cascade Glacier DEM could be interpolated. The average of all the calculated values, 2.70 m, is the measured winter snow balance, $\bar{b}_m(s)$, on May 6, 1998.

The winter season had ended prior to May 5-6 when the balance was measured. Average daily air temperature at the hut was generally above freezing after April 23. The stage of the South Fork Cascade River began rising on April 23. Runoff from the South Fork Cascade River basin was about 60 mm between April 23 and May 5, thus the measured winter snow balance on May 5-6 was adjusted to 2.76 m for the maximum winter balance, $\bar{b}_m(s)$, which occurred near April 23.

Net Balance

Eight stakes were used to measure the melt during the ablation season (fig 1). The aluminum stakes were 33 mm in diameter and 2.0 m long with a coupling on one end to allow joining sections. A wooden plug was always inserted into the bottom of the stake to inhibit melt into the firn or ice. The stakes were set in holes that always penetrated into firn or ice. Stakes 2 and 4 were set on May 5, 1998, and provided an index of ablation rate throughout the ablation season (fig 5, table 7). Other stakes were set as the snowline progressed up glacier. Measurement at each stake on October 19, 1998, after snow that did not melt away had fallen, indicated the minimum balance at each location (table 7). Firn density was estimated at 0.60 if 1 year old, and assumed to be of greater density as it became older. Ice density was assumed to be 0.90. These values are plotted in figure 11, and a line was hand drawn through the points to form the net balance-altitude curve and table (table 14) that is required for the area-averaged glacier net balance, $\bar{b}_n$, grid-index method calculation (Krimmel, 1996b). The 1998 net balance was -1.86 m.

Balance Year to Water Year Adjustments

The final balance increment, $\bar{b}_1$, for the 1997 balance year was estimated at 0.0 m water equivalent (Krimmel, 1998). This value becomes the initial balance increment, $\bar{b}_0$, for the 1998 balance year.

The glacier was visited on October 19, 1998, at which time there was 0.05 m of new snow on the terminus of the glacier, and as much as 0.50 m of new snow on the upper glacier. Precipitation occurred on 12 of the first 17 days of October, and on most of those days the air temperature was near freezing or below, suggesting that most of the precipitation was snow on the glacier. Between storms the air temperature was as high as 12°C from October 5 to 7 and 5°C from October 11 to 12, suggesting that some snow and ice melt occurred in October. Records from all three stage recorders also suggested that melt occurred during October. The glacier probably reached its 1998 minimum mass on October 11 just prior to a storm that deposited snow on the entire glacier. It is estimated that melt from October 1-11, called $\bar{b}_1$, was 0.05 m.

The annual balance, $\bar{b}_a$, is defined by Mayo and others (1972) as the change in snow, firn, and ice storage between the beginning and end of a fixed period, which here is the water year. The measured values of $\bar{b}_0$, $\bar{b}_1$, and $\bar{b}_n$ at South Cascade Glacier for the 1997 balance year can be used to derive the annual balance, $\bar{b}_a$, where $\bar{b}_a = \bar{b}_n + \bar{b}_0 - \bar{b}_1 = -1.81$ m.

Balance Measurement Errors

Errors in glacier balance measurements are difficult to quantify. In prior years of balance measurements at South Cascade Glacier, error values ranging around 0.10 m were placed on the balance values (Meier and others, 1971). In 1965 and 1966, more information was used to derive the balances than in 1992-98. The availability of less information in 1998 would suggest that greater errors should be assigned to the 1998 balance. The relative paucity of data for 1998 is offset somewhat, however, by the experience gained since the mid-1960's, when 20 to 30 ablation stakes were used and it was found that spatial variations in balance were similar from year to year (Meier and Tangborn, 1965). Estimated errors are $\bar{b}_m(s)$, and $\bar{b}_n$, ±0.20 m; $\bar{b}_0$ and $\bar{b}_1$, ±0.05 m; and the calculated error for $\bar{b}_a$ is ±0.21 m. Although other factors that affect the balance, such as internal accumulation of ice, superimposed ice, internal melt, and basal melt, are possible, they are not considered in this report. These unknowns are thought to be small and do not change the error estimations.

GLACIER SURFACE SPEED

Certain features on the glacier surface can survive several years if ablation does not destroy them. The surface exposed in 1998 was, over much of the glacier, that formed in 1995. The years 1996 and 1997 buried and preserved the 1995 surface, but most of the 1996 and 1997 material was melted away in 1998. Thus it was possible to identify the same crevasses on the Sept 14, 1998 and Sept 12, 1995, vertical photography. Photogrammetry was used to find the positions, estimated to be accurate to ±1.0 m, of 66 features on both dates (fig. 12, table 15). Annual horizontal speed (over the 3.006-year period) was calculated from the displacements and is displayed next to the vectors on figure 12.

LONG-TERM BALANCE RECORD

The snow accumulation during the winter of 1997-98 was near normal. Since the winter snow balance record began in 1959, 22 winters have had a smaller winter snow balance and 17 have had a larger winter snow balance (table 16). Average winter snow balance since 1959 is 2.68 m. Net balance, however, was unusually negative: only 3 years have been more negative since the net balance record began in 1953. Average net balance since 1959 (the year in which seasonal balance records began) is -0.54 m. The difference between the winter balance and net balance is the summer balance. The 1998 summer balance was the most negative of any year since the record began (fig. 13). The 1998 summer was unusually hot and dry, resulting in a large mass loss during the summer.

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Tangborn, W.V., Mayo, L.R., Scully, D.R., and Krimmel, R.M., 1977, Combined ice and water balances of Maclure Glacier, California, South Cascade Glacier, Washington, and Wolverine and Gulkana Glaciers, Alaska, 1967 water year: U.S. Geological Survey Professional Paper 715-B, 20 p.

FIGURE 1. South Cascade Glacier and vicinity.

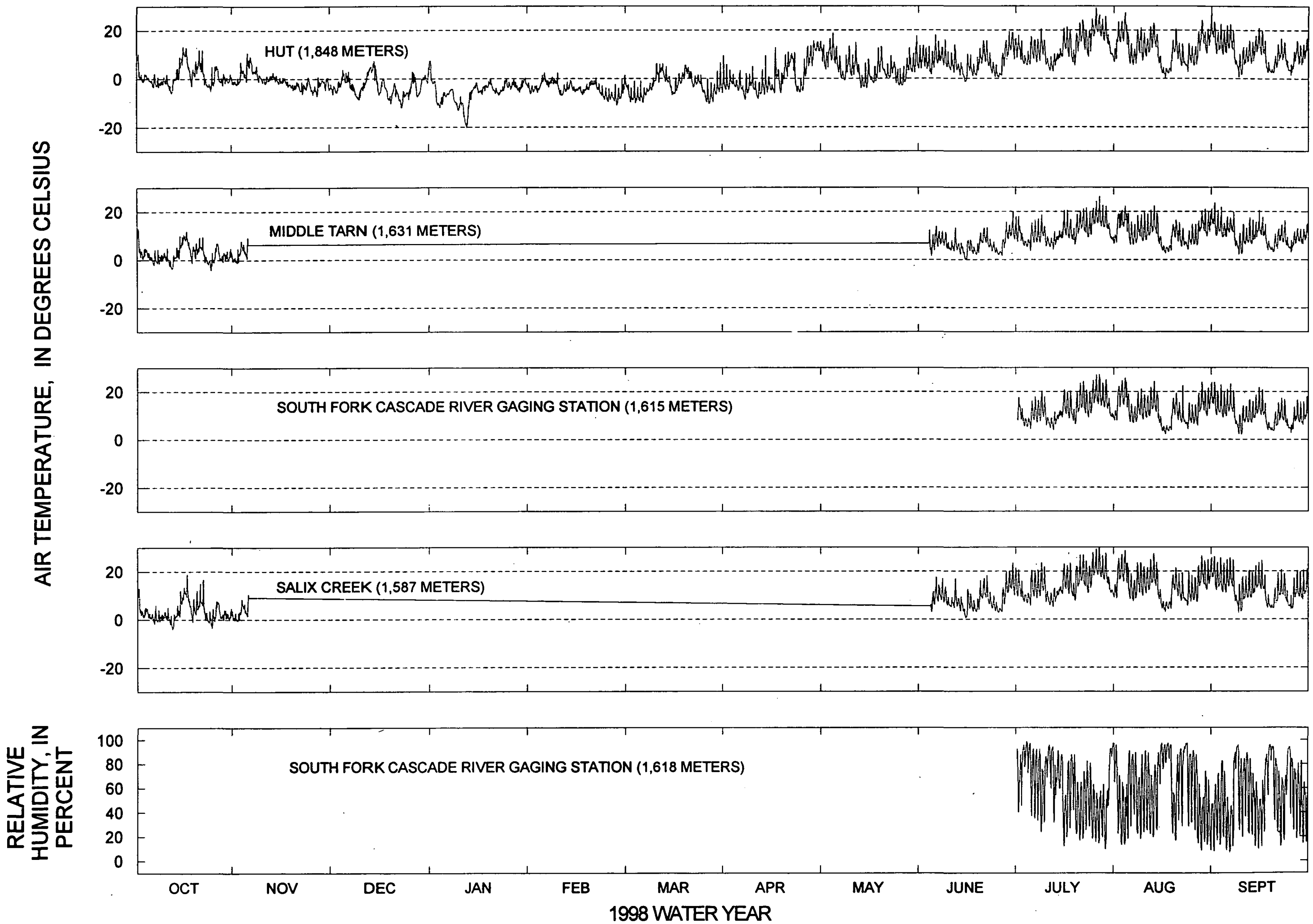

FIGURE 2. Air temperature and humidity near South Cascade Glacier during the 1998 water year.

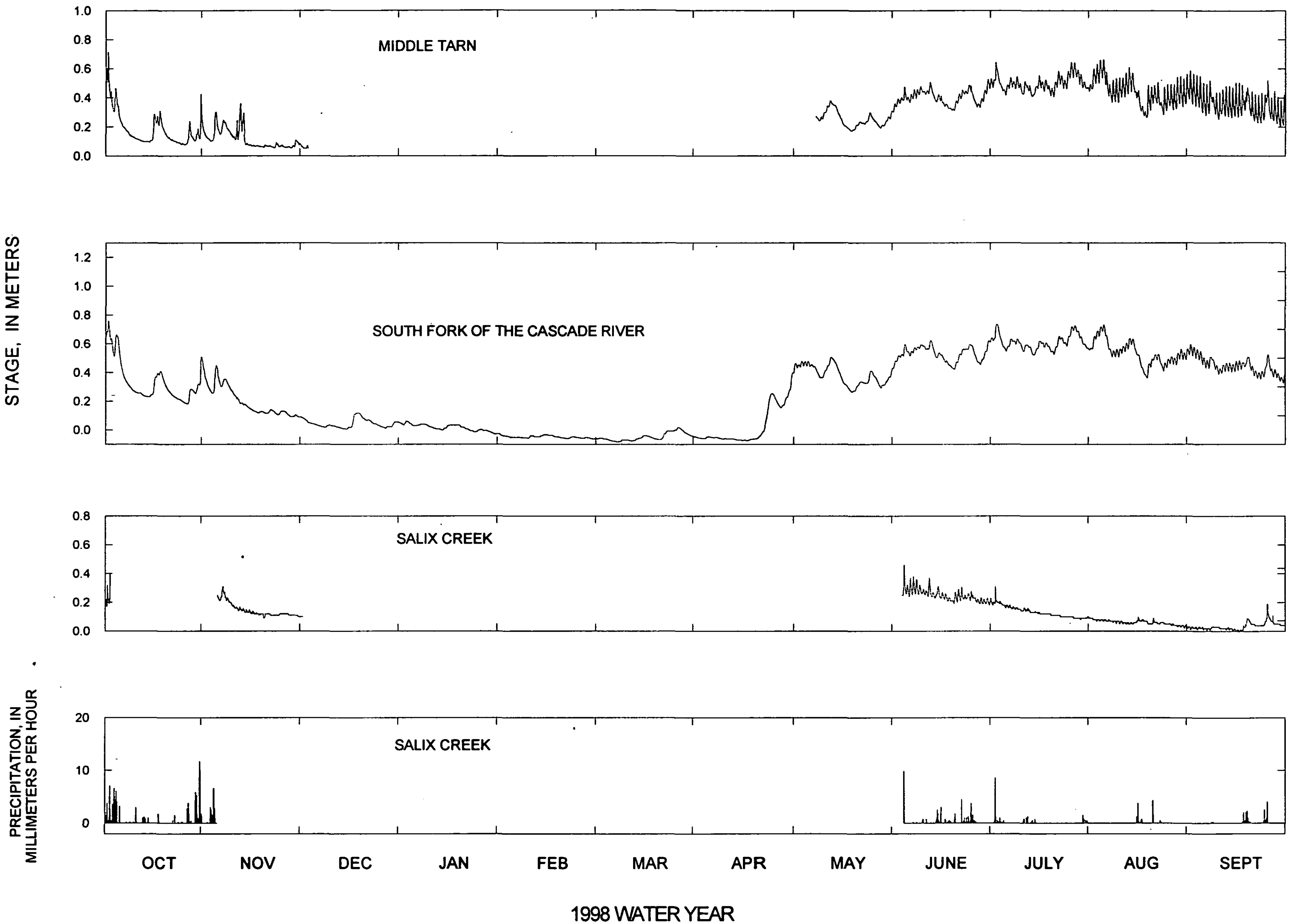

FIGURE 3. Instantaneous water stages and hourly precipitation at gaging stations near South Cascade Glacier during the 1998 water year.

