Hydrologic Conditions and Hazards In the Kennicott River Basin, Wrangell-St. Elias National Park and Preserve, Alaska

By Ronald L. Rickman and Danny S. Rosenkrans

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CONVERSION FACTORS AND VERTICAL DATUM INFORMATION

Multiply	by	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
cubic foot (ft^3)	0.02832	cubic meter
foot per hour (ft/hr)	0.3048	meter per hour
foot per day (ft/d)	0.3048	meter per day
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
ton	0.9072	Megagram

VERTICAL DATUM

For this report, the U.S. Geological Survey vertical datum of 1908 was used. This datum is derived from USGS monument "K," established in 1908 with a stamped elevation of 1,414 ft above sea level. Monument "K" is located in the town of McCarthy.

NOTE

In this report, "**Kennecott**" pertains to the mining company and mill site and "**Kennicott**" to geographic features. The rational for this dual spelling and usage is as follows: the mining company is named for Robert Kennicott, a pioneer surveyor; somehow, probably inadvertently, an "e" was substituted for the "i" in the company name. In 1908, the Post Office of "Kennecott" was established and continued until 1938. Present day map usage favors the original spelling honoring Robert Kennicott (Orth, 1967, p. 510).

GLOSSARY

A glossary of technical terms used in this report starts on page 52. A term defined in the glossary appears in **bold** type at its first reference in the text.

Hydrologic Conditions and Hazards in the Kennicott River Basin Wrangell-St. Elias National Park and Preserve, Alaska

By Ronald L. Rickman[1] and Danny S. Rosenkrans[2]

Abstract

McCarthy, Alaska, is on the Kennicott River, about 1 mile from the terminus of Kennicott Glacier in the Wrangell-St. Elias National Park and Preserve. Most visitors to McCarthy and the park cross the West Fork Kennicott River using a hand-pulled tram and cross the East Fork Kennicott River on a temporary footbridge. Outburst floods from glacier-dammed lakes result in channel erosion, aggradation, and migration of the Kennicott River, which disrupt transportation links, destroy property, and threaten life. Hidden Creek Lake, the largest of six glacier-dammed lakes in the Kennicott River Basin, has annual outbursts that cause the largest floods on the Kennicott River. Outbursts from Hidden Creek Lake occur from early fall to mid-summer, and lake levels at the onset of the outbursts have declined between 1909 and 1995. Criteria for impending outbursts for Hidden Creek Lake include lake stage near or above 3,000 to 3,020 feet, stationary or declining lake stage, evidence of recent calving of large ice blocks from the ice margin, slush ice and small icebergs stranded on the lakeshore, and fresh fractures in the ice-margin region.

The lower Kennicott Glacier has thinned and retreated since about 1860. The East and West Fork Kennicott River channels migrated in response to changes in the lower Kennicott Glacier. The largest channel changes occur during outburst floods from Hidden Creek Lake, whereas channel changes from the other glacier-dammed lake outbursts are small. Each year, the West Fork Kennicott River conveys a larger percentage of the Kennicott Glacier drainage than it did the previous year.

Outburst floods on the Kennicott River cause the river stage to rise over a period of several hours. Smaller spike peaks have a very rapid stage rise. Potential flood magnitude was estimated by combining known maximum discharges from Hidden Creek Lake and Lake Erie outburst floods with a theoretical large regional flood. Flood hazard areas at the transportation corridor were delineated, and possible future geomorphological changes were hypothesized.

INTRODUCTION

The town of McCarthy (fig. 1) is located in the largest national park system unit in the United States, Wrangell-St. Elias National Park and Preserve. The park contains some of the highest mountains in North America, many glaciers and ice fields, and abundant wildlife. More than 591,000 tons of copper ore was mined and processed in the McCarthy area between 1908 and 1938. Most of this copper came from Bonanza Ridge, 6 mi north of McCarthy and was transported to the coast by the Copper River and Northwestern Railway (CR&NWR). Railway bridges spanning the Kennicott River were commonly damaged or destroyed by floods and channel migration (McCarthy Weekly News, 1921-26; Janson, 1975; Friend, 1988). The railway ceased operations in 1938 and the railroad bed was gradually converted to the McCarthy Road.

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[1]U.S. Geological Survey, Anchorage, Alaska
[2]National Park Service, Copper Center, Alaska

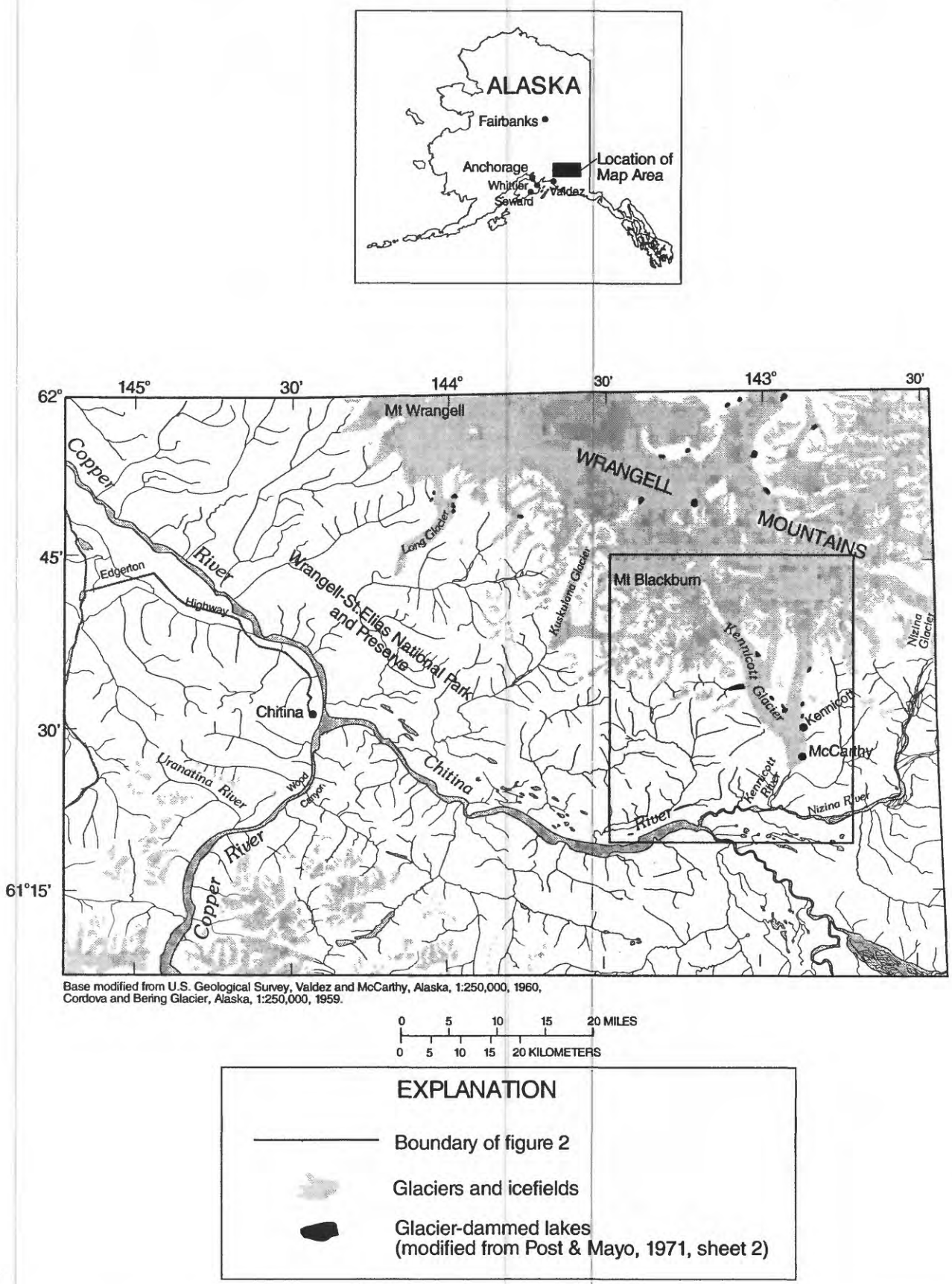

Figure 1. Location of Kennicott River Basin in Wrangell-St.Elias National Park and Preserve.

The rich colorful history and natural beauty of the McCarthy area attract several thousand visitors annually. Most of the visitors drive the McCarthy Road 59 mi from Chitina to the west side of the Kennicott River (fig. 2). The road ends at the river because bridges were destroyed in 1981 by catastrophic flooding caused by the Hidden Creek Lake outburst. Access to the Kennecott mines and the town of McCarthy requires visitors and residents to cross the West Fork Kennicott River in a hand-pulled tram suspended from a cable. A temporary footbridge has been constructed on the East Fork in addition to a hand-pulled tram. This bridge washes out on an annual basis. The hand-pulled trams and temporary bridge are scheduled to be replaced with permanent footbridges in 1997. A privately owned visitor parking and camping area is located on alluvial terraces near the tram crossing of the West Fork Kennicott River near the Kennicott Glacier terminus. The town of McCarthy (fig. 2) is also located on an alluvial terrace approximately 1 mi east of the visitor parking area.