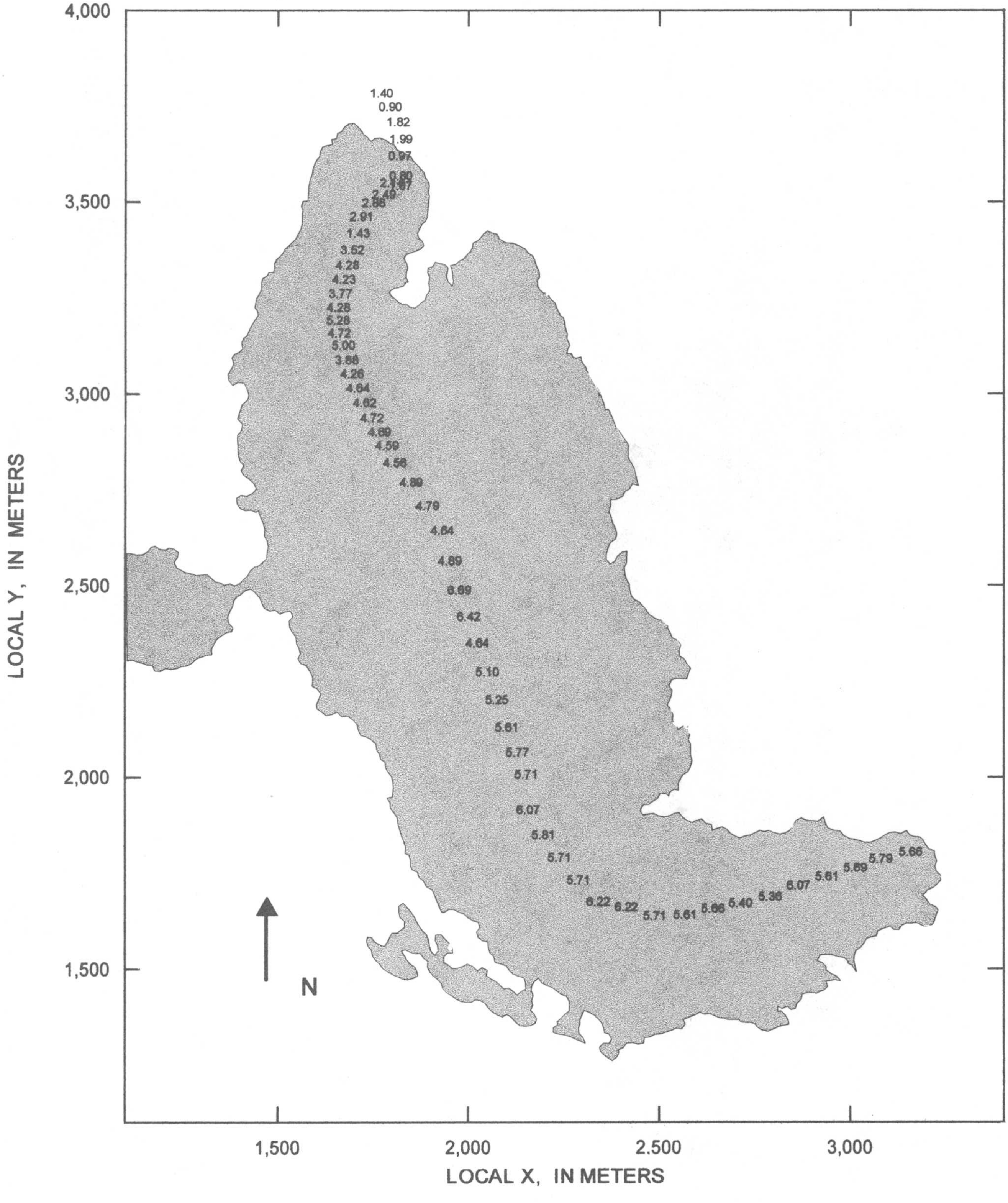

FIGURE 4. Snow depths, in meters, on South Cascade Glacier on May 5-6, 1998. Table 5 gives the locations of the probe points.

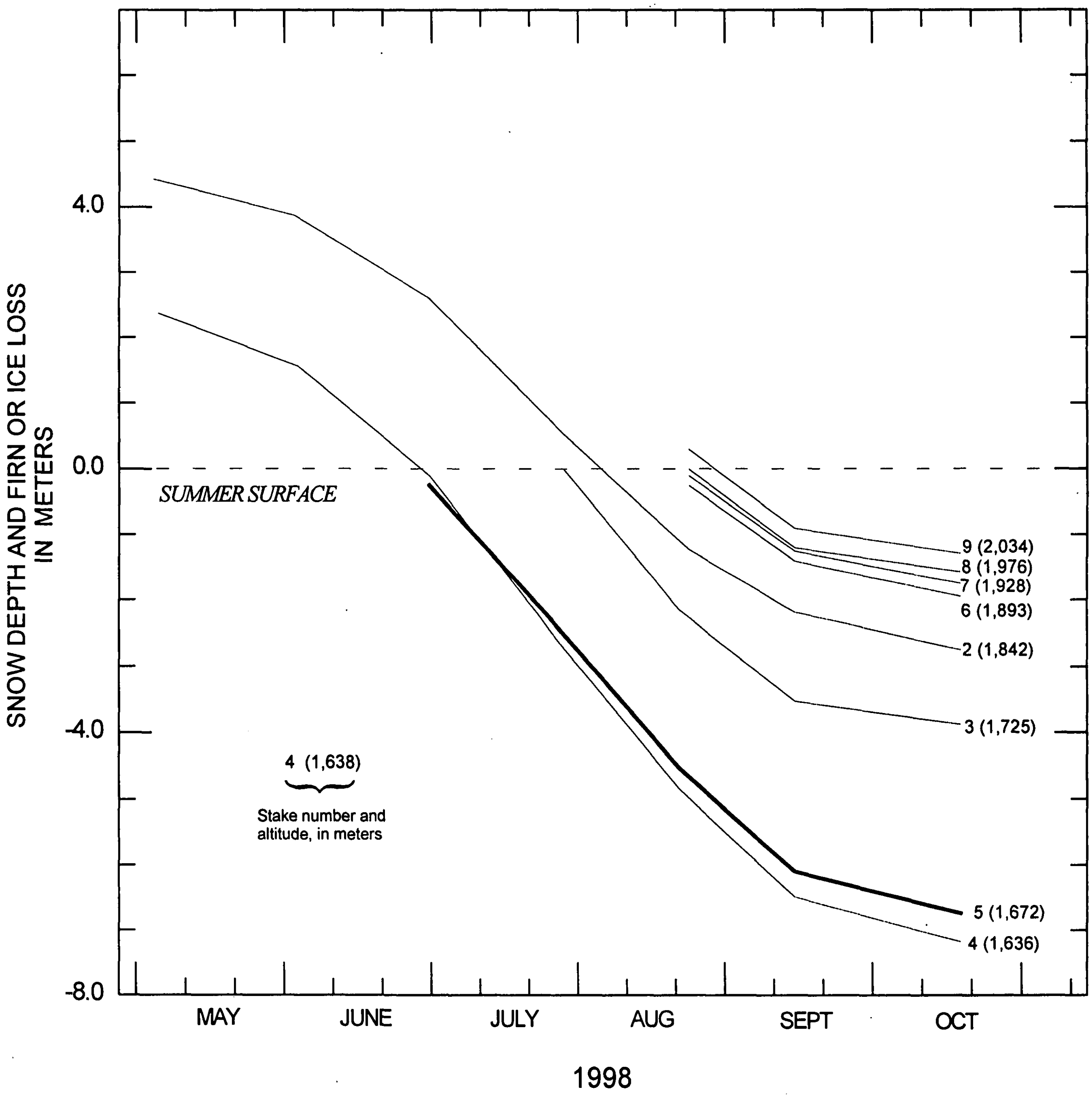

FIGURE 5. Snow depth and firn or ice loss at South Cascade Glacier at each 1998 stake. Measurements are accurate to 0.1 meter. Stake locations shown in figure 1and table 7.

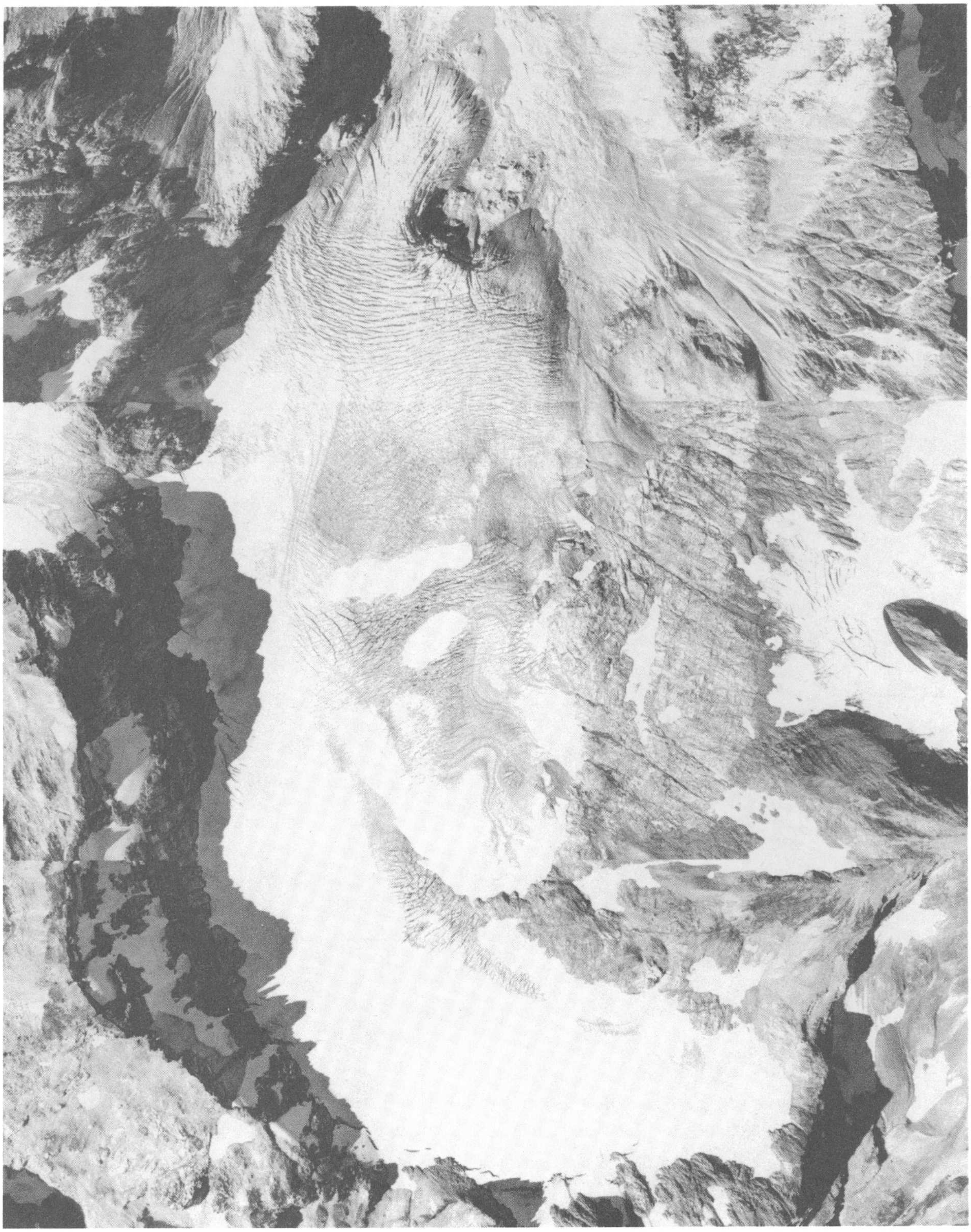

Figure 6. Vertical photograph of South Cascade Glacier, September 14, 1998. The maximum width of the glacier is about 1 km, north is approximately up.

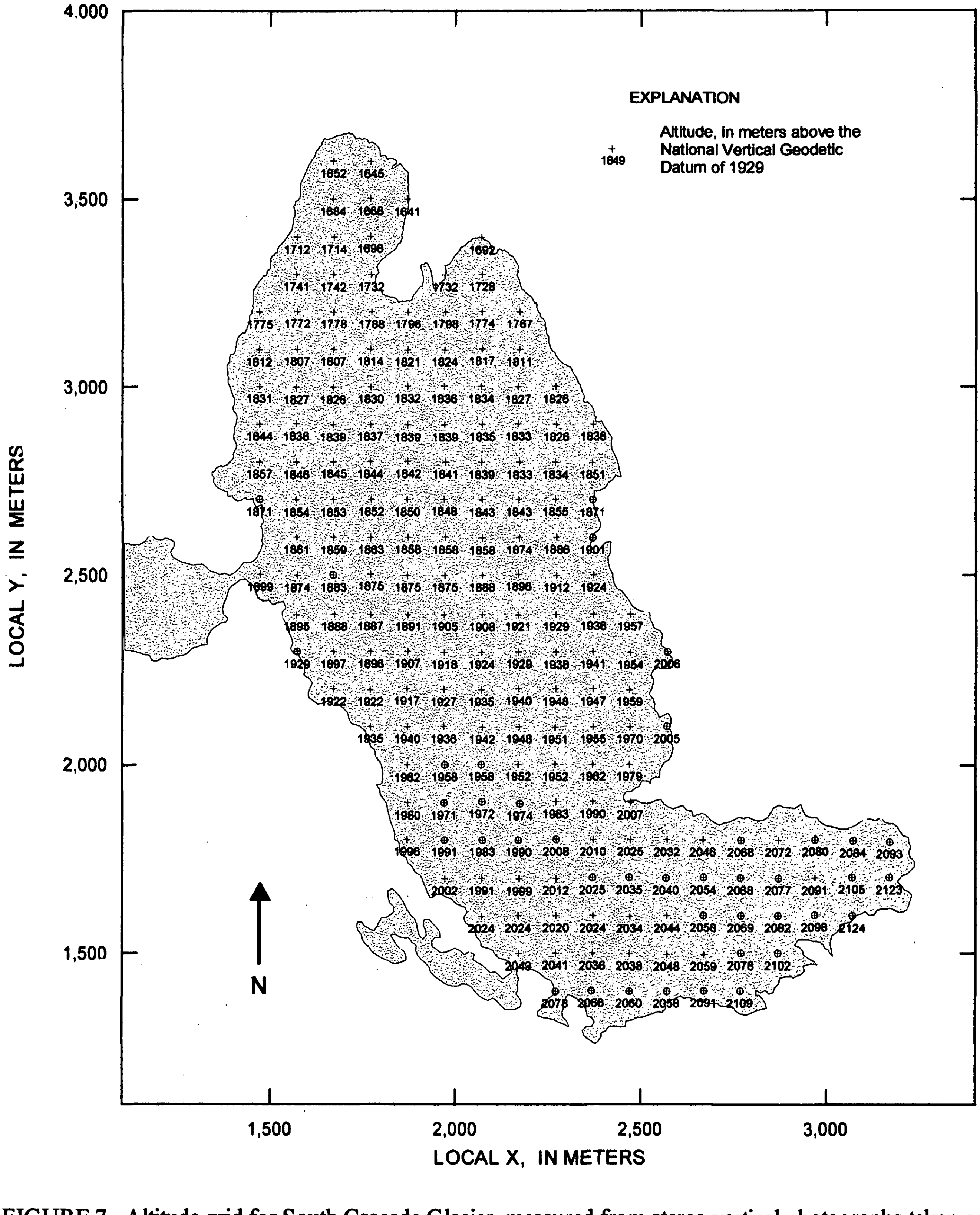

FIGURE 7. Altitude grid for South Cascade Glacier, measured from stereo vertical photographs taken on September 14, 1998. Crosses with circles indicate values from the 1997 grid were used. Tabular data are in table 8.

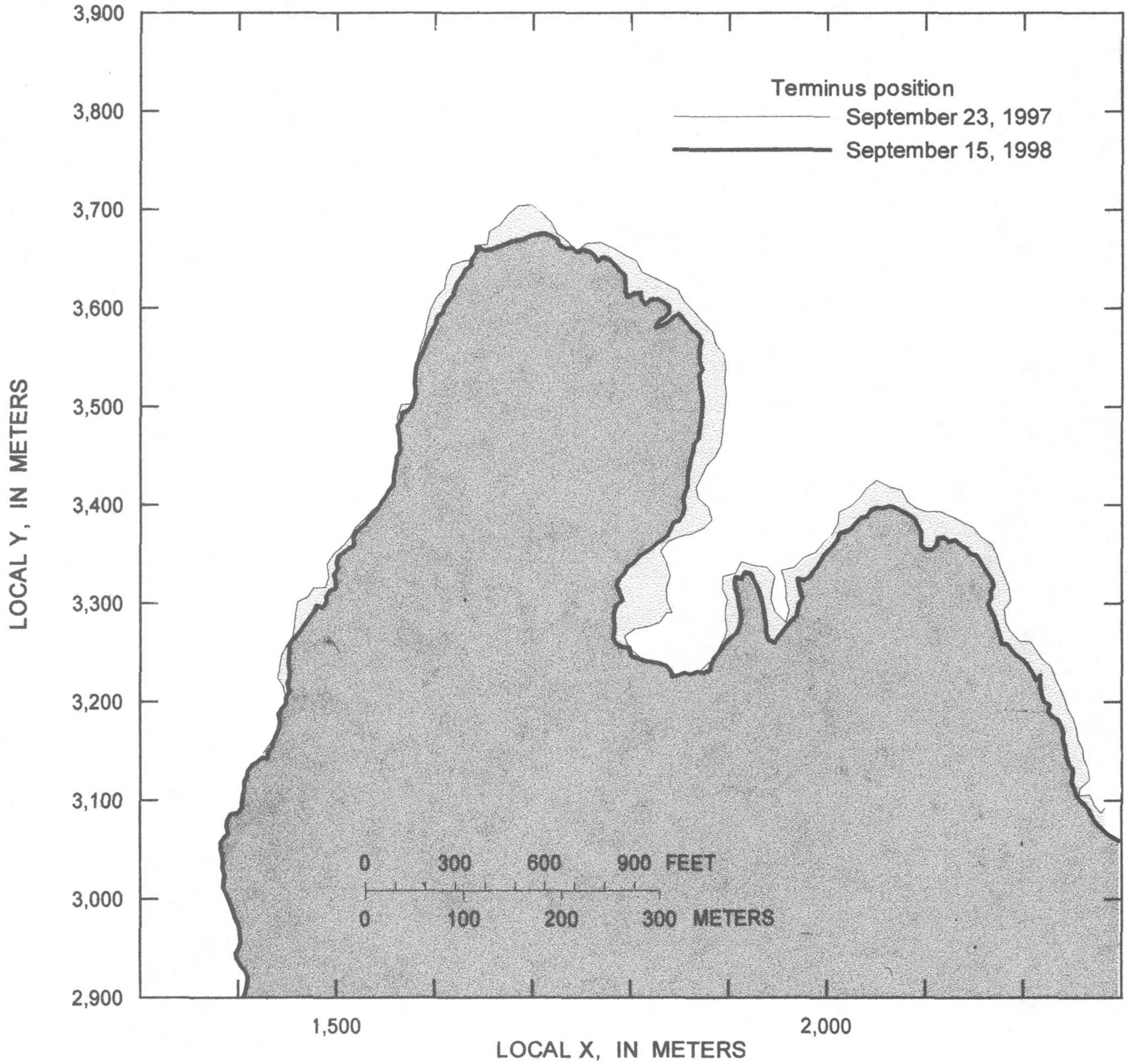

FIGURE 8. South Cascade Glacier terminus positions for September 23, 1997, and September 14, 1998.

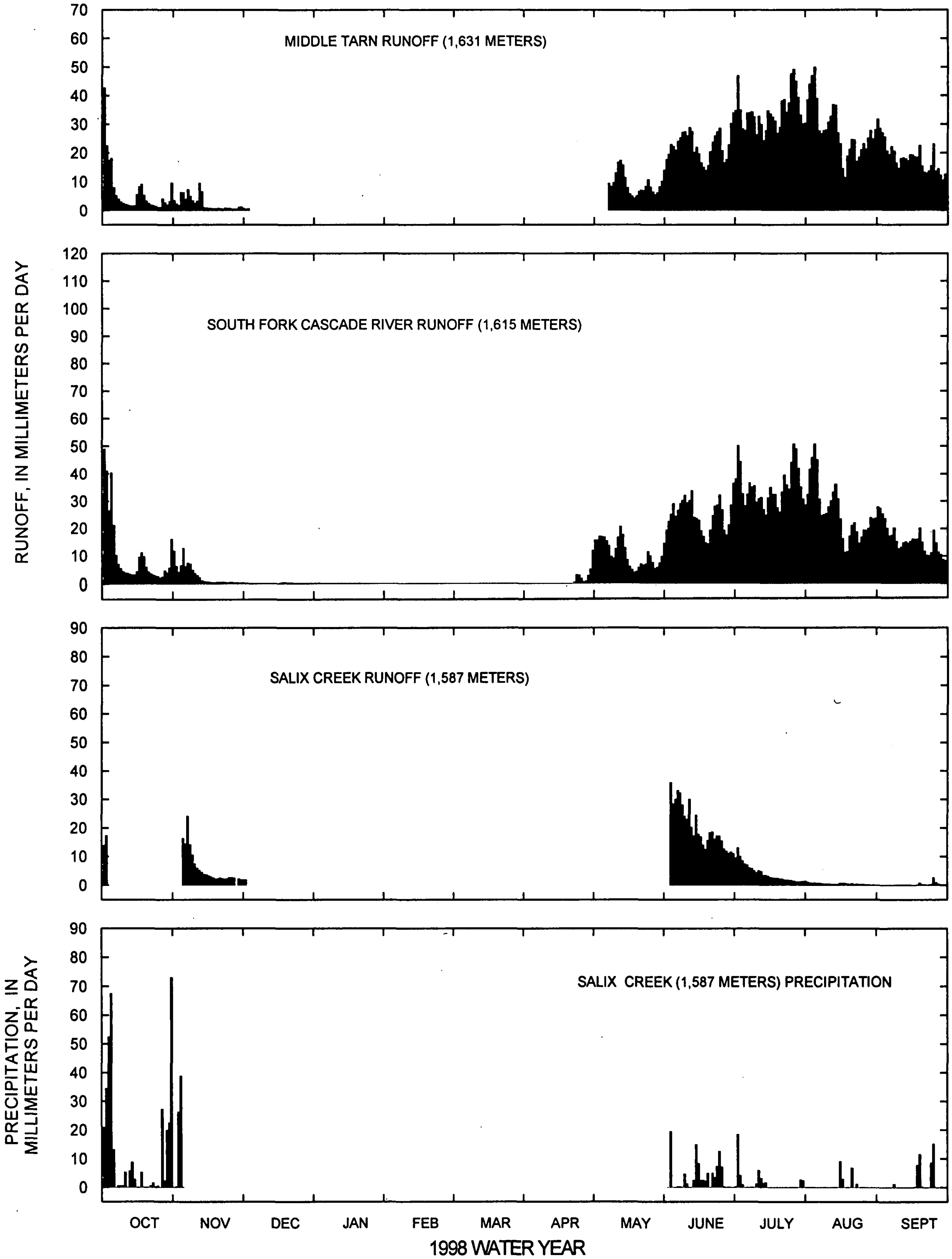

FIGURE 9. Daily runoff and precipitation at gaging stations near South Cascade Glacier during the 1998 water year. Data are missing when no "zero" line is shown.

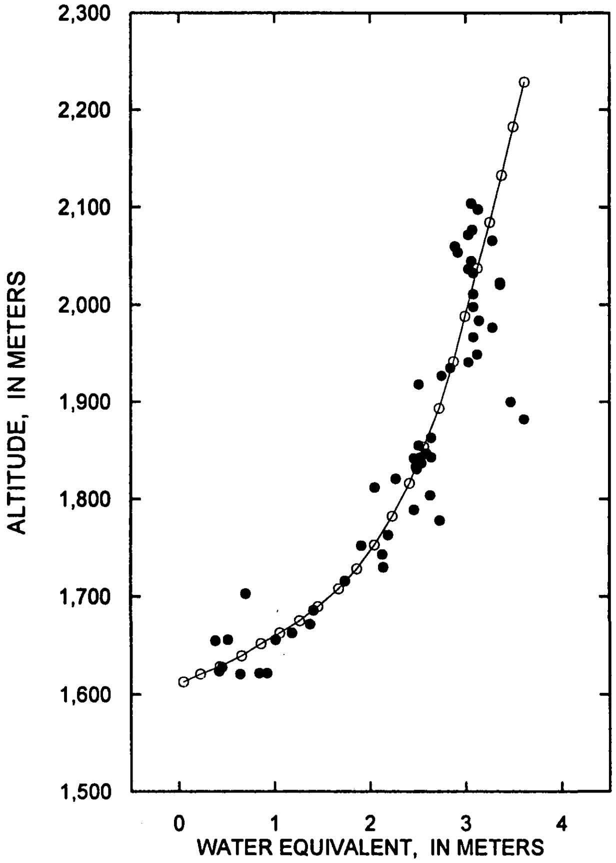

FIGURE 10. Measured winter snow balance at South Cascade Glacier, May 5-6, 1998. Solid circles are measured, open circles are along a hand-drawn curve used for interpolation.

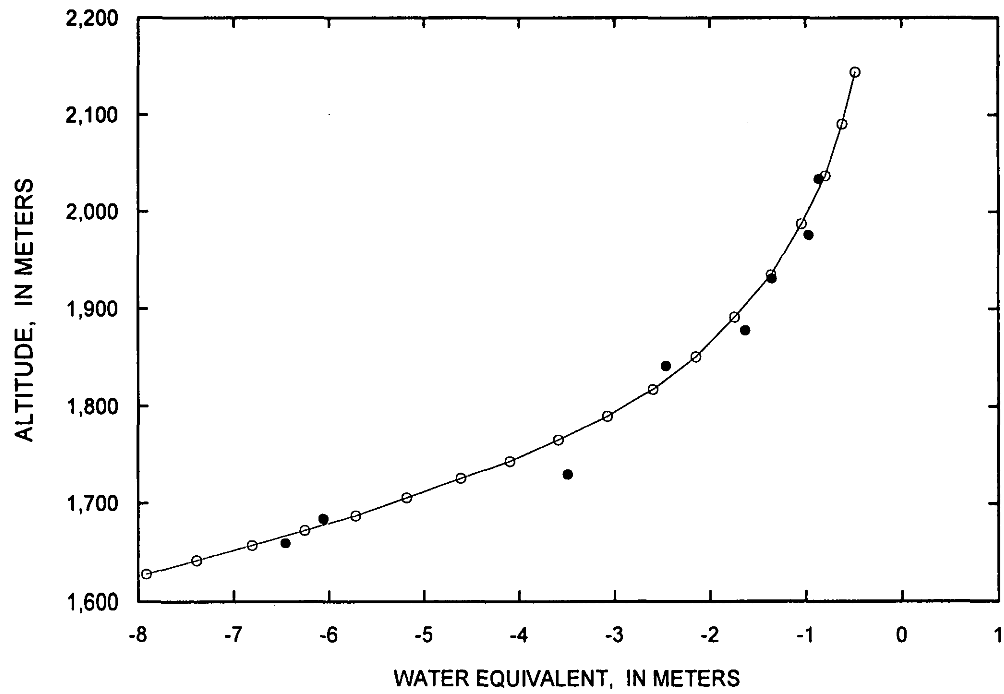

FIGURE 11. Net balance as a function of altitude at South Cascade Glacier, 1998. Solid circles are measured, open circles are along a hand-drawn curve used for interpolation.