Numerous glacier-dammed lakes are located in the Kennicott River Basin (fig. 2). **Outburst floods**[1] (jökulhlaups) are common in the Kennicott River and cause considerable loss of property, disruption of transportation links into Wrangell-St. Elias National Park and Preserve, and threaten human life. Flooding is the largest cause of river channel instability, channel migration, and channel rerouting. It is the policy of the National Park Service to preserve flood-plain values and minimize hazardous conditions associated with flooding. The U.S. Geological Survey (USGS), in cooperation with the National Park Service, evaluated hydrologic conditions and natural hazards in the Kennicott River Basin.

Purpose and Scope

The purpose of this study was to identify, describe, and measure hydrologic conditions and hazards in the Kennicott River Basin that threaten park visitors, residents, and transportation routes in the park's most heavily used area. This report describes the results of the study; the study area is shown on figure 2.

The work included the following elements:

- Identify, map, and describe glacier-dammed lakes. Evaluate the timing and mechanism of outbursts, historical lake levels, and develop outburst predictive criteria for Hidden Creek Lake, which will provide warning of imminent flooding in the Kennicott River.
- Identify, map, and describe changes to Kennicott Glacier from 1909 to 1995, including internal drainage, glacier terminus changes, and outwash evolution to gain insight into probable and possible future changes in and around the transportation corridor.
- Describe the Kennicott River source, river stage, streamflow, channel erosion, aggradation, and migration.
- Evaluate hydrologic hazards for the West Fork Kennicott River and East Fork Kennicott River in and around the transportation corridor, determine whether specific hazards could be monitored in the future, and identify appropriate monitoring mechanisms. Other natural hazards, such as rockslides and snow avalanches were beyond the scope of this study.

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[1]**Bold** words defined in "Glossary"

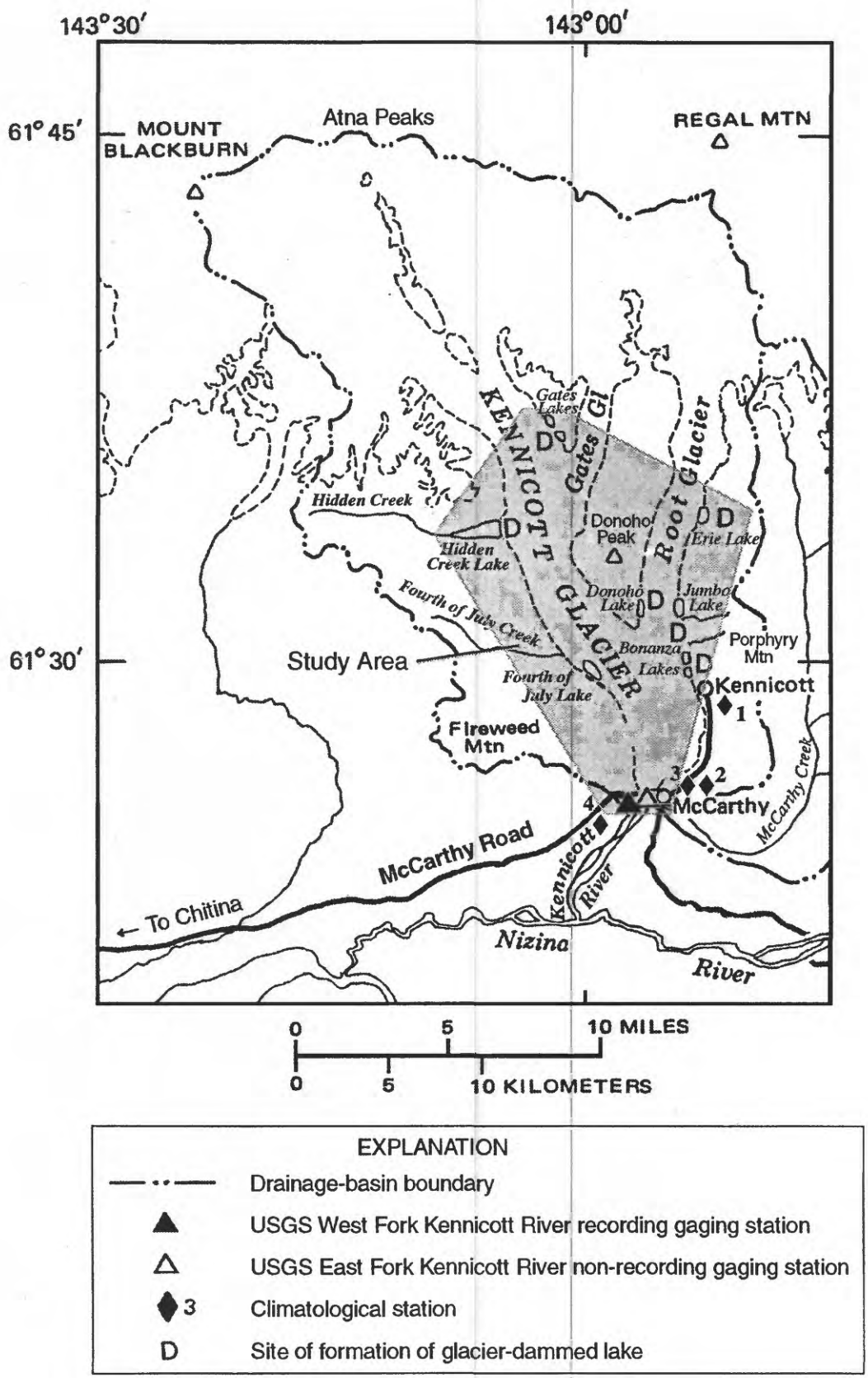


Figure 2. Location of study area, glacier-dammed lakes, and selected data-collection sites in the Kennicott River Basin.

Acknowledgments

The assistance, cooperation, and information from the following residents of McCarthy are gratefully acknowledged. Edward LaChapelle, Professor Emeritus of Geophysics and Atmospheric Sciences, University of Washington, provided valuable field assistance, as well as historical and technical information regarding past flooding, flood damage, and glaciers. The Schrage family provided historical background of the tram area. Steve Siren allowed us to install and operate a stream-gaging station on his property. Kelly Bay provided valuable up-to-date information on the status of glacier-dammed lakes in the Kennicott Basin. Randy Elliot made field observations.

The assistance of the State of Alaska Department of Transportation and Public Facilities is appreciated. Donald Friend, Arizona State University, provided topographic information for Hidden Creek Lake as well as detailed eyewitness accounts of Hidden Creek Lake outburst flooding. Roger Elconin, Humboldt State University, provided valuable information concerning timing and interrelation of glacier-dammed lakes in the Kennicott Basin. Michael Martin, National Park Service, assisted with the 1995 surveys and data reduction. The assistance of Gary Smillie, National Park Service Water Resources Division is appreciated. Funding to support this project was provided by the National Park Service, Fort Collins, Colorado. Finally, we gratefully acknowledge the assistance of USGS personnel Timothy Brabets, Dennis Trabant, Chad Smith, Liska Snyder, Linda Harris, Joseph Walder, Carolyn Driedger, and Lynn Yehle.

DESCRIPTION OF THE KENNICOTT DRAINAGE BASIN

Climate

The Kennicott River Basin area (figs. 1 and 2) is located in a transitional climate zone between the wet, temperate climate of the coast and the drier climate with larger temperature extremes of the interior. Precipitation and surface-water runoff quantities vary because of the large elevation range and the presence of glaciers (Emery and others, 1985). Climate data have been collected at four climatological stations (Kennicott, McCarthy, McCarthy 1 NE, and McCarthy 3 SW; fig. 2, and table 1). Currently, climatological data collected at McCarthy 3 SW, about 3 mi southwest of McCarthy, are published monthly by the National Oceanic and Atmospheric Administration (1922-90) and are summarized intermittently by the Arctic Environmental Information and Data Center (Leslie, 1989). Precipitation data for additional sites in and near the Wrangell- St. Elias National Park have been summarized by Jones and Glass (1993).

Table 1. Precipitation at selected climatological stations in the Kennicott River Basin near McCarthy
[Data from National Weather Service (National Oceanic and Atmospheric Administration, 1922-90)]

Site No. (fig. 2)	Station name	Latitude	Longitude	Elevation (feet)	Period of record	Mean annual precipitation (inches)	Maximum daily rainfall[1] (inches)
1	Kennicott	61° 29'	142° 53'	2,210	1/22-8/47	23.26	1.97
2	McCarthy 1 NE	61° 26'	142° 54'	1,540	10/76-2/83	20.82	2.00
3	McCarthy	61° 26'	142° 55'	1,380	7/68-9/76	17.23	1.13
4	McCarthy 3 SW	61° 25'	143° 00'	1,250	1/84-10/90	21.47	2.33

[1]For months May through September

Recorded values of annual precipitation range from 10.11 in. at McCarthy during 1969 to 30.68 in. at Kennicott in 1944. According to the generalized mean annual precipitation map of the Copper River basin (Jones and Fahl, 1994), mountainous areas above the precipitation collection sites shown in table 1 receive from 40 to more than 80 in.