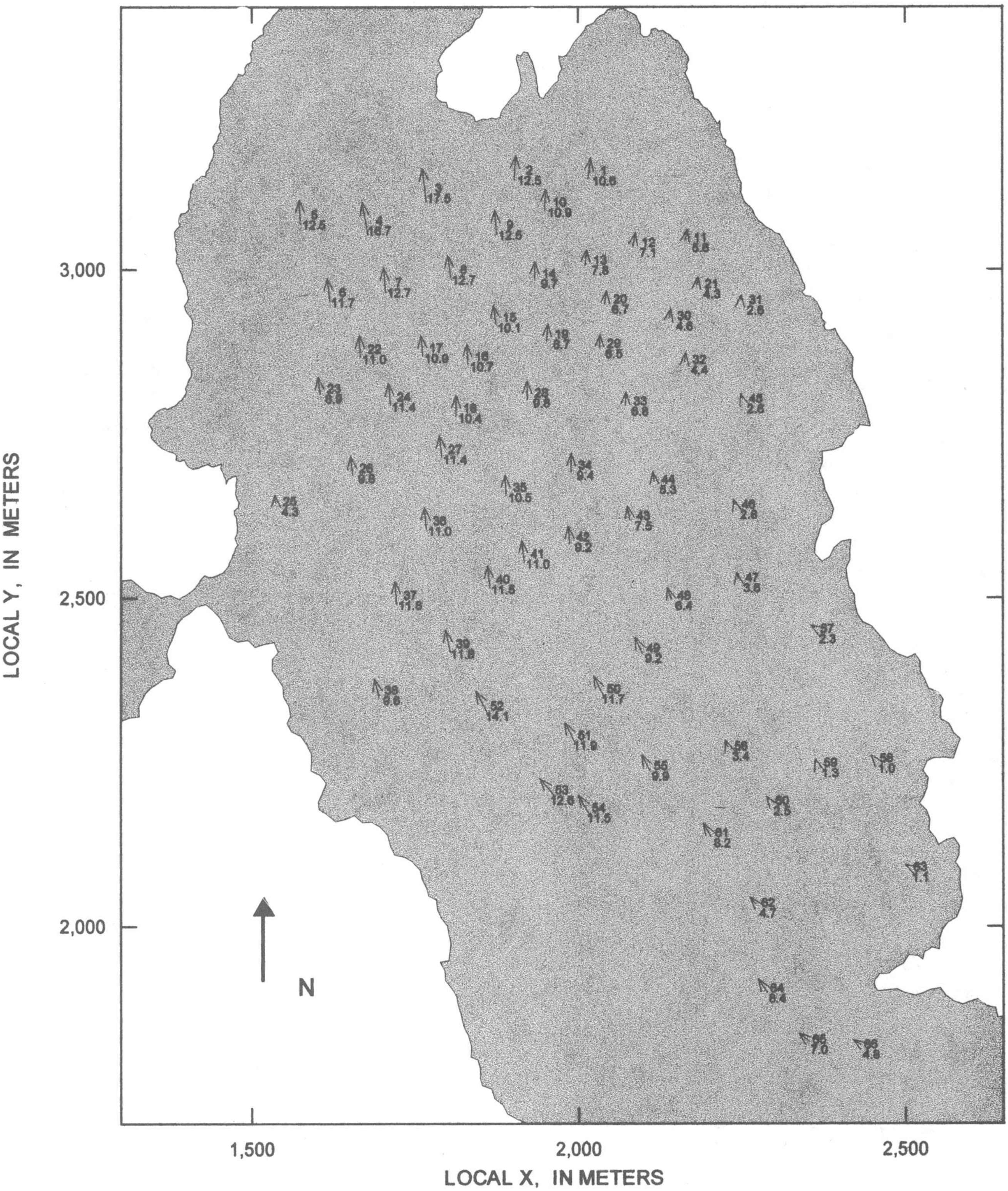

FIGURE 12. South Cascade Glacier surface velocity, measured from vertical photographs taken on September 12, 1995 and September 14, 1998. The vector tail is at the 1995 position and the vector head is at the 1998 position. At each vector the upper number is the feature identifier (Table 15), and the lower number is the horizontal speed in meters per year. The glacier outline is from 1998.

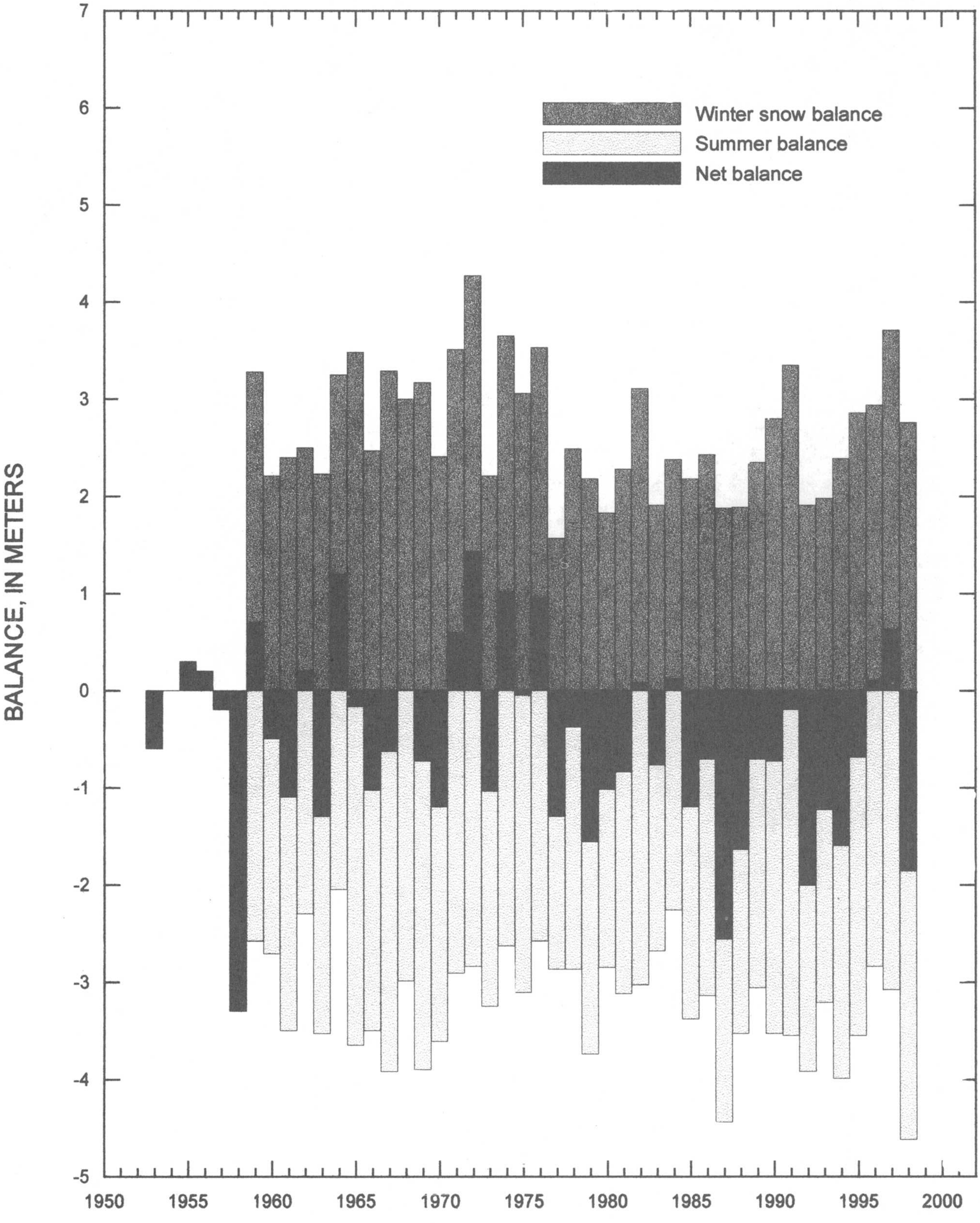

FIGURE 13. South Cascade Glacier balances, 1953-98.

Table 1. Air temperature at 1,587 meters altitude, Salix Creek Basin, 1998 water year

[Daily maximum, minimum, and average air temperature, in degrees Celsius. Air temperature is sampled once an hour at the Salix Creek gaging station (fig. 1). A -99.0 indicates no data]

DAY	Oct.			Nov.			Dec.			Jan.			Feb.			Mar.		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
1	13.1	3.0	8.2	3.2	-0.6	1.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
2	3.7	0.8	2.4	8.4	2.3	5.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
3	5.1	1.4	3.5	6.5	2.6	4.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
4	4.6	0.5	2.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
5	2.5	-0.4	1.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
6	6.2	-1.7	1.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
7	4.1	-0.8	0.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
8	2.3	0.2	1.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
9	3.4	0.3	1.7	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
10	5.1	-0.2	1.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
11	1.8	-4.0	-1.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
12	2.3	-3.4	-0.4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
13	6.0	1.3	2.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
14	12.1	1.2	6.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
15	13.6	7.5	10.4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
16	18.9	7.9	11.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
17	9.0	1.8	5.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
18	8.7	-1.0	3.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
19	12.2	2.0	5.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
20	15.0	4.9	8.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
21	16.7	2.9	7.9	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
22	3.0	-0.6	1.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
23	3.5	-2.1	-0.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
24	4.6	-3.5	0.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
25	7.7	-0.7	3.9	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
26	7.2	0.8	4.4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
27	2.3	0.0	1.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
28	4.0	0.5	2.4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
29	2.6	0.4	1.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0				-99.0	-99.0	-99.0
30	4.7	-0.1	2.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0				-99.0	-99.0	-99.0
31	2.7	-0.2	0.7				-99.0	-99.0	-99.0	-99.0	-99.0	-99.0				-99.0	-99.0	-99.0
MONTHLY AVERAGE			3.2			--			--			--			--			--

DAY	Apr.			May			June			July			Aug.			Sept.		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	21.4	9.8	14.9	14.4	8.7	11.2	26.1	14.3	20.6
2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	20.7	9.4	14.2	25.4	9.0	18.7	23.8	12.1	17.0
3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	15.9	8.0	11.0	26.9	16.7	20.9	25.6	12.1	17.7
4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	10.2	7.1	8.6	28.7	15.7	22.1	23.3	11.2	15.7
5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	11.4	2.9	7.0	10.9	6.6	8.6	23.3	10.7	18.2	24.8	11.0	17.1
6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	17.5	5.9	11.0	20.5	5.5	13.3	19.0	8.4	12.8	25.7	13.6	18.6
7	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	14.2	7.3	10.3	20.2	9.4	14.3	16.1	7.5	11.6	24.7	10.5	16.7
8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	17.0	8.0	10.9	20.6	8.7	13.6	23.6	8.8	15.9	10.1	6.4	8.2
9	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	13.5	6.5	9.9	23.6	9.5	16.0	23.5	11.1	16.9	14.6	2.6	8.1
10	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	9.1	5.6	6.7	21.9	9.8	14.1	21.9	9.8	15.8	17.8	3.2	9.9
11	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	9.1	5.2	6.6	11.7	7.1	9.0	21.5	10.7	15.6	17.9	8.5	11.6
12	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	16.9	4.7	9.6	11.2	5.9	7.8	24.9	12.1	17.6	20.4	8.9	13.1
13	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	8.7	5.3	6.8	13.1	5.1	9.0	27.4	15.1	19.7	19.5	8.9	13.1
14	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	9.5	3.4	6.1	11.8	7.9	10.1	23.7	10.2	16.9	22.3	11.2	15.4
15	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	4.5	0.5	2.5	13.7	10.8	12.1	12.4	6.1	9.5	23.7	13.5	17.2
16	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	12.5	0.9	6.5	23.3	10.5	16.9	7.3	4.2	5.4	24.6	12.4	16.5
17	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	10.5	4.5	6.6	22.5	12.0	16.9	7.1	3.0	5.1	18.4	7.4	12.1
18	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	7.8	3.3	4.7	23.5	10.5	16.1	7.2	4.3	5.7	10.3	4.6	6.5
19	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	8.5	3.0	5.0	15.0	8.7	11.4	18.5	4.3	13.2	5.9	4.6	5.1
20	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	16.2	4.2	9.9	22.1	7.7	15.8	21.4	12.0	15.6	13.0	4.6	8.3
21	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	17.0	8.6	12.3	26.7	14.0	18.9	19.0	9.5	12.8	19.4	7.5	11.8
22	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	18.2	7.5	11.5	26.8	15.1	20.0	19.3	7.6	11.6	20.7	10.0	13.3
23	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	11.3	5.5	7.6	24.2	12.0	17.7	8.9	7.6	8.1	19.0	8.8	12.9
24	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	9.8	4.5	6.2	22.2	11.0	16.3	19.6	5.5	11.5	11.9	5.4	7.7
25	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	7.1	3.2	4.7	27.9	13.4	20.7	18.3	7.2	11.6	9.9	4.2	5.9
26	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	4.5	2.7	3.6	29.2	18.6	22.8	17.4	7.8	11.6	17.2	4.3	10.0
27	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	13.2	2.9	8.2	30.4	18.5	23.2	22.3	7.2	14.5	20.3	9.7	13.5
28	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	19.7	6.2	13.0	26.6	17.4	20.6	26.4	14.0	19.4	19.8	9.0	12.6
29	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	19.9	11.1	14.4	27.6	16.4	20.9	24.4	13.2	18.1	20.5	8.1	12.6
30	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	23.5	12.6	16.7	17.7	12.0	15.5	24.8	12.1	16.9	21.0	11.0	14.2
31				-99.0	-99.0	-99.0				12.2	10.5	11.5	25.7	15.7	20.2			
MONTHLY AVERAGE			--			--			--			14.9			14.3			12.8

TABLE 2. Air temperature at 1,615 meters altitude, South Cascade Glacier Basin, 1998 water year

[Daily maximum, minimum, and average air temperature, in degrees Celsius. Air temperature is sampled once an hour at the South Fork Cascade River gaging station (fig. 1). A -99.0 indicates no data]

DAY	Oct.			Nov.			Dec.			Jan.			Feb.			Mar.			Apr.			May			June			July			Aug.			Sept.		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	12.0	8.1	9.7	24.0	12.4	18.4
2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	17.7	8.1	12.8	22.2	8.1	16.7	20.1	10.2	14.4
3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	13.1	7.3	10.0	24.7	13.4	19.0	22.9	11.0	15.4
4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	8.8	5.5	7.1	25.7	14.5	19.6	20.1	9.2	13.4
5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	9.2	5.1	7.0	24.0	9.9	16.7	21.1	9.9	14.5
6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	16.3	4.3	10.7	14.9	7.3	10.7	23.2	11.7	15.9
7	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	18.0	8.1	11.8	13.8	7.0	9.7	20.5	9.2	14.3
8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	16.3	7.0	11.3	19.8	7.3	13.2	9.5	5.5	7.0
9	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	20.5	7.7	13.4	21.1	9.9	14.6	10.2	2.4	6.0
10	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	18.0	9.2	12.2	18.7	8.4	13.1	14.1	2.0	8.0
11	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	9.2	5.8	7.8	18.4	9.2	13.3	13.8	7.0	9.9
12	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	9.2	4.7	6.8	21.8	9.9	15.0	16.6	7.3	11.0
13	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	11.7	3.9	7.3	24.3	12.7	17.2	15.9	7.0	10.8
14	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	10.2	6.6	8.9	19.8	8.8	14.9	18.7	9.2	12.8
15	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	12.0	9.5	11.0	10.2	5.5	8.1	21.8	11.0	15.2
16	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	20.8	9.2	15.1	5.5	3.6	4.3	20.8	10.2	14.0
17	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	19.8	10.6	14.6	5.8	2.4	3.9	15.2	6.6	10.5
18	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	20.5	8.8	13.8	5.5	3.6	4.6	7.3	3.9	5.6
19	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	12.7	7.7	9.9	17.3	3.9	12.1	5.1	3.9	4.2
20	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	19.8	6.6	12.9	19.4	10.2	14.0	11.7	3.6	7.0
21	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	23.6	11.3	16.4	15.6	8.1	11.2	15.6	5.8	9.6
22	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	24.3	13.1	17.5	22.5	7.0	10.4	17.3	8.4	12.0
23	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	20.8	11.0	15.4	8.1	6.6	7.1	17.0	7.3	11.1
24	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	19.8	9.2	13.8	15.2	4.3	9.3	8.8	4.7	6.6
25	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	24.7	11.0	17.8	14.5	7.0	9.9	6.2	2.8	4.8
26	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	27.2	15.9	20.5	14.5	6.6	9.7	13.8	4.3	8.6
27	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	27.2	14.9	20.3	19.4	5.8	12.4	16.6	8.4	11.3
28	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	23.6	14.1	18.0	24.0	12.0	16.9	15.9	7.0	10.0
29	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0				-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	25.0	13.4	18.2	20.5	11.0	15.5	15.9	6.2	10.0
30	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0				-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	17.3	10.6	14.0	21.5	9.9	14.6	18.0	9.2	12.3
31	-99.0	-99.0	-99.0				-99.0	-99.0	-99.0	-99.0	-99.0	-99.0				-99.0	-99.0	-99.0				-99.0	-99.0	-99.0				11.0	9.2	10.0	24.0	13.1	18.3			
MONTHLY AVERAGE			–			–			–			–			–			–			–			–			–			–			12.4			10.8

Table 3. Air temperature at 1,631 meters altitude, South Cascade Glacier Basin, 1998 water year

[Daily maximum, minimum, and average air temperature, in degrees Celsius. Air temperature is sampled once every hour at Middle Tarn gaging station (fig. 1). A -99.0 indicates no data]

DAY	Oct.			Nov.			Dec.			Jan.			Feb.			Mar.		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
1	13.1	2.9	8.0	4.7	-1.3	0.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
2	3.8	0.5	2.2	7.9	2.1	4.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
3	5.0	1.6	3.4	6.6	2.3	4.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
4	4.3	0.2	2.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
5	1.5	-1.2	0.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
6	4.4	-2.1	0.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
7	4.6	-1.4	0.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
8	2.4	-0.3	0.7	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
9	3.3	0.3	1.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
10	5.0	-0.4	0.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
11	-0.4	-3.7	-2.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
12	2.3	-3.5	-0.7	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
13	5.4	1.0	2.3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
14	10.1	0.7	5.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
15	10.7	6.1	8.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
16	12.0	7.2	9.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
17	7.6	1.4	4.9	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
18	5.9	-1.4	3.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
19	7.1	0.7	3.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
20	9.4	3.3	5.7	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
21	9.7	2.1	5.4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
22	2.3	-1.0	0.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
23	0.1	-3.0	-1.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
24	3.2	-4.2	-0.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
25	7.0	-1.1	2.9	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
26	6.9	0.4	4.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
27	1.8	-0.8	0.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
28	3.3	0.0	2.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
29	3.9	-0.1	1.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0				-99.0	-99.0	-99.0
30	5.0	-0.6	2.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0				-99.0	-99.0	-99.0
31	1.1	-0.7	0.2				-99.0	-99.0	-99.0	-99.0	-99.0	-99.0				-99.0	-99.0	-99.0
MONTHLY AVERAGE			2.5			--			--			--			--			--

DAY	Apr.			May			June			July			Aug.			Sept.		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	18.0	8.4	11.9	10.3	6.7	8.3	23.7	11.2	17.2
2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	18.1	7.4	12.1	19.1	8.2	15.5	20.6	9.8	13.5
3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	11.3	6.3	9.2	20.5	13.4	17.1	21.9	9.4	14.2
4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	7.7	5.7	6.6	22.3	13.8	17.6	15.1	9.4	11.8
5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	10.3	1.5	5.5	8.3	5.2	6.8	19.2	9.9	15.4	17.8	9.5	12.9
6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	13.9	3.9	8.8	15.4	3.6	9.9	15.7	6.2	10.0	17.4	11.3	14.1
7	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	11.6	5.4	8.5	16.6	7.1	10.7	14.6	6.2	9.6	19.8	8.1	13.7
8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	11.8	6.3	8.5	17.0	7.2	10.5	18.4	6.8	11.9	9.0	5.2	6.6
9	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	11.4	4.8	8.0	18.6	6.9	12.1	18.7	8.1	13.0	11.0	2.1	6.1
10	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	7.2	4.4	5.3	13.9	7.8	11.0	19.6	7.8	12.3	14.7	2.4	7.9
11	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	8.1	3.7	5.3	9.6	5.5	7.5	19.0	8.1	12.4	13.1	6.3	8.8
12	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	13.3	3.5	7.4	9.0	5.2	6.8	20.7	10.0	13.8	17.4	7.0	10.5
13	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	6.7	3.5	5.3	11.9	4.2	7.5	22.3	11.5	15.5	16.5	6.5	10.4
14	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	6.9	2.2	4.6	9.8	6.4	8.5	19.5	7.6	14.4	15.7	8.7	11.5
15	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	4.0	0.1	1.8	12.0	8.8	10.4	9.7	5.2	7.8	20.6	11.4	13.7
16	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	8.1	0.2	4.4	20.5	9.0	13.8	5.8	3.5	4.5	17.8	9.8	12.6
17	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	8.2	3.5	5.3	20.5	9.8	13.7	5.3	2.7	4.1	14.7	6.8	10.1
18	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	5.3	2.5	3.6	16.7	8.9	12.4	5.8	3.2	4.6	7.8	4.0	5.7
19	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	6.7	2.1	3.7	13.0	6.3	9.7	14.7	3.8	11.6	5.3	3.4	4.4
20	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	11.3	4.2	8.1	18.9	6.4	12.1	16.5	9.3	12.3	10.8	3.3	6.6
21	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	13.3	6.9	9.7	20.2	10.7	15.1	15.5	7.3	10.3	12.8	4.6	8.6
22	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	13.3	6.1	8.9	21.1	12.3	15.9	13.1	5.4	8.5	14.5	7.8	10.4
23	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	8.5	4.9	6.1	21.6	10.7	14.5	7.5	5.6	6.7	16.4	7.0	10.4
24	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	7.5	3.5	5.2	19.7	9.3	12.7	12.0	4.2	8.0	9.5	5.0	6.5
25	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	5.0	2.5	3.6	21.3	10.3	16.4	14.8	6.2	9.6	8.1	3.1	5.3
26	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	3.3	2.0	2.7	24.3	15.1	18.6	14.7	6.2	9.3	11.8	5.2	8.1
27	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	8.5	1.6	5.4	26.4	15.1	18.8	16.1	6.0	11.0	13.1	7.0	10.0
28	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	15.7	4.9	9.8	22.6	13.4	16.6	20.4	11.9	15.4	12.9	6.8	9.2
29	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	14.5	8.5	11.3	22.2	13.4	16.6	21.0	10.8	14.9	12.8	6.5	9.3
30	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	19.7	10.1	13.2	15.1	9.8	13.0	19.7	9.7	13.4	15.0	8.4	11.1
31				-99.0	-99.0	-99.0				9.5	7.8	8.8	21.1	11.6	17.1			
MONTHLY AVERAGE			--			--			--			12.0			11.3			10.0

Table 4. Air temperature at 1,848 meters altitude, South Cascade Glacier Basin, 1998 water year

[Daily maximum, minimum, and average air temperature, in degrees Celsius. Air temperature is sampled once an hour at the Hut (fig. 1)]

DAY	Oct.			Nov.			Dec.			Jan.			Feb.			Mar.		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
1	10.3	0.4	5.3	0.3	-2.5	-1.5	-2.7	-6.4	-4.4	-1.0	-9.8	-3.2	-3.0	-5.7	-4.2	1.4	-4.5	-1.9
2	2.0	-1.3	0.1	7.0	-1.1	2.3	-1.0	-5.8	-4.5	-9.9	-12.0	-10.8	-2.9	-5.9	-4.5	-2.5	-7.6	-4.5
3	2.0	-1.3	0.7	3.7	0.6	2.2	-0.8	-3.3	-2.1	-7.6	-11.9	-9.8	1.4	-3.5	-1.7	-3.7	-9.7	-7.6
4	1.6	-0.8	0.2	10.8	-1.2	5.0	3.9	-1.2	1.2	-5.5	-7.6	-6.6	2.5	-1.3	0.1	-0.9	-10.2	-7.0
5	-0.6	-3.0	-1.3	9.2	3.3	7.0	2.6	-1.5	0.1	-5.4	-7.0	-6.3	-0.8	-3.6	-2.0	-3.6	-8.9	-7.3
6	2.2	-3.4	-1.4	3.7	2.2	2.8	3.1	-3.9	-0.5	-4.3	-5.3	-4.7	0.7	-2.2	-1.1	-0.9	-9.3	-7.1
7	0.7	-3.4	-2.1	5.3	-0.3	2.3	-1.9	-4.9	-3.5	-4.5	-9.9	-8.3	0.1	-2.3	-1.2	-3.8	-10.0	-7.1
8	-0.7	-2.7	-1.8	1.6	-1.2	0.5	-4.3	-8.1	-6.5	-10.0	-13.1	-11.7	2.4	-4.6	-2.0	-4.0	-6.9	-5.4
9	0.9	-2.3	-0.9	0.3	-1.7	-0.8	-3.6	-8.6	-6.6	-7.2	-11.9	-10.2	-4.7	-7.0	-6.2	-1.9	-5.1	-4.0
10	1.9	-2.7	-1.1	1.2	-2.1	-0.5	-1.4	-4.9	-3.0	-10.2	-18.7	-14.7	-2.5	-6.8	-4.8	0.3	-4.7	-1.8
11	-2.7	-6.0	-4.3	1.3	-0.9	0.2	3.7	-2.2	0.9	-10.5	-20.3	-16.5	-1.3	-5.5	-3.9	6.3	-1.0	1.8
12	0.2	-5.7	-2.3	2.6	-0.1	1.0	5.0	2.6	4.0	-4.9	-10.4	-7.0	-0.7	-4.1	-2.4	6.0	-1.7	2.4
13	4.3	-0.4	1.0	1.4	-1.0	-0.1	7.4	-0.7	4.7	-2.9	-4.9	-3.9	-3.4	-5.6	-4.4	6.3	0.6	3.3
14	9.0	-0.2	4.5	0.5	-2.0	-1.0	4.1	-6.6	-1.6	-1.7	-5.9	-3.5	-4.0	-5.1	-4.7	5.0	-1.3	0.5
15	13.3	5.8	9.5	0.6	-1.7	-0.6	-1.2	-6.7	-4.7	-4.9	-6.2	-5.4	-3.3	-6.0	-4.4	0.8	-3.7	-1.2
16	12.9	6.2	10.0	0.5	-2.5	-1.2	0.1	-3.6	-1.5	-2.9	-6.6	-4.2	-4.5	-6.7	-5.6	-3.3	-6.8	-5.6
17	5.1	-0.9	2.8	-0.9	-3.2	-2.4	-3.4	-8.4	-5.5	-2.5	-3.7	-3.2	-2.2	-4.9	-4.1	0.4	-6.4	-3.8
18	4.1	-3.1	1.1	-2.2	-4.7	-3.3	-7.2	-10.4	-8.7	-0.1	-2.8	-1.7	-1.1	-4.7	-2.8	2.2	-3.8	-1.1
19	7.5	1.0	3.8	-1.3	-4.3	-3.1	-1.7	-7.0	-4.4	-2.1	-5.3	-4.2	-0.8	-2.7	-1.9	2.5	-2.3	-0.1
20	11.9	4.2	6.7	-1.3	-4.9	-2.9	-2.8	-7.5	-5.5	-3.9	-6.1	-5.4	0.3	-4.5	-2.3	5.6	-0.3	3.1
21	11.9	1.1	5.5	-1.3	-6.3	-4.5	-7.2	-11.9	-9.2	-4.5	-6.9	-5.9	-2.1	-6.4	-4.7	4.6	0.1	2.6
22	2.0	-2.8	-1.2	-2.2	-4.5	-3.4	-5.0	-12.0	-8.2	-3.2	-5.3	-4.7	-2.9	-8.2	-6.4	2.9	-3.6	-0.1
23	-2.0	-4.0	-2.9	0.7	-3.6	-1.2	-5.5	-7.1	-6.3	-0.3	-3.6	-1.6	-3.7	-8.7	-7.1	1.1	-3.7	-1.8
24	5.1	-5.2	-1.7	-2.3	-6.7	-4.6	-3.2	-8.7	-5.8	-1.4	-4.6	-3.1	-4.1	-9.6	-7.8	1.6	-2.3	-0.7
25	5.3	-2.9	2.2	-2.9	-5.6	-4.7	2.9	-3.9	-0.5	-0.4	-3.9	-2.4	-5.5	-8.5	-7.3	1.5	-5.3	-2.4
26	5.5	-1.0	2.0	0.8	-7.2	-3.4	0.7	-7.6	-2.8	-1.3	-3.9	-2.8	-2.4	-11.0	-7.9	-4.7	-8.7	-6.1
27	0.4	-2.8	-1.1	-0.6	-2.8	-1.6	-4.5	-7.4	-6.2	-3.2	-5.7	-4.4	-3.9	-10.9	-7.9	-0.2	-10.4	-7.5
28	2.4	-1.7	0.3	-0.9	-4.7	-2.0	0.7	-3.5	-0.8	-0.4	-4.2	-2.3	-0.3	-8.3	-5.7	-1.6	-10.5	-7.1
29	0.6	-1.5	-0.8	0.6	-4.6	-1.4	1.6	-1.1	0.0	0.3	-2.5	-1.1				-2.2	-9.9	-6.0
30	2.2	-2.1	-0.1	-2.2	-4.5	-3.8	7.4	-2.0	3.0	-1.7	-5.5	-3.3				3.1	-6.8	-3.3
31	-0.8	-2.2	-1.5				7.4	-2.1	0.5	-2.9	-6.3	-4.8				6.6	-5.7	-1.7
MONTHLY AVERAGE			1.0			-0.8			-2.9			-5.7			-4.2			-2.9