Physical Description

The Kennicott River originates on the south side of the Wrangell Mountains and terminates at the confluence with the Nizina River (fig. 2). The basin upstream from the confluence with McCarthy Creek is 352 mi^2 in size, of which approximately 46 percent is covered by glaciers and perennial snow. Several peaks in the Kennicott River Basin are higher than 13,000 ft: Mount Blackburn is the highest at an elevation of 16,390 ft. Bedrock of the upper basin includes andesitic flows and pyroclastics of the Wrangell volcanic field, and intrusive rocks which include **dacite** (MacKevett, 1972). Bedrock in the Hidden Creek Valley and lower reaches of the Kennicott River valley is made up of predominately the Chitistone Limestone, Nizina Limestone, Nikolai Greenstone, all of Triassic age, and of the McCarthy Formation of Triassic and Jurassic age (MacKevett, 1972).

Glaciers

The largest glacier in the basin is Kennicott Glacier (fig. 2), which is 28 mi long and drains the south side of Atna Peaks and the southeast side of Mount Blackburn. Root Glacier (fig. 2), a tributary to Kennicott Glacier, is the second largest glacier in the basin. This glacier is 17 mi long, drains the south side of Regal Mountain, and merges with Kennicott Glacier immediately south of Donoho Peak.

Kennicott Glacier has been described by Bateman (1922), Field (1975), Denton (1975), and Jones and Glass (1993). Drawings and descriptions by Bateman, as well as aerial photographs from the last 60 years, indicate that the lower part of Kennicott Glacier has thinned and retreated. An ice-cored moraine at the glacier terminus has thawed. Botanical observations at the terminal moraine indicate that the maximum advance occurred about 1860 (Viereck, 1967). A 360-year-old group of trees, partly buried by alluvial deposits, indicates that the glacier has not extended beyond its 1860 maximum since at least 1600 (Viereck, 1967).

Glaciers in the Wrangell Mountains commonly block ice-free tributary valleys, forming unstable lakes. Many glacier-dammed lakes drain rapidly on an annual basis. Failures of the glacier-ice dams cause periodic flooding downstream. Two glacier-dammed lakes are found along Kennicott Glacier and four along Root Glacier; numerous **supraglacial** lakes are found on both glaciers. The largest glacier-dammed lake is Hidden Creek Lake, located on the west flank of Kennicott Glacier (fig. 2).

Kennicott River

The Kennicott River flows from the terminus of Kennicott Glacier 4.7 mi to the confluence with the Nizina River. Two channels currently flow from the terminus of the glacier. The West Fork Kennicott River is the larger channel, located on the western side of a terminal **moraine** and the smaller East Fork Kennicott River is on the eastern side. A capture channel at the toe of the Kennicott Glacier terminus currently diverts much of the flow from the East Fork Kennicott River into the West Fork Kennicott River. Mean annual discharge for the combined flow of the East and West Forks Kennicott River at McCarthy is estimated to be about 1,300 ft^3/s (Jones and Glass, 1993).

HYDROLOGIC CONDITIONS

Glacier-Dammed Lakes

Six glacier-dammed lakes and numerous small ponds that drain periodically are known in the Kennicott basin (fig. 2). In this report, Bonanza Lakes are considered a single lake, as are Gates Lakes. Physical characteristics of the larger lakes are summarized in table 2 and described below.

Table 2. Selected physical characteristics of glacier-dammed lakes in the Kennicott Basin

Lake name (fig. 2)	Distance up-glacier from McCarthy (miles)	Surface elevation[1] (feet) (USGS 1908 datum)	Estimated depth[1] (feet)	Approximate surface area[1] (square miles)
Hidden Creek	10	3,000	350	0.5- 0.75
Erie	9	3,000	>100	0.12
Donoho	6	2,500	>100	0.03
Gates	12	3,400	Unknown	0.012-0.015
Jumbo	5	2,100	50-75	0.02
Bonanza	3.8	2,000	75-100	0.008-0.013

[1]At maximum observed lake stage

Three other small lakes perched in the lateral moraines near Fourth of July Creek, Donoho Peak, and upper Kennicott Glacier did not drain during the study, and appear to be isolated from the active glacial system.

Hidden Creek Lake

Hidden Creek Lake is the largest glacier-dammed lake in the Kennicott basin and is located approximately 10 mi northwest of McCarthy (fig. 2). The lake abuts the western margin of Kennicott Glacier (fig. 3). Melt from glaciers, rock-glacier ice, and snow, as well as rainfall and ground water, contribute to lake inflow. The lake is at an elevation of approximately 3,000 ft and has a surface area ranging from 0.5 to 0.75 mi^2 when full. Historical records reveal that Hidden Creek Lake (originally called Icy Lake) has had outbursts since at least the turn of the century (Moffit, 1938). The lake was first described in 1907 (Moffit and Maddren, 1909) and the earliest reported outburst was in 1909 (Moffit and Capps, 1911).

Hidden Creek Lake is located adjacent to the Kennicott Glacier **ablation** zone. Kennicott Glacier has retreated since its 1860 maximum, leaving conspicuous terminal lateral moraines. Currently, lateral moraines near the terminus are situated approximately 100 ft above the adjacent glacier ice surface indicating substantial loss of glacial mass since 1860. The 1957 and 1994 ice-margin positions have retreated approximately 750 and 1,100 ft, respectively, from the 1860 moraine (fig. 3). Retreat is most extensive along the southeast corner of the lake, near the drain hole. The western lake boundary at maximum stage has migrated downvalley over time, concurrently with retreat of the ice margin in the lake basin.

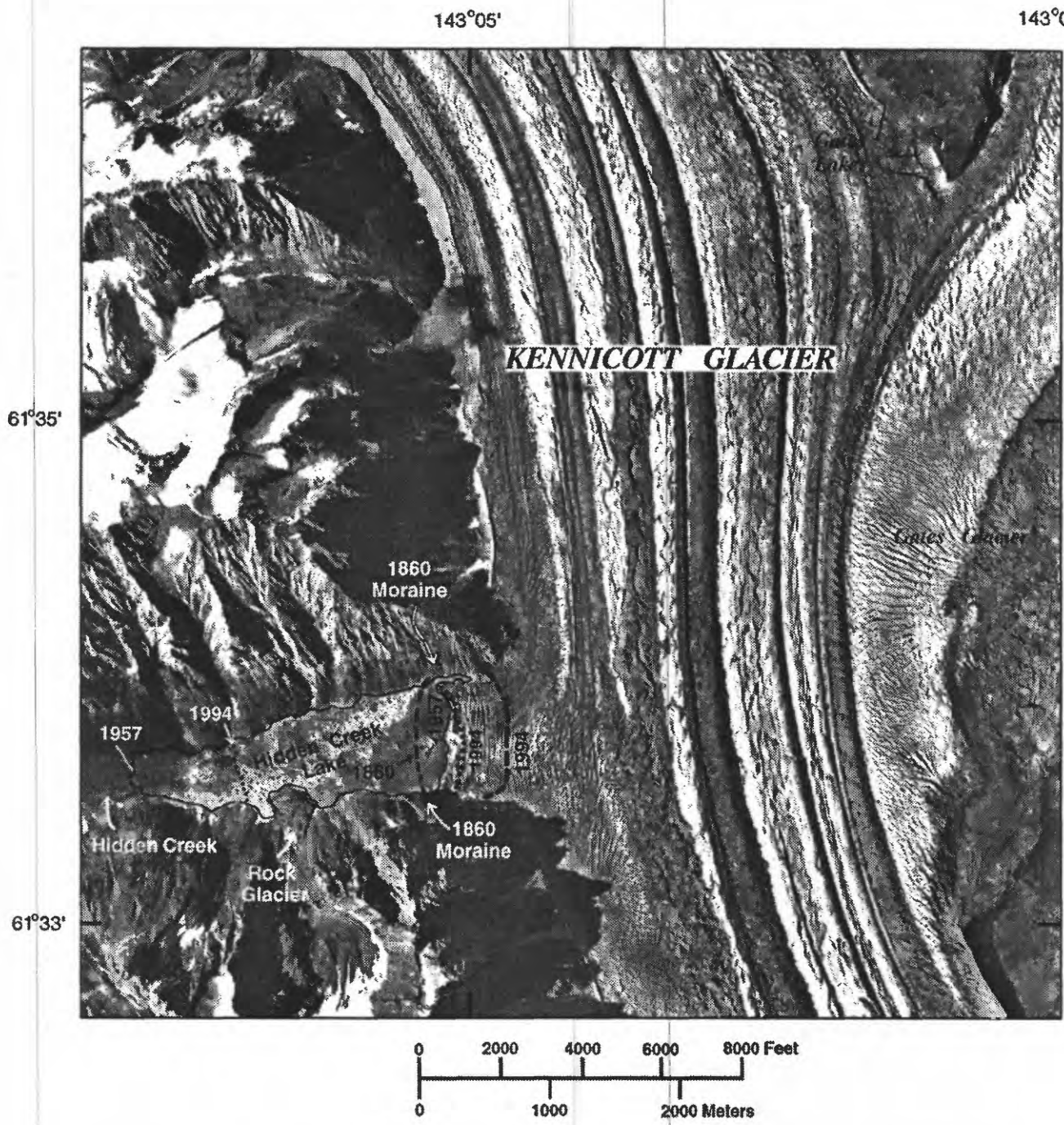


Figure 3. Maximum stage and glacier margin position for selected years at Hidden Creek Lake (U.S. Geological Survey, July 29, 1957 aerial photograph.)

Ice Dam and Outbursts

Observations during the study show that glacier ice adjacent to Hidden Creek Lake floats as the lake fills and settles as the lake drains. Time-lapse photography obtained during the summers of 1994 and 1995 recorded the collapse of the Kennicott Glacier margin during the outbursts. Retreat of the ice margin is fastest when it is floating. One week prior to the 1994 outburst, large icebergs calved from the ice margin. The 1957 aerial photograph (fig. 3), taken 5 days prior to the outburst, shows a large iceberg in front of the ice dam. Calving of large icebergs may signal floating of the ice margin and water leaking through the ice dam.

A series of **arcuate** crevasses develop across the glacier where it pushes into Hidden Creek Valley (fig. 3). These crevasses mark the zones of vertical and horizontal displacement along which the ice margin rises and falls. They extend 1,200 ft back from the ice margin, indicating that the ice floats over a wide zone. Direct measurement of ice-margin lifting was not possible, but scaling of features indicates that the margin rises 75 ft or more as lake level rises.

Thickness of the glacier dam is a factor controlling maximum lake stage. When lake stage reaches approximately nine-tenths the ice thickness at the damming point, the ice floats, thus allowing the lake to drain (Post and Mayo, 1971). The lake is approximately 350 ft deep adjacent to Kennicott Glacier (Friend, 1988). Depth soundings along the glacier were not practical because of safety concerns. Lack of historical and current glacier thickness data prevents reconstruction of glacier thickness in the ice-dam region. Continued decreasing glacier thickness and retreat of the ice margin are reducing the effectiveness of the ice dam to impound water.

Timing and Mechanism of Outbursts

Historically, Hidden Creek Lake has drained annually during the late summer or early fall. There have been no reported winter outbursts. A complete list of known lake conditions from 1860 to 1995 is presented in appendix 1. On the basis of 25 known outburst dates between 1911 and 1995 (fig. 4), Hidden Creek Lake has shown a trend toward earlier outburst dates. During years in which the date of the outburst was not recorded, the approximate time of outburst can be deduced from observations before and after the outburst had occurred (fig. 5). Trends between 1970 and 1995 are less obvious: all outbursts occurred between early July and mid-August. Since 1988, Hidden Creek Lake has drained annually between July 5 and August 3.

Survey monuments were established at several locations in and around the Hidden Creek Lake basin. Monument locations and elevations were tied to a common datum using the Global Positioning System (GPS). Information about monument locations, elevations, and survey error can be found in appendix 2. Historical lake elevations were determined by surveying matching points from historical photographs with points on the ground (appendix 3). Whenever possible, several points around the lake perimeter were surveyed for each photograph to verify the maximum elevations. A list of the photographs used is found in appendix 1.

Dropstones found in the alluvial fan zone were surveyed. The uppermost limit of lake deposits (thickness increases down valley) is slightly higher than the 1957 lake level (3,083 and 3,071 ft, respectively). Isolated dropstones protrude through or rest upon the recent alluvium up to 3,101 ft elevation, which corresponds closely to the surveyed maximum stage for 1916. Remnants of a very old washline follow the 3,152-foot-elevation contour. This washline is the highest known water level and is thought to have formed about 1860 during the little ice age. Maximum lake elevation

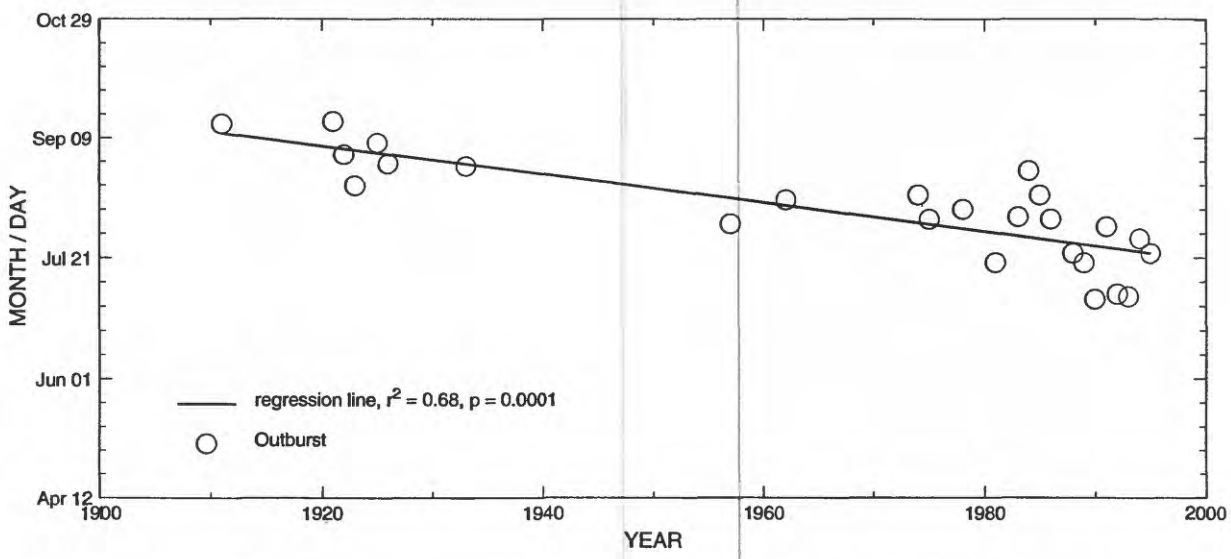


Figure 4. Known and reported outburst dates for Hidden Creek Lake, 1911 to 1995.

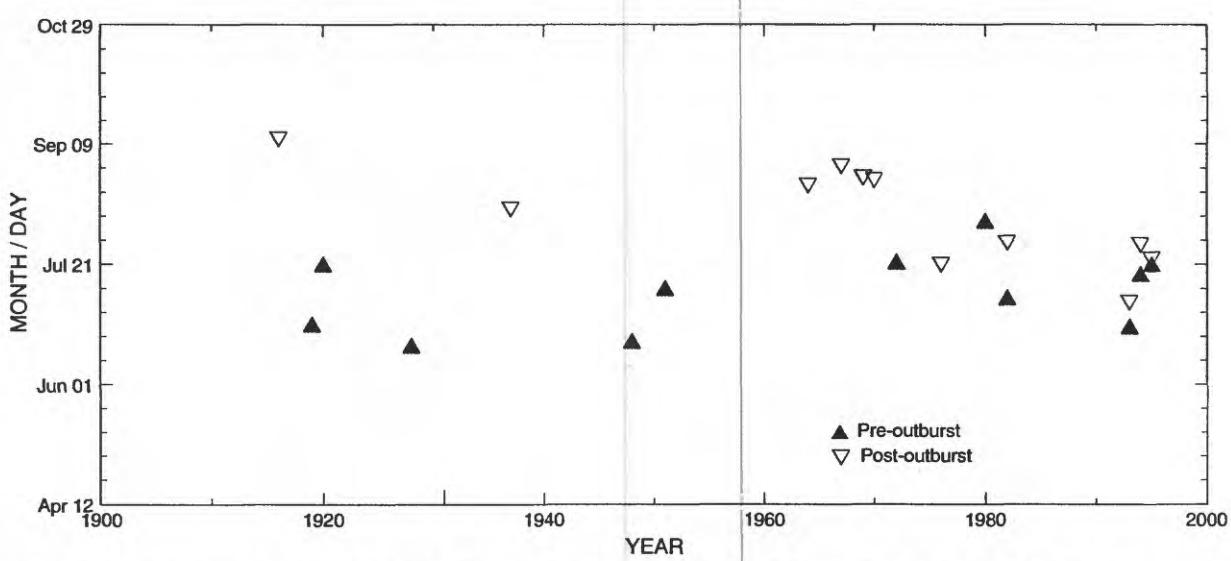


Figure 5. Known pre- and post-outburst dates for Hidden Creek Lake, 1911 to 1995.

data for 1860 to 1995 show a decreasing trend with time (fig. 6). Maximum lake stages, 1990 to present, have been between 3,000 and 3,020 ft and are significantly lower than pre-1957 stages (fig. 6). The 1992, 1994, and 1995 lake levels reached 3,002, 3,021, and 3,007 ft, respectively.

The combination of increasingly early outbursts and lower lake levels prior to outburst are probably caused by thinning of the Kennicott Glacier at the dam. Ice deformation and ice/bed separation caused by glacier movement may also play a role in the outburst timing. Determining the outburst mechanism is beyond the scope of this study. Outburst mechanisms for glacier-dammed lakes are discussed more thoroughly by Embleton and King (1975, p. 540-41) and Knight and Tweed (1991, p. 175-184).