DAY	Apr.			May			June			July			Aug.			Sept.		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
1	9.5	-6.1	-1.3	15.3	11.1	12.6	13.6	4.0	7.0	16.6	7.8	12.3	15.4	6.7	9.5	23.5	12.1	18.6
2	5.8	-4.6	-1.7	13.8	4.9	9.3	13.7	6.1	9.2	18.0	8.6	12.9	23.5	15.1	18.0	19.4	10.1	14.5
3	3.5	-4.6	-1.3	10.9	3.7	6.8	12.7	3.9	7.5	15.6	6.6	9.8	23.8	15.0	19.0	22.6	10.8	16.2
4	1.8	-2.9	-1.4	16.5	7.3	11.5	13.2	2.6	6.2	9.5	5.9	6.9	27.3	15.3	21.3	19.9	10.0	14.4
5	-0.8	-4.5	-2.8	18.8	7.4	11.5	11.1	1.7	5.8	11.3	5.6	7.4	22.0	7.8	15.7	22.1	10.6	15.7
6	3.4	-5.1	-1.8	13.3	4.2	8.3	18.0	4.4	10.1	17.4	5.7	12.0	14.4	6.1	9.6	22.5	12.6	17.0
7	-2.9	-7.4	-4.9	9.3	0.7	4.6	15.3	6.1	9.0	16.0	8.1	11.7	12.2	5.5	8.7	20.2	7.8	14.3
8	2.1	-8.7	-4.6	3.0	-0.6	1.1	12.8	6.6	9.4	16.2	6.6	11.2	20.2	6.7	14.4	7.4	4.0	5.9
9	1.9	-6.0	-2.9	9.7	-0.7	3.1	16.1	4.8	8.9	20.6	7.2	13.7	21.1	7.9	14.6	10.2	0.6	4.8
10	5.0	-4.7	-1.8	13.4	2.0	7.1	11.1	4.3	5.9	16.0	7.1	12.0	18.8	7.3	12.9	13.1	1.6	7.8
11	-1.0	-7.6	-4.7	9.7	1.1	3.9	10.6	3.3	5.8	8.3	4.9	6.4	16.4	9.2	12.7	13.0	6.5	9.0
12	-1.5	-8.4	-5.1	14.9	3.6	7.5	13.9	2.4	7.5	9.0	3.2	5.0	21.5	10.8	15.8	15.8	7.1	10.7
13	3.7	-6.4	-2.9	5.7	-1.3	2.6	6.0	2.9	4.3	10.2	2.8	6.1	23.0	14.4	18.4	15.3	6.3	10.6
14	9.5	-6.8	-2.1	1.2	-3.9	-1.9	6.5	1.3	3.7	10.4	6.2	8.4	18.2	8.6	14.1	17.7	9.9	13.3
15	0.7	-5.9	-2.3	6.4	-4.0	-1.4	2.0	-1.3	0.1	12.3	8.5	9.8	9.2	3.7	6.5	21.1	12.5	15.8
16	-2.6	-4.9	-4.1	8.0	-3.4	1.9	10.2	-1.0	4.3	20.8	9.0	14.9	4.5	1.9	2.8	19.7	9.9	14.1
17	12.8	-6.1	1.3	0.9	-1.5	-0.4	9.8	2.4	4.7	21.4	10.4	15.1	4.1	0.2	2.8	15.8	4.5	9.4
18	3.7	-4.4	0.3	4.9	-2.0	0.9	5.9	1.0	2.7	20.3	8.9	14.3	6.9	2.1	3.4	6.9	2.6	4.0
19	2.4	-6.1	-1.7	12.6	0.3	5.0	8.9	1.2	3.7	11.8	5.7	8.3	15.9	7.1	11.3	4.1	2.4	3.0
20	9.8	-0.3	4.0	13.2	2.5	7.4	12.5	5.6	8.6	18.7	5.3	13.6	20.5	10.3	14.0	9.6	2.5	6.0
21	10.9	0.7	5.8	4.1	1.1	2.9	15.7	7.4	11.2	23.0	12.5	17.7	14.6	7.1	10.4	14.3	5.7	9.5
22	10.3	6.5	8.3	6.0	0.2	1.9	15.6	6.3	9.6	24.2	13.6	18.8	14.4	5.2	8.9	16.8	7.9	11.1
23	10.8	-3.1	3.2	9.4	0.3	3.5	10.6	3.3	6.1	20.1	10.1	15.6	7.0	4.9	5.8	15.1	7.6	10.9
24	-3.1	-5.5	-4.3	6.6	2.1	4.6	6.7	2.1	3.9	19.6	8.9	14.4	14.6	2.6	9.0	7.6	3.5	5.4
25	-0.3	-5.7	-3.6	3.7	-2.5	0.0	5.6	0.7	2.2	24.7	13.2	19.9	13.4	6.0	8.8	5.9	1.5	3.7
26	8.1	-5.1	1.2	4.1	-3.0	-1.5	2.3	0.4	1.3	29.2	18.6	22.3	13.2	5.3	8.5	11.3	4.2	7.8
27	13.4	1.8	7.9	4.9	-2.9	-0.5	10.5	1.2	6.3	26.3	18.9	22.0	19.4	7.2	13.6	15.8	6.1	11.5
28	13.6	5.1	9.3	8.4	-1.4	3.6	15.7	7.1	11.4	24.6	16.1	19.8	24.3	13.7	19.1	14.0	5.9	9.6
29	15.6	7.4	11.6	12.6	2.9	6.0	19.5	9.6	13.2	25.7	15.6	19.6	19.3	11.4	15.7	14.2	6.8	10.3
30	15.1	11.3	13.2	10.3	2.4	4.8	19.1	10.9	15.1	18.1	11.3	14.9	20.5	10.4	15.6	16.8	11.0	13.1
31				17.7	4.6	8.9				10.6	8.6	9.9	27.0	17.2	20.5			
MONTHLY AVERAGE			0.4			4.4			6.8			13.1			12.3			10.6

Table 5. Snow depths at South Cascade Glacier, May 5-6, 1998

[Depths, in meters (m), ±0.05 meters, measured with a probe rod; X and Y are local coordinates, ±10 meters. Surface altitude (Z), in meters above National Geodetic Vertical Datum of 1929. Locations mapped in figure 4]

X	Y	Z	Snow depth (m)	X	Y	Z	Snow depth (m)	X	Y	Z	Snow depth (m)	X	Y	Z	Snow depth (m)
3159	1811	2104	5.66	2198	1856	1984	5.81	1808	2826	1842	4.56	1683	3341	1730	4.28
3081	1793	2098	5.79	2158	1921	1977	6.07	1788	2871	1845	4.59	1696	3381	1716	3.52
3014	1770	2077	5.69	2153	2013	1967	5.71	1768	2906	1843	4.69	1712	3425	1703	1.43
2940	1747	2072	5.61	2131	2070	1949	5.77	1748	2944	1837	4.72	1720	3468	1686	2.91
2867	1724	2066	6.07	2103	2136	1941	5.61	1729	2983	1833	4.62	1752	3504	1672	2.86
2793	1695	2060	5.36	2077	2207	1935	5.25	1711	3022	1831	4.64	1779	3525	1663	2.49
2714	1678	2054	5.40	2051	2280	1927	5.10	1696	3059	1821	4.26	1799	3556	1656	2.14
2643	1664	2045	5.66	2026	2355	1918	4.64	1682	3095	1812	3.88	1823	3549	1656	1.07
2570	1647	2037	5.61	2002	2425	1900	6.42	1673	3133	1804	5.00	1824	3574	1655	0.80
2491	1644	2033	5.71	1978	2494	1882	6.69	1663	3165	1789	4.72	1821	3626	1628	0.97
2417	1668	2023	6.22	1953	2570	1863	4.89	1659	3198	1778	5.28	1824	3670	1622	1.99
2342	1682	2021	6.22	1934	2650	1855	4.64	1660	3231	1763	4.28	1816	3715	1622	1.82
2290	1738	2011	5.71	1894	2713	1847	4.79	1665	3267	1752	3.77	1796	3755	1624	0.90
2240	1796	1998	5.71	1852	2775	1843	4.89	1674	3304	1743	4.23	1773	3790	1621	1.40

Table 6. Snow density at South Cascade Glacier, May 5, 1998

[Measured in a snow pit, through the entire thickness of the snow, at local X = 1808, Y = 2826, Z = 1842 meters, location P1 (fig. 1). Diameter of snow tube used in pit = 0.0723 meter]

Sample bottom depth (meters)	Sample length (meters)	Mass (kilograms)	Density
0.44	0.44	0.815	0.45
0.87	0.43	0.775	0.44
1.30	0.43	1.020	0.58
1.69	0.39	0.930	0.58
2.07	0.38	0.945	0.60
2.46	0.39	0.870	0.54
2.84	0.38	0.910	0.58
3.21	0.37	0.875	0.58
3.53	0.32	0.765	0.58
3.89	0.36	0.775	0.53
4.18	0.29	0.620	0.52
4.43	0.25	0.575	0.56

Total water equivalent = 2.40 meters
Average density = 0.54

Table 7. Stake measurements at South Cascade Glacier in the 1998 balance year

[Surface material may be snow (s), firn (f), or ice (i). Balance is the gain or loss of material, referenced to the previous year's melt horizon, in water content. Local X, Y, and Z coordinates (in meters) given for each stake. Stake locations are shown on figure 1 and stake readings are plotted in figure 5]

Date	Surface material	Depth (meters)	Density	Balance (meters)
Stake 2 [X = 1808, Y = 2826, Z = 1842]				
May 5	s	4.43	0.54	2.39
June 3	s	3.87	.55	2.13
July 1	s	2.60	.56	1.46
July 29	s	.53	.58	.31
Aug. 24	i	-1.23	.90	-1.11
Sept. 15	i	-2.19	.90	-1.97
Oct. 19	i	-2.74	.90	-2.46
Stake 3 [X = 1692, Y = 3336, Z = 1725]				
July 29	i	0.00	0.90	0.00
Aug. 22	i	-2.15	.90	-1.93
Sept. 15	i	-3.53	.90	-3.18
Oct. 19	i	-3.88	.90	-3.49
Stake 4 [X = 1807, Y = 3550, Z = 1636]				
May 5	s	2.37	0.50	1.19
June 4	s	1.55	.52	.81
July 1	i	-.10	.90	-.09
July 29	i	-2.72	.90	-2.45
Aug. 22	i	-4.84	.90	-4.36
Sept. 15	i	-6.49	.90	-5.84
Oct. 10	i	-7.18	.90	-6.46