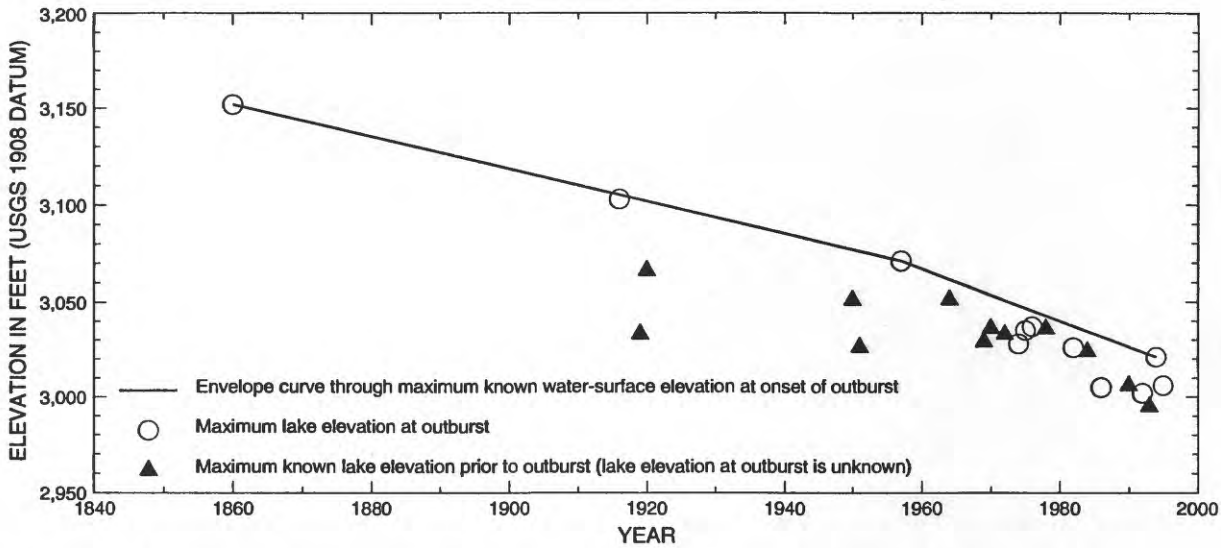


Figure 6. Maximum known water-surface elevations at onset and prior to outbursts for Hidden Creek Lake.

After the lake drains, Hidden Creek traverses the former lakebed and flows under Kennicott Glacier at the southeast corner of the former lake basin in what appears to be the remnants of a large drainage cavern. Glacier-dammed lake drainage conduits reseal by **plastic deformation** and collapse of glacial ice (Embleton and King, 1975, p. 340).

Hidden Creek Lake Bed

The Hidden Creek Lake bed can be divided into three distinct zones: *alluvial fan*, *ice-cored*, and *depression* (fig. 7).

The *alluvial fan zone* is an active alluvial fan filling the valley bottom. The 2 percent bed slope is incised by Hidden Creek. A thin glacial-lake dropstone veneer overlies fluvial deposits (fig. 8). Greenstone and limestone constitute most of the fluvial gravel, and make up all of the rock outcrops in Hidden Creek Valley.

The *ice-cored zone* is the area between the 1860 side-valley moraine and a rock glacier, and is incised by several small streams (figs. 3 and 7). Ice is exposed in the incised streambanks of Hidden Creek. Large blocks of ice remain attached to the substrate and do not float when covered by lake water. Part of the lake bottom is probably an ice-cored down-slope extension of the upper alluvial fan zone, but has been lowered because of melting of the ice core. The ice core is overlaid with well-rounded gravel, similar to that found in the alluvial fan zone.

The *depression zone* is an oval-shaped depression between the 1860 moraine and the ice dam (figs. 7 and 9). It is covered and choked with large icebergs after the lake drains. This large depression was formed after Kennicott Glacier retreated from its side-valley moraine. Depression depth may exceed 350 ft near the ice dam, and contains a significant portion of the total lake volume (Friend, 1988). A small lake that was formed when the photograph was taken is shown in figure 9. This small lake had drained by the next morning, and began re-forming.

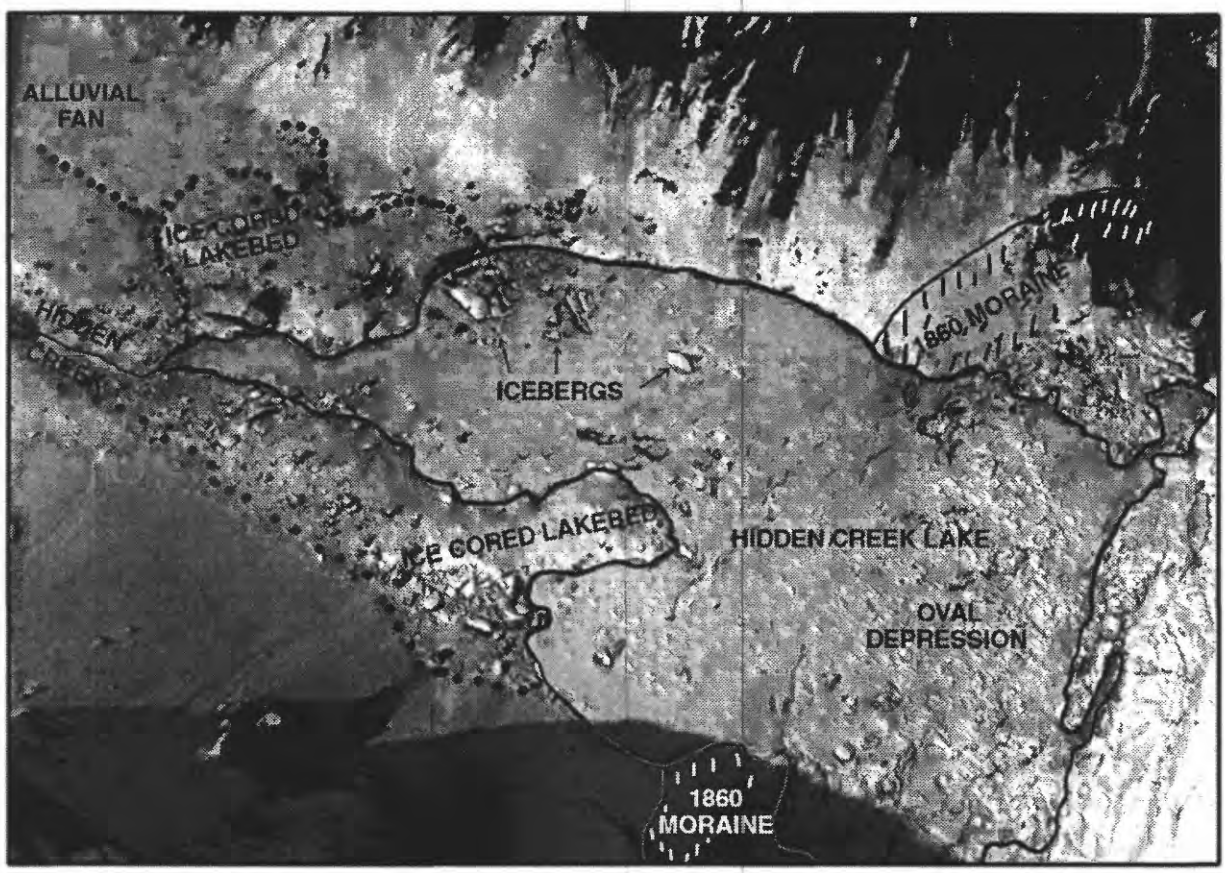


Figure 7. Alluvial-fan, ice-cored, and depression zones of Hidden Creek Lake bed, May 12, 1994.

Lake Volume and Stages, 1994 and 1995

A lake stage-volume curve was developed by plotting 1994 and 1995 Hidden Creek Lake survey data (fig. 10; appendix 3). Volumes for the surveyed part of the lakebed were calculated using Geographic Information System (GIS) software. Much of the lakebed was choked with icebergs and was not surveyed. Volume was adjusted to include the oval depression at the ice dam, using data from Friend (1988). The approximate change in lake volume with elevation is shown in figure 10. However, this illustration does not reflect total volume of water retained because the volume beneath the ice wedge between the ice margin and the dam, and within glacier fractures cannot be measured.

Lake level rose approximately 2 ft/d between July 1 and July 9, 1994 (Joseph Walder, USGS, written commun., 1995). Lake levels were observed to become stationary or slowly drop prior to the 1986 outburst (Friend, 1988). This was also documented using time-lapse photography for the 1994 and 1995 outbursts. Slow declines in lake stage up to 6 days prior to outburst were not noticeable from aerial observations made in 1994 and 1995.

Figure 8. Hidden Creek Lake bed deposits capping fluvial gravels, August 31, 1994.

Criteria for Pending Outbursts

The following criteria indicate when an outburst of Hidden Creek Lake is imminent:

- Lake stage near or above the level of recent maximum stages (3,000 to 3,020 ft).
- Stationary or declining lake stage during the period in which meltwater and rain would be expected to be raising the lake stage (July and August).
- Evidence of recent calving of large ice blocks from the ice margin.
- Formation of a "clean ice" washline along the ice margin. This is visible after a small decline in lake stage.
- Slush ice and small icebergs stranded on the lakeshore.
- Fresh fractures and escarpments in the ice margin region.

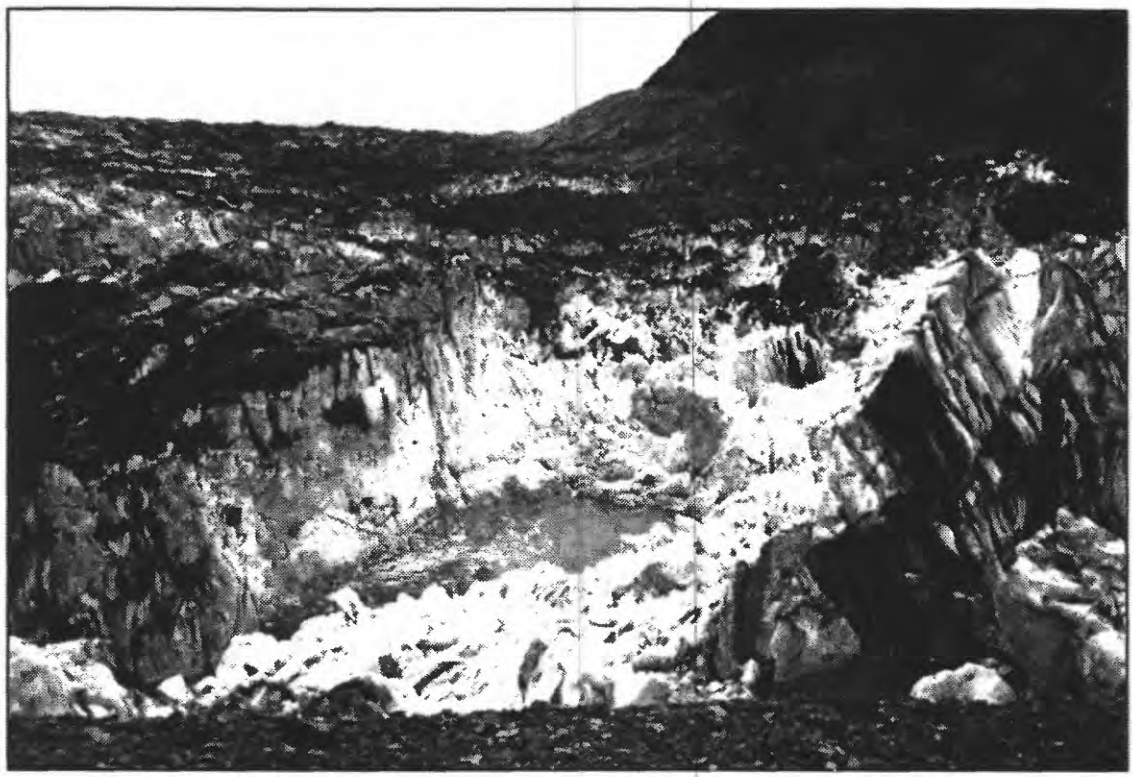


Figure 9. Large depression near the glacier margin, Hidden Creek Lake, August 31, 1994.

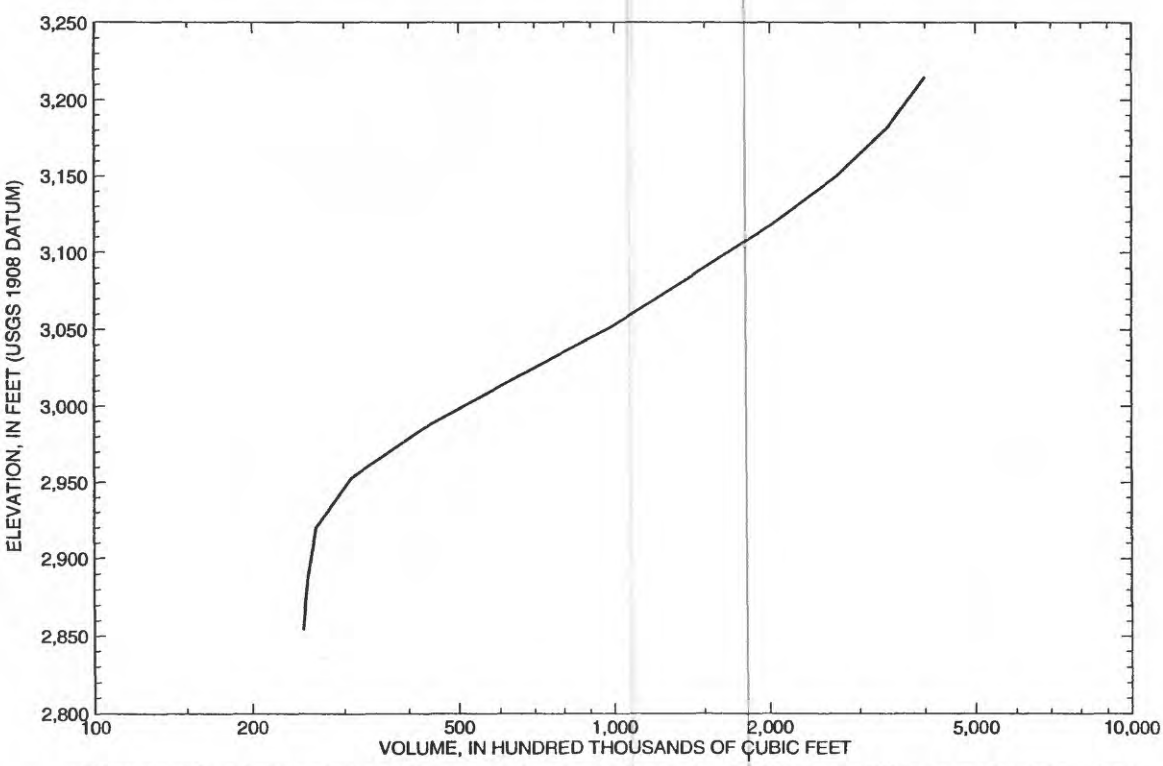


Figure 10. Hidden Creek Lake volume (based on 1994 and 1995 survey data; not adjusted to exclude volume displaced by icebergs)

Other Glacier-Dammed Lakes

Erie Lake is the second largest glacier-dammed lake in the Kennicott basin (fig. 2, table 2). **Strandlines** indicate that recent maximum lake stages are lower than historical lake levels (fig. 11). The lake usually outbursts during July or early August, based on observations made in 1982, 1988, and 1993-95. The Erie Lake outburst occurred before the Hidden Creek Lake outburst in 1994, and after the Hidden Creek Lake outburst in 1995. Erie Lake drained in 3 days during the 1994 outburst. One of the **englacial** or **subglacial** conduits, observed during the 1994 outburst, is located at the up-glacier end of the lake, indicating a complex drainage system (Roger Elconin, Humboldt State University, written commun., 1994). A compilation of Erie Lake fill and drain information can be found in appendix 4.

Donoho Lake is located at the confluence of the Root and Kennicott Glaciers (fig. 2). Its main source of inflow is a small creek (fig. 12) that drains non-glacier lakes below Donoho Peak, as well as snowmelt and glacier icemelt from the surrounding glaciers. During 1994, the lake drained in early June after Jumbo Lake drained, and prior to Erie and Hidden Creek Lake outbursts. Unidentified englacial and (or) subglacial sources, as well as rain and glacier meltwater, refill the lake periodically after the initial early summer outburst. As Hidden Creek Lake drains, Donoho Lake refills with muddy water and remains full until Hidden Creek Lake is empty, at which time Donoho Lake also drains. Muddy water refilling this lake is a good indicator that the Hidden Creek Lake outburst has begun. A summary of historical data and references for Donoho Lake can be found in appendix 4.

Since 1948, two or three small lakes, referred to as Gates Lakes, have formed near the confluence of the Gates and Kennicott Glaciers (fig. 2). These are usually the last glacier-dammed lakes in the Kennicott basin to drain; however, monitoring in 1994 revealed small declines in water level in July. They did not drain until late fall.

Jumbo Lake is adjacent to Root Glacier between Erie Lake and Bonanza Lakes (fig. 2). Amazon Creek, Jumbo Creek glacier meltwater, and rainwater all contribute to Jumbo Lake. Historical records show that the lake is empty during July and August (appendix 4). The lake slowly drained over a 6-day period between May 20 and May 26 during 1994. This lake is connected to the internal drainage system of Root and Kennicott Glaciers: it refills when Hidden Creek Lake drains. Jumbo Lake prior to draining in 1994 is shown in figure 13.

Bonanza Lakes consist of two small ponds located adjacent to the Kennecott Mining Company mill at Kennicott (figs. 2 and 14). In four of six years in which outburst can be defined, the outburst occurred in May or June. They remain empty throughout the summer.

Numerous small supraglacial lakes are found on the Kennicott, Root, and Gates Glaciers. Individual lake volumes are relatively small compared with the volumes of the glacier-dammed lakes previously discussed, but the combined volume released when conduits are opened during lake outbursts may be significant.