Date	Surface material	Depth (meters)	Density	Balance (meters)
Stake 5 [X = 1704, Y = 3491, Z = 1672]				
July 1	i	-0.25	0.90	-0.22
July 29	i	-2.51	.90	-2.26
Aug. 22	i	-4.53	.90	-4.08
Sept. 15	i	-6.10	.90	-5.49
Oct. 19	i	-6.74	.90	-6.60
Stake 6 [X = 1928, Y = 2496, Z = 1893]				
Aug. 24	f	-0.25	0.60	-0.15
Sept. 15	i	-1.41	.90	-1.15
Oct. 19	i	-1.95	.90	-1.63
Stake 7 [X = 2018, Y = 2217, Z = 1928]				
Aug. 24	f	-0.1	0.70	-0.07
Sept. 15	f	-1.26	.70	-.88
Oct. 19	f	-1.75	.77	-1.35
Stake 8 [X = 2189, Y = 1884, Z = 1976]				
Aug. 24	f	0.00		0.00
Sept. 15	f	-1.21	0.60	-.73
Oct. 19	f	-1.57	.62	-.97
Stake 9 [X = 2526, Y = 1693, Z = 2034]				
Aug. 24	s	0.3	0.60	0.18
Sept. 15	f	-.91	.60	-.54
Oct. 19	f	-1.29	.60	-.86

Table 8. South Cascade Glacier altitude grid, September 14, 1998

[Surface altitude (Z), in meters above National Geodetic Vertical Datum of 1929, was measured near the central point for each grid cell. Coordinates X and Y are local. Z is accurate to ±2 meters. An asterisk indicates that the Z value is from the 1997 altitude grid. Grid map is shown in figure 7]

X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
2171	1499	2043	1670	2301	1897	1972	2800	1841	1668	3500	1684
2271	1501	2041	1770	2300	1896	2070	2800	1839	1770	3501	1668
2370	1500	2036	1870	2301	1907	2171	2800	1833	1870	3500	1641
2469	1498	2038	1968	2299	1918	2269	2800	1834	1670	3600	1652
2570	1497	2048	2070	2299	1924	2369	2799	1851	1771	3600	1645
2671	1497	2059	2170	2300	1929	1471	2901	1844	2270	1400	2078 *
2071	1598	2024	2270	2300	1938	1568	2902	1838	2570	1400	2058 *
2169	1600	2024	2370	2300	1941	1669	2900	1839	2470	1400	2060 *
2272	1601	2020	2471	2298	1954	1769	2900	1837	2368	1401	2066 *
2371	1600	2024	1570	2400	1895	1870	2899	1839	2671	1401	2091 *
2471	1598	2034	1672	2401	1888	1971	2899	1839	2769	1401	2109 *
2571	1600	2044	1770	2399	1887	2072	2901	1835	2770	1500	2078 *
1971	1698	2002	1871	2400	1891	2169	2902	1833	2870	1500	2102 *
2071	1699	1991	1970	2400	1905	2271	2900	1826	3070	1600	2124 *
2171	1697	1999	2071	2399	1908	2372	2901	1836	2770	1601	2069 *
2271	1699	2012	2168	2400	1921	1470	3001	1831	2870	1601	2082 *
2970	1700	2091	2270	2401	1929	1569	2999	1827	2669	1601	2058 *
1870	1801	1996	2371	2401	1938	1669	2999	1826	2968	1602	2098 *
2371	1802	2010	2471	2400	1957	1770	3000	1830	2871	1699	2077 *
2472	1802	2025	1471	2501	1899	1871	3002	1832	2769	1700	2068 *
2570	1801	2032	1572	2499	1874	1969	3001	1836	2568	1700	2040 *
2668	1800	2046	1770	2502	1875	2069	3002	1834	3168	1701	2123 *
2871	1800	2072	1870	2499	1875	2169	3000	1827	2469	1701	2035 *
1871	1898	1980	1970	2499	1875	2270	3001	1826	2669	1701	2054 *
2270	1901	1983	2071	2499	1888	1469	3100	1812	2370	1701	2025 *
2370	1902	1990	2169	2502	1896	1571	3100	1807	3069	1702	2105 *
2472	1900	2007	2271	2500	1912	1670	3101	1807	3170	1795	2093 *
1870	1999	1962	2371	2501	1924	1769	3100	1814	3071	1798	2084 *
2170	2001	1952	1571	2601	1861	1871	3099	1821	2170	1800	1990 *
2270	2001	1952	1670	2600	1859	1970	3099	1824	2770	1800	2068 *
2371	2001	1962	1770	2600	1863	2070	3102	1817	2072	1800	1983 *
2469	2001	1979	1870	2601	1858	2172	3100	1811	1970	1800	1991 *
1770	2101	1935	1971	2600	1858	1470	3200	1775	2970	1801	2080 *
1871	2101	1940	2071	2599	1858	1571	3202	1772	2271	1802	2008 *
1969	2101	1936	2171	2600	1874	1669	3200	1778	2173	1896	1974 *
2072	2099	1942	2271	2601	1886	1772	3200	1788	1969	1898	1971 *
2172	2101	1948	1569	2700	1854	1871	3200	1796	2071	1901	1972 *
2270	2099	1951	1670	2700	1853	1972	3200	1798	1971	2000	1958 *
2371	2101	1955	1772	2700	1852	2069	3201	1774	2070	2001	1958 *
2472	2101	1970	1869	2701	1850	2172	3200	1767	2571	2101	2005 *
1671	2201	1922	1969	2701	1848	1570	3300	1741	2570	2300	2006 *
1770	2199	1922	2071	2700	1843	1669	3299	1742	1571	2301	1929 *
1869	2201	1917	2171	2701	1843	1772	3300	1732	1669	2500	1883 *
1969	2200	1927	2269	2702	1855	1971	3299	1732	2369	2599	1901 *
2070	2199	1935	1471	2800	1857	2070	3300	1728	2370	2700	1871 *
2171	2202	1940	1570	2800	1846	1572	3399	1712	1470	2701	1871 *
2270	2201	1948	1671	2802	1845	1672	3400	1714			
2371	2201	1947	1769	2800	1844	1769	3401	1698			
2470	2199	1959	1871	2802	1842	2070	3398	1692			

Table 9. Precipitation (gage catch) at 1,587 meters altitude, Salix Creek gaging station, 1998 water year

[Precipitation is summed every hour and the daily sum is given in millimeters. A -99.0 indicates no data]

DAY	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	21.1	0.3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	0.0	0.0	0.0
2	34.5	26.4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	0.3	0.0	0.0
3	52.6	38.9	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	0.0	18.5	0.0	0.0
4	67.6	0.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	19.6	4.3	0.0	0.0
5	13.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	0.0	1.0	0.0	0.0
6	0.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	0.0	0.0	0.0	0.0
7	0.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	0.3	0.0	0.0	0.0
8	0.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	0.3	0.0	0.0	1.3
9	0.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	0.0	0.0	0.0	0.0
10	5.3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	4.8	0.0	0.0	0.0
11	0.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	1.3	1.3	0.0	0.0
12	5.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	0.0	6.1	0.0	0.0
13	8.9	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	0.0	3.3	0.0	0.0
14	2.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	2.5	1.5	0.0	0.0
15	0.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	15.0	1.8	0.0	0.0
16	0.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	8.4	0.0	9.1	0.0
17	5.3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	2.5	0.0	3.1	0.3
18	0.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	2.5	0.0	0.0	7.9
19	0.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	2.3	0.0	0.0	11.7
20	0.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	5.1	0.0	0.0	0.3
21	0.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	0.0	0.0	6.9	0.0
22	1.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	5.1	0.0	0.0	0.0
23	0.3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	3.6	0.0	1.3	0.0
24	0.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	7.4	0.0	0.0	8.6
25	0.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	12.7	0.0	0.0	15.2
26	27.4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	7.1	0.0	0.0	0.0
27	2.3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	0.3	0.0	0.0	0.0
28	20.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	0.0	0.0	0.0	0.0
29	22.6	-99.0	-99.0	-99.0		-99.0	-99.0	-99.0	0.0	0.0	0.0	0.0
30	73.2	-99.0	-99.0	-99.0		-99.0	-99.0	-99.0	0.0	2.8	0.0	0.0
31	0.0		-99.0	-99.0		-99.0		-99.0		2.5	0.0	
SUM	367.0	--	--	--	--	--	--	--	--	43.4	20.3	45.2

Table 10. Runoff from Salix Creek Basin, 1998 water year

[Daily runoff in millimeters, averaged over the basin; no data indicated by -99.0]

DAY	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	14.0	-99.0	2.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	11.1	1.5	0.1
2	17.4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	9.7	1.2	0.1
3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	13.2	1.0	0.0
4	-99.0	16.4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	36.1	10.2	0.9	0.1
5	-99.0	14.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	28.6	8.6	0.9	0.0
6	-99.0	24.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	30.1	7.5	0.8	0.0
7	-99.0	14.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	33.2	7.2	0.8	0.0
8	-99.0	10.7	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	32.4	6.1	0.7	0.1
9	-99.0	7.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	28.2	5.9	0.6	0.1
10	-99.0	6.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	24.4	5.2	0.6	0.1
11	-99.0	5.3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	23.2	4.5	0.5	0.0
12	-99.0	4.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	30.2	5.2	0.5	0.0
13	-99.0	4.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	20.4	4.9	0.4	0.0
14	-99.0	3.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	17.4	3.6	0.4	0.0
15	-99.0	3.4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	24.6	3.6	0.5	0.0
16	-99.0	3.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	17.9	3.3	1.0	0.0
17	-99.0	2.7	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	17.0	2.9	0.8	0.0
18	-99.0	2.4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	14.1	2.8	0.7	0.1
19	-99.0	2.4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	12.7	2.7	0.5	0.9
20	-99.0	2.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	15.8	2.5	0.4	0.4
21	-99.0	2.4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	18.5	2.4	0.7	0.2
22	-99.0	2.3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	18.7	2.3	0.5	0.2
23	-99.0	2.4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	16.3	2.1	0.5	0.1
24	-99.0	2.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	17.3	2.0	0.4	0.3
25	-99.0	2.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	17.3	1.9	0.3	2.7
26	-99.0	2.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	15.6	1.8	0.3	1.1
27	-99.0		-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	12.8	1.6	0.2	0.5
28	-99.0	2.4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	12.0	1.5	0.2	0.3
29	-99.0	2.0	-99.0	-99.0		-99.0	-99.0	-99.0	11.2	1.3	0.1	0.2
30	-99.0	2.0	-99.0	-99.0		-99.0	-99.0	-99.0	11.7	1.4	0.1	0.2
31	-99.0		-99.0	-99.0		-99.0		-99.0		1.5	0.1	
SUM	--	--	--	--	--	--	--	--	--	140.2	17.9	8.0

Table 11. Runoff from South Fork Cascade River Basin, 1998 water year

[Daily runoff in millimeters, averaged over the basin]

DAY	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	49.2	6.4	0.3	0.2	0.0	0.0	0.0	12.2	14.8	36.7	28.8	28.0
2	41.2	4.3	0.3	0.3	0.0	0.0	0.0	15.9	19.6	38.4	32.7	27.5
3	26.7	6.6	0.2	0.2	0.0	0.0	0.0	16.1	22.9	50.4	41.9	25.5
4	40.4	12.9	0.2	0.2	0.0	0.0	0.0	17.4	25.5	44.6	46.1	23.9
5	21.3	6.4	0.2	0.2	0.0	0.0	0.0	17.2	29.3	32.9	50.9	20.3
6	10.4	7.7	0.2	0.2	0.0	0.0	0.0	17.0	24.7	28.5	45.3	17.4
7	7.1	7.3	0.2	0.2	0.0	0.0	0.0	15.7	26.9	32.8	30.9	17.7
8	5.5	5.1	0.2	0.2	0.0	0.0	0.0	13.9	29.2	36.9	25.0	20.4
9	4.5	3.8	0.2	0.2	0.0	0.0	0.0	10.1	30.5	35.4	25.3	15.4
10	4.0	3.0	0.2	0.1	0.0	0.0	0.0	9.4	32.3	35.8	25.7	12.8
11	3.8	2.3	0.2	0.1	0.0	0.0	0.0	12.9	29.6	29.7	28.0	13.5
12	3.4	1.2	0.1	0.1	0.0	0.0	0.0	16.9	30.5	31.0	30.2	14.9
13	3.2	0.9	0.1	0.1	0.0	0.0	0.0	21.0	33.9	31.5	33.4	15.3
14	3.2	0.7	0.1	0.2	0.0	0.0	0.0	18.0	24.2	27.2	36.4	14.7
15	4.4	0.7	0.1	0.2	0.0	0.0	0.0	13.1	23.9	25.2	30.9	15.4
16	9.6	0.6	0.3	0.2	0.0	0.0	0.0	8.8	23.2	31.3	23.7	16.3
17	11.4	0.6	0.5	0.2	0.0	0.0	0.0	6.4	19.3	35.2	16.4	16.2
18	9.9	0.6	0.5	0.2	0.0	0.0	0.0	5.3	17.3	32.7	11.5	16.4
19	6.0	0.5	0.4	0.1	0.0	0.0	0.0	4.3	15.0	32.6	11.8	20.4
20	4.4	0.6	0.3	0.1	0.0	0.0	0.0	4.6	14.6	27.8	17.4	15.1
21	3.5	0.7	0.3	0.1	0.0	0.0	0.0	6.1	19.6	26.2	21.3	11.9
22	3.1	0.5	0.2	0.1	0.0	0.0	0.1	7.3	24.9	33.4	22.3	10.5
23	2.8	0.5	0.2	0.1	0.0	0.1	0.7	7.0	28.3	39.7	18.9	10.4
24	2.6	0.6	0.2	0.1	0.0	0.1	3.4	7.3	28.7	36.2	14.8	11.4
25	2.2	0.6	0.2	0.1	0.0	0.1	3.3	11.8	32.4	34.6	17.0	19.6
26	2.5	0.5	0.1	0.1	0.0	0.1	2.1	10.2	26.9	44.3	19.6	14.9
27	4.7	0.4	0.2	0.1	0.0	0.1	0.8	7.9	19.5	50.9	19.5	11.5
28	4.0	0.5	0.2	0.1	0.0	0.1	1.1	5.7	17.7	49.2	20.2	10.7
29	5.9	0.4	0.3	0.1		0.1	3.1	6.2	21.5	42.2	24.1	8.9
30	16.3	0.4	0.3	0.1		0.1	5.4	7.7	28.7	35.4	23.7	8.5
31	12.0		0.2	0.0		0.0		10.1		31.0	23.9	
SUM	329.1	77.0	7.0	4.2	0.8	1.1	20.5	343.3	735.2	1099.4	817.2	485.0

Table 12. Runoff from Middle Tarn Basin, 1998 water year

[Daily runoff in millimeters, averaged over the basin. A -99.0 indicates no data]

DAY	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	42.8	2.5	0.6	-99.0	-99.0	-99.0	-99.0	-99.0	14.2	34.1	30.5	31.8
2	22.7	2.0	0.8	-99.0	-99.0	-99.0	-99.0	-99.0	17.9	34.9	38.6	28.6
3	17.6	6.4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	19.7	47.1	44.1	27.1
4	18.3	6.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	23.1	35.1	47.1	25.7
5	8.1	4.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	22.4	28.5	50.1	20.9
6	5.5	7.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	21.2	28.0	39.1	19.6
7	4.2	5.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	24.2	34.0	27.8	22.3
8	3.2	3.6	-99.0	-99.0	-99.0	-99.0	-99.0	9.6	25.5	34.2	26.8	20.8
9	2.7	2.7	-99.0	-99.0	-99.0	-99.0	-99.0	8.5	27.3	34.5	27.8	16.7
10	2.4	3.4	-99.0	-99.0	-99.0	-99.0	-99.0	9.9	27.5	32.7	28.1	14.8
11	2.1	9.7	-99.0	-99.0	-99.0	-99.0	-99.0	13.2	26.1	26.5	30.9	18.2
12	1.8	6.7	-99.0	-99.0	-99.0	-99.0	-99.0	16.8	28.9	32.9	32.9	18.4
13	1.8	1.2	-99.0	-99.0	-99.0	-99.0	-99.0	17.5	27.6	30.1	36.9	18.1
14	1.8	1.1	-99.0	-99.0	-99.0	-99.0	-99.0	15.9	20.4	24.4	36.7	17.5
15	5.7	1.0	-99.0	-99.0	-99.0	-99.0	-99.0	11.6	22.1	28.0	27.1	19.5
16	8.5	0.9	-99.0	-99.0	-99.0	-99.0	-99.0	8.1	19.9	34.8	23.3	19.4
17	9.3	0.9	-99.0	-99.0	-99.0	-99.0	-99.0	6.0	16.7	33.8	14.7	18.8
18	5.5	0.8	-99.0	-99.0	-99.0	-99.0	-99.0	5.1	15.2	32.7	11.6	18.6
19	3.5	1.0	-99.0	-99.0	-99.0	-99.0	-99.0	4.4	14.1	31.3	19.0	22.7
20	2.6	0.9	-99.0	-99.0	-99.0	-99.0	-99.0	5.2	15.7	27.0	21.4	15.6
21	2.1	0.7	-99.0	-99.0	-99.0	-99.0	-99.0	6.7	20.6	29.1	24.7	13.5
22	1.8	1.0	-99.0	-99.0	-99.0	-99.0	-99.0	7.3	23.8	38.2	24.5	13.1
23	1.6	0.9	-99.0	-99.0	-99.0	-99.0	-99.0	7.1	26.0	38.7	17.2	13.9
24	1.3	0.9	-99.0	-99.0	-99.0	-99.0	-99.0	8.6	27.5	34.3	18.7	15.7
25	1.3	0.7	-99.0	-99.0	-99.0	-99.0	-99.0	11.0	28.7	37.6	21.2	23.2
26	4.3	0.7	-99.0	-99.0	-99.0	-99.0	-99.0	8.4	21.0	47.9	23.3	13.8
27	3.0	0.7	-99.0	-99.0	-99.0	-99.0	-99.0	6.7	16.7	49.4	21.4	14.6
28	2.2	1.4	-99.0	-99.0	-99.0	-99.0	-99.0	5.7	17.8	45.2	25.2	12.4
29	3.4	1.4	-99.0	-99.0		-99.0	-99.0	6.4	22.9	39.5	27.9	10.7
30	9.8	0.9	-99.0	-99.0		-99.0	-99.0	8.5	30.5	33.3	24.9	12.7
31	3.7		-99.0	-99.0		-99.0		10.4		30.4	28.2	
SUM	204.2	77.4	--	--	--	--	--	--	665.2	1068.2	871.6	558.5

Table 13. Values used to interpolate snow water equivalent at any altitude on South Cascade Glacier, 1998 [values in meters]

Altitude	Snow water equivalent
1613	0.0
1621	0.2
1629	0.4
1640	0.7
1652	0.9
1663	1.1
1675	1.3
1690	1.5
1708	1.7
1728	1.9
1753	2.0
1783	2.2
1816	2.4
1854	2.6
1893	2.7
1942	2.9
1988	3.0
2038	3.1
2085	3.3
2133	3.4
2183	3.5
2229	3.6

Table 14. Values used to interpolate net balance at any altitude on South Cascade Glacier, 1998 [values in meters]

Altitude	Net balance
1627	-7.92
1641	-7.39
1657	-6.81
1673	-6.26
1687	-5.72
1706	-5.19
1726	-4.61
1743	-4.10
1765	-3.59
1790	-3.07
1818	-2.60
1851	-2.15
1891	-1.74
1935	-1.36
1987	-1.04
2037	-0.79
2091	-0.62
2144	-0.48

TABLE 15. Positions of velocity features, ±1.0 m, on South Cascade Glacier on September 12, 1995, and September 14, 1998

[Coordinates X, Y, and Z are local, in meters]

	Sept. 12, 1995			Sept. 14, 1998				Sept. 12, 1995			Sept. 14, 1998		
ID	X	Y	Z	X	Y	Z	ID	X	Y	Z	X	Y	Z
1	2015.8	3138.2	1816.7	2019.7	3169.9	1799.4	34	1989.5	2692.1	1852.8	1989.4	2720.4	1845.5
2	1902.6	3136.0	1819.0	1904.9	3173.6	1805.2	35	1889.7	2656.1	1858.9	1888.6	2687.6	1851.0
3	1767.9	3102.3	1817.9	1761.3	3154.6	1801.8	36	1767.9	2605.0	1864.5	1765.0	2638.0	1858.2
4	1678.4	3052.8	1819.8	1669.9	3102.4	1808.9	37	1722.3	2490.2	1881.6	1719.6	2525.6	1871.9
5	1575.4	3068.4	1814.2	1573.1	3106.0	1804.3	38	1694.8	2348.5	1895.1	1688.6	2376.6	1890.0
6	1619.7	2951.4	1835.7	1616.4	2986.3	1827.3	39	1804.5	2416.7	1890.8	1796.9	2451.3	1882.4
7	1705.1	2964.7	1833.0	1702.6	3002.8	1825.7	40	1865.1	2515.2	1876.1	1861.6	2549.4	1865.4
8	1806.1	2984.3	1836.3	1800.4	3022.0	1829.4	41	1917.4	2554.9	1867.9	1913.8	2587.7	1857.8
9	1875.6	3052.8	1833.1	1872.4	3090.3	1821.6	42	1987.6	2581.8	1864.5	1984.8	2609.4	1855.1
10	1949.1	3090.1	1828.2	1950.6	3122.7	1820.3	43	2079.6	2618.0	1859.3	2075.4	2640.1	1850.2
11	2164.5	3044.0	1823.4	2167.9	3060.6	1818.1	44	2116.7	2676.6	1848.4	2114.7	2692.3	1842.1
12	2083.9	3035.0	1832.7	2088.5	3055.7	1824.7	45	2251.2	2803.5	1836.1	2248.8	2811.0	1830.1
13	2011.1	3006.6	1837.7	2013.7	3029.8	1832.8	46	2240.6	2641.6	1876.2	2238.4	2649.6	1867.3
14	1933.8	2982.6	1840.2	1933.8	3011.7	1833.9	47	2244.8	2528.3	1905.8	2242.9	2538.9	1900.2
15	1875.1	2915.7	1844.4	1870.1	2945.6	1838.0	48	2142.7	2497.5	1896.5	2136.5	2515.7	1886.9
16	1831.1	2854.9	1845.0	1829.9	2886.9	1840.8	49	2098.4	2414.6	1908.2	2087.0	2439.8	1899.9
17	1762.8	2867.8	1843.3	1759.6	2900.3	1837.1	50	2039.0	2348.9	1920.9	2024.1	2380.6	1910.3
18	1813.6	2777.5	1848.5	1813.1	2808.7	1844.2	51	1996.1	2278.4	1925.4	1979.4	2310.1	1919.8
19	1952.1	2891.5	1844.7	1954.0	2917.6	1839.9	52	1863.9	2320.7	1906.7	1843.7	2358.0	1897.4
20	2041.6	2947.6	1840.0	2043.5	2967.5	1835.5	53	1965.8	2196.4	1929.4	1941.1	2225.2	1923.2
21	2182.2	2975.8	1832.2	2184.1	2988.5	1828.9	54	2018.4	2169.7	1936.5	2000.3	2199.3	1931.5
22	1666.8	2866.4	1842.5	1665.3	2899.6	1835.7	55	2111.1	2234.4	1935.1	2097.3	2260.6	1929.1
23	1605.2	2810.0	1849.1	1602.2	2836.5	1843.8	56	2228.6	2273.1	1938.5	2225.2	2282.8	1937.1
24	1712.7	2793.3	1853.2	1710.2	2827.4	1844.9	57	2361.8	2454.1	1929.9	2355.8	2457.8	1926.6
25	1537.2	2644.9	1865.3	1536.1	2657.8	1857.7	58	2450.2	2257.9	1956.0	2448.3	2260.4	1952.1
26	1655.3	2686.5	1859.5	1651.7	2715.7	1850.5	59	2363.6	2250.2	1946.4	2362.5	2254.0	1944.1
27	1791.7	2713.2	1854.6	1787.6	2747.4	1846.8	60	2292.2	2191.5	1949.9	2287.9	2197.5	1947.6
28	1922.7	2801.6	1846.1	1922.0	2830.9	1839.0	61	2203.8	2135.4	1949.3	2191.5	2156.8	1943.8
29	2032.8	2881.7	1842.0	2033.5	2901.1	1838.7	62	2272.1	2033.2	1956.4	2263.3	2044.3	1951.8
30	2139.8	2925.9	1839.6	2142.2	2939.6	1832.3	63	2502.8	2092.3	1979.6	2499.9	2094.0	1975.5
31	2249.2	2953.6	1831.8	2249.9	2961.3	1826.6	64	2289.1	1899.2	1987.3	2275.2	1920.0	1975.4
32	2163.5	2859.4	1838.7	2164.5	2872.6	1832.7	65	2353.6	1824.8	2010.4	2337.2	1837.2	1982.5
33	2072.8	2793.3	1842.1	2073.2	2813.6	1838.5	66	2431.6	1819.8	2021.7	2419.9	1827.7	2018.5

TABLE 16. Mass balance time series at South Cascade Glacier

[For years 1986-91, net balance, $\bar{b}_n$, was determined by the index regression method discussed in Krimmel (1989) and has an error of 0.23 m. For years 1959-64 and 1968-82, winter balance, $\bar{b}_m$(s), was determined from unpublished snow accumulation maps and has an error of 0.12 m. For years 1983-1991, $\bar{b}_m$(s) was determined using the index station regression discussed in Krimmel (1989) and has an error of 0.23 m. For years 1992 to 1998, $\bar{b}_n$ and $\bar{b}_m$(s) were determined by the grid-index method (Krimmel, 1996b)]

Year[1]	$\bar{b}_m$(s) (meters)	$\bar{b}_n$ (meters)	Year[1]	$\bar{b}_m$(s) (meters)	$\bar{b}_n$ (meters)
[2]1959	3.28	0.70	1979	2.18	-1.56
1960	2.21	-0.50	1980	1.83	-1.02
1961	2.40	-1.10	1981	2.28	-0.84
1962	2.50	0.20	1982	3.11	0.08
1963	2.23	-1.30	1983	1.91	-0.77
1964	3.25	1.20	1984	2.38	0.12
[3]1965	3.48	-0.17	1985	2.18	-1.20
1966	2.47	-1.03	1986	2.43	-0.71
[4]1967	3.29	-0.63	1987	1.88	-2.56
[5]1968	3.00	0.01	1988	1.89	-1.64
1969	3.17	-0.73	1989	2.35	-0.71
1970	2.41	-1.20	1990	2.80	-0.73
1971	3.51	0.60	1991	3.35	-0.20
1972	4.27	1.43	1992	1.91	-2.01
1973	2.21	-1.04	1993	1.98	-1.23
1974	3.65	1.02	1994	2.39	-1.60
1975	3.06	-0.05	1995	2.81	-0.69
1976	3.53	0.95	1996	2.94	0.10
1977	1.57	-1.30	1997	3.71	0.63
1978	2.49	-0.38	1998	2.76	-1.86

[1] Balance year (for example, 1959 is from the minimum balance in 1958 to the minimum balance in 1959, and the 1959 $\bar{b}_m$(s) occurred in the spring of 1959)

[2] $\bar{b}_n$ for years 1959 through 1964 from Meier and Tangborn (1965)

[3] Years 1965 through 1966 from Meier and others (1971)

[4] Year 1967 from Tangborn and others (1977)

[5] $\bar{b}_n$ for years 1968 through 1985 from Krimmel (1989)

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