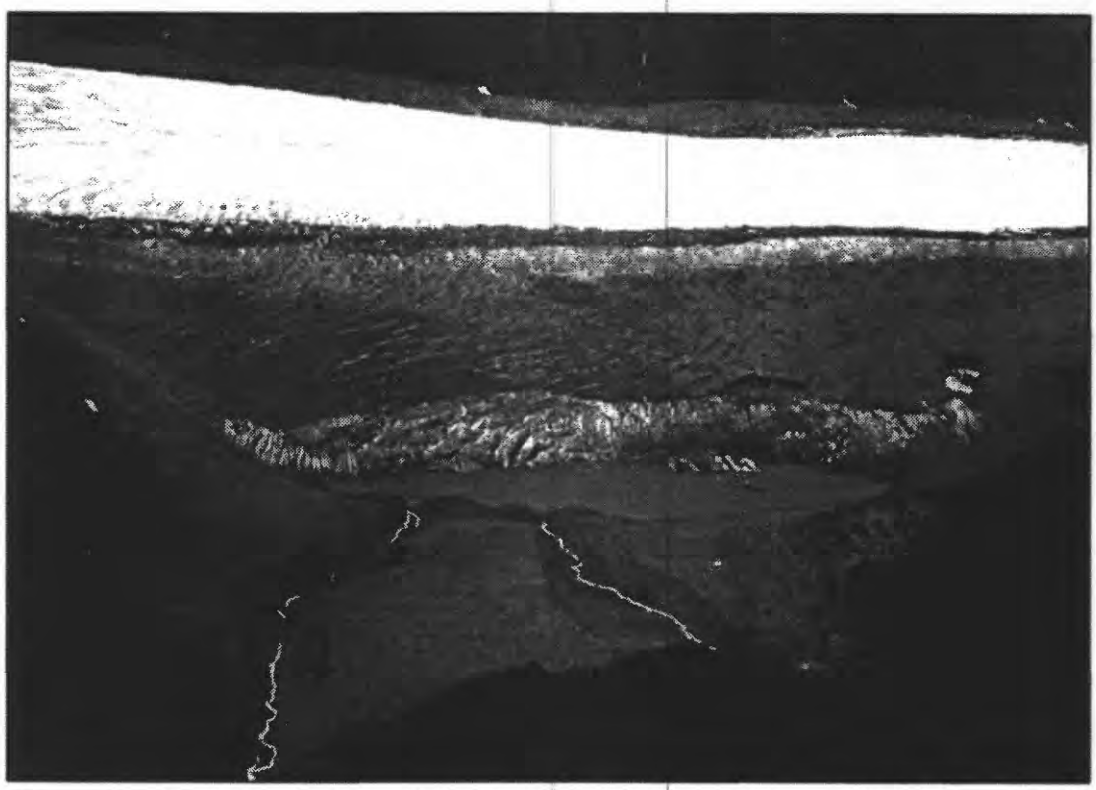


Figure 11. Erie Lake draining, July 16, 1994. (Note wash line and lightly vegetated strandlines.)

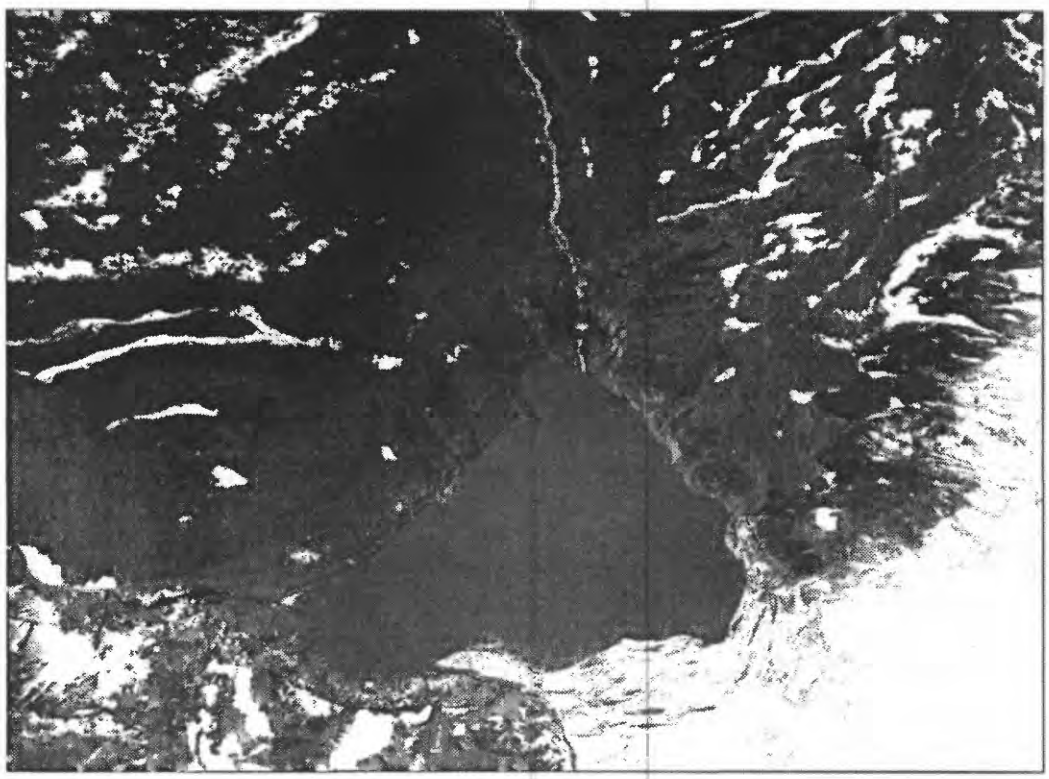


Figure 12. Donoho Lake on May 12, 1994, prior to its early summer outburst.

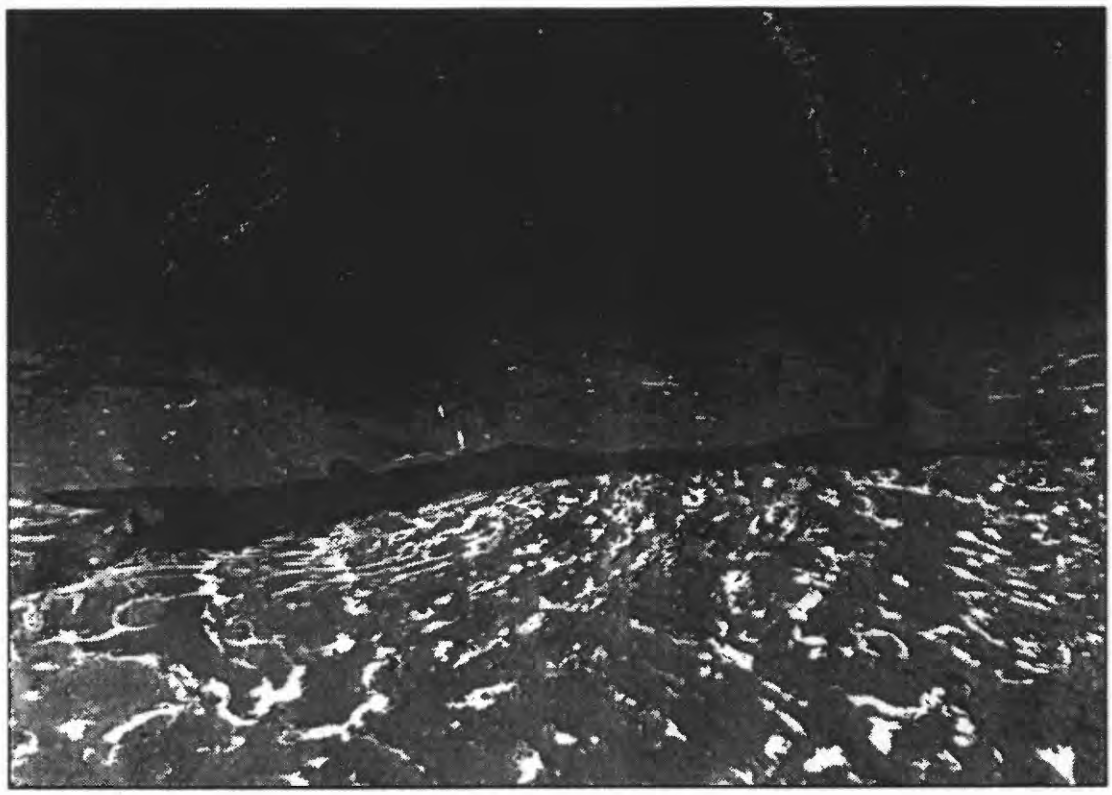


Figure 13. Jumbo Lake on May 12, 1994, prior to draining.

Figure 14. Bonanza Lakes near Kennecott mill site, May 12, 1994.

Kennicott Glacier

Internal Drainage

Englacial and subglacial drainage conduits generally follow the line of maximum hydraulic gradient (Embleton and King, 1975, p. 353). Hydraulic gradients were calculated using the 1957 maximum lake elevation for Hidden Creek Lake and the elevations of **lake/holes**, Jumbo Lake, and Donoho Lake. The largest hydraulic gradient (0.031 ft/ft) was from Hidden Creek Lake to east lake/hole 1 and west lake/hole 3 (shown on figures 16 and 19, respectively, later in this report), and the smallest (0.028 ft/ft) from Hidden Creek Lake to Donoho and Jumbo Lakes (fig. 2).

Outburst flood waters from Hidden Creek Lake enter Kennicott Glacier, refill Donoho and Jumbo Lakes, and emerge first along the eastern margin of Kennicott Glacier, not at the lake/holes of maximum hydraulic gradient. Historical records indicate that Hidden Creek Lake flood waters have consistently emerged from the glacier along the eastern margin above the East Fork Kennicott River (Bateman, 1922; McCarthy Weekly News, 1921-26; Janson, 1975; and Friend, 1988).

Bedrock and subglacial topography have an unknown influence on the internal drainage system. Small dacite knobs have recently become exposed through the thinning ice along the western flank of Kennicott Glacier. It is possible that these resistant bedrock knobs form topographic high points underneath Kennicott Glacier (fig. 15), south of Fourth of July Creek (fig. 2), and may divert englacial and subglacial water toward Donoho Lake and the eastern margin of the glacier. Crevasse patterns suggest that the glacier passes over an irregular subsurface in this region. Mapping of subglacial landforms was beyond the scope of this study. If the dacite forms discontinuous high points or is not present, future outburst flood water may emerge from the western side of Kennicott Glacier. Future flood hazard potential would change significantly if more of the outburst flood waters were to emerge from the western side of the glacier.

A series of **en echelon** fractures were developed in Kennicott Glacier adjacent to Root Glacier in 1994 and 1995 as flood waters flowed to Jumbo Lake. During the early part of the 1994 Hidden Creek Lake outburst, the hydraulic pressures were sufficient to fracture the ice. Numerous supraglacial ponds drained and water was observed to flow from these fractures. During outburst floods, supraglacial lakes and possible englacial and subglacial waters are tapped, compounding the flood magnitude in the Kennicott River.

Terminus Advance and Retreat

The maximum advance of Kennicott Glacier is estimated to have occurred about 1860. This estimate is based on tree-ring data collected from stands of trees in the Kennicott basin and glacier margins (Barry Hecht, Balance Hydrologic, Inc., oral commun., 1996; Viereck, 1967). Kennicott Glacier and associated outwash areas have changed dramatically as the glacier has retreated from its 1860 maximum (figs. 16-19).

Changes in the glacier terminus were small between 1860 and 1909, as shown by the plan map generated during the survey for the Copper River and Northwestern Railway (fig. 20), which depicts the glacier margin near its maximum extent. Survey data from 1911, 1912, and 1920 suggest that glacier retreat began shortly after 1909. The western 1860 **trim line** was reported to be approximately 175 ft above the 1957 glacier position (Field, 1975). Photographs taken in the early 1900's show a significantly higher glacier ice surface elevation for areas near the Kennecott mill and glacier terminus. The terminus of Kennicott Glacier has retreated 2,000 ft since 1909 and the corresponding active stream channel/ice margin water elevation has dropped as much as 70 ft, as indicated from geomorphic profile surveys (figs. 21A-B). The average glacier retreat rate between 1909 and 1995 was approximately 20 ft annually (fig. 21A). Glacier retreat west of the West Fork Kennicott River has been less dramatic (figs. 16, 19, 21C-E).

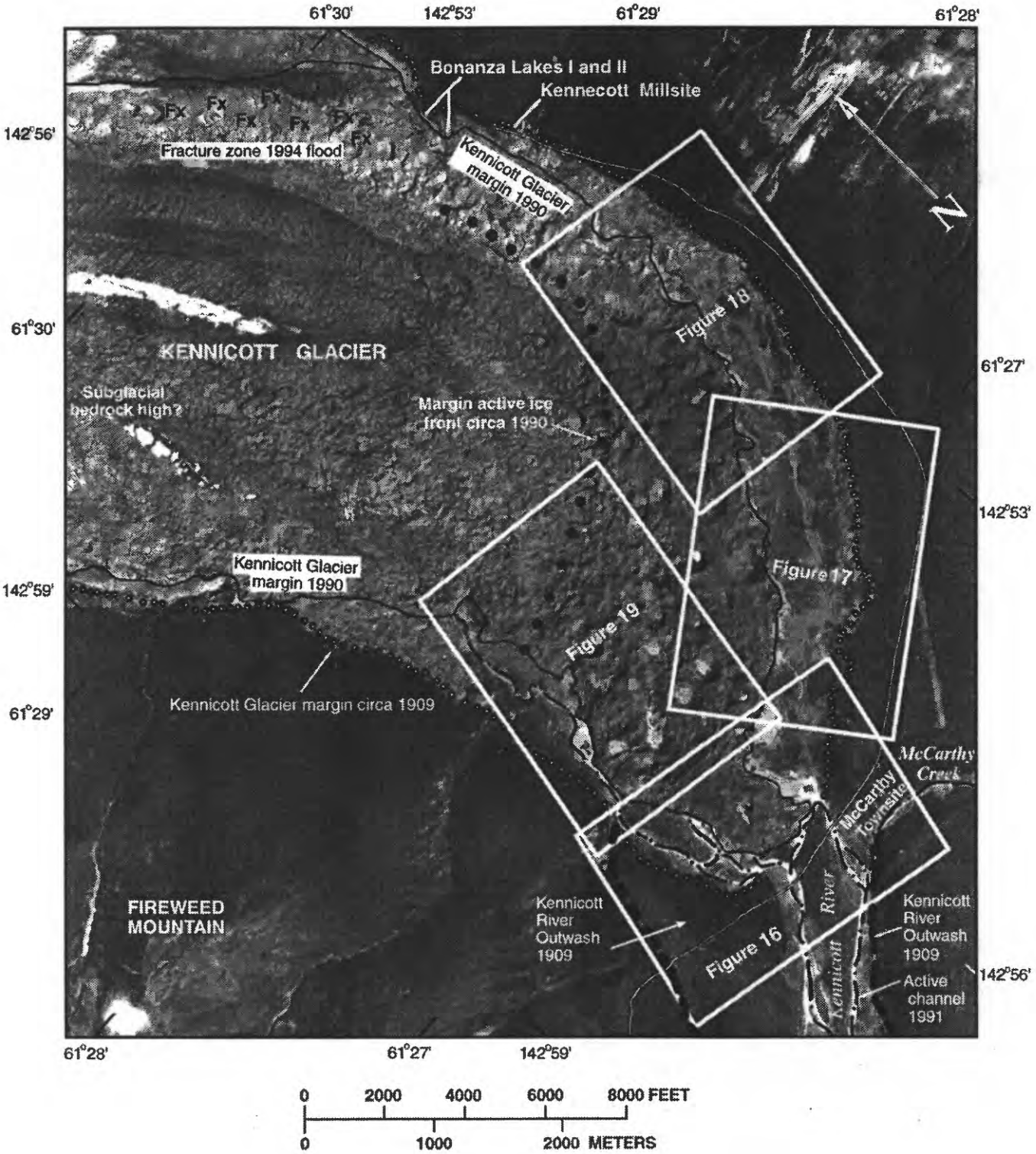


Figure 15. Kennicott Glacier and outwash history, 1860 to 1995, index map. (National Park Service Aerial Photograph)

KENNICOTT GLACIER AND OUTWASH HISTORY, 1860 TO 1995

EXPLANATION FOR FIGURES 16, 17, 18, AND 19

1860 X–X–X–X–X Feature formed in association with 1860 advance

Leading edge of 1860 moraine

X–––X–––X Pre-1909: feature formed during 1860-1909 period

Pre-1909: channel formed during 1860-1909 period

1909 Circa 1909 feature or channel

1925 1925 Circa 1925 channel

1937 Circa 1937 lake or channel

1957 Circa 1957 lake or channel

1966 X X X X X X Circa 1966 channel

1970 Circa 1970 channel or lake

1978 1978 Circa 1978 channel

1983 Circa 1983 channel or lake

1985 Circa 1985 channel or lake

1988 1988 Circa 1988 channel or lake

1990 Photo base Circa 1990 feature (aerial photograph, August 22, 1990, scale 1:10,500)

1994 1994 Circa 1994 feature

1995 1995 Circa 1995 feature

Margin geomorphic feature

Margin active ice front, pre-1948

Margin active ice front, 1990

1970-83 Minimum known time period that channel/lake was active

1985 Point where water exits glacier and corresponding year

Geomorphic profile monument

GP2 Geomorphic profile and number (see fig. 21)

Trees buried by outwash deposits 860 years before present: Carbon-14 dating (Gordon Jacoby, Tree Ring Laboratory, Columbia University, written commun., 1995.)

Fx Fracture in ice

L Lake or pond

FP Flood plain

CH Channel

OW Outwash

FLD Flood

B Waterboil/fountain

PH Historic "pothole" feature

ELH /WLH East or West lake/hole where water accumulates or exits glacier

0 500 1000 1500 FEET

0 100 200 300 400 METERS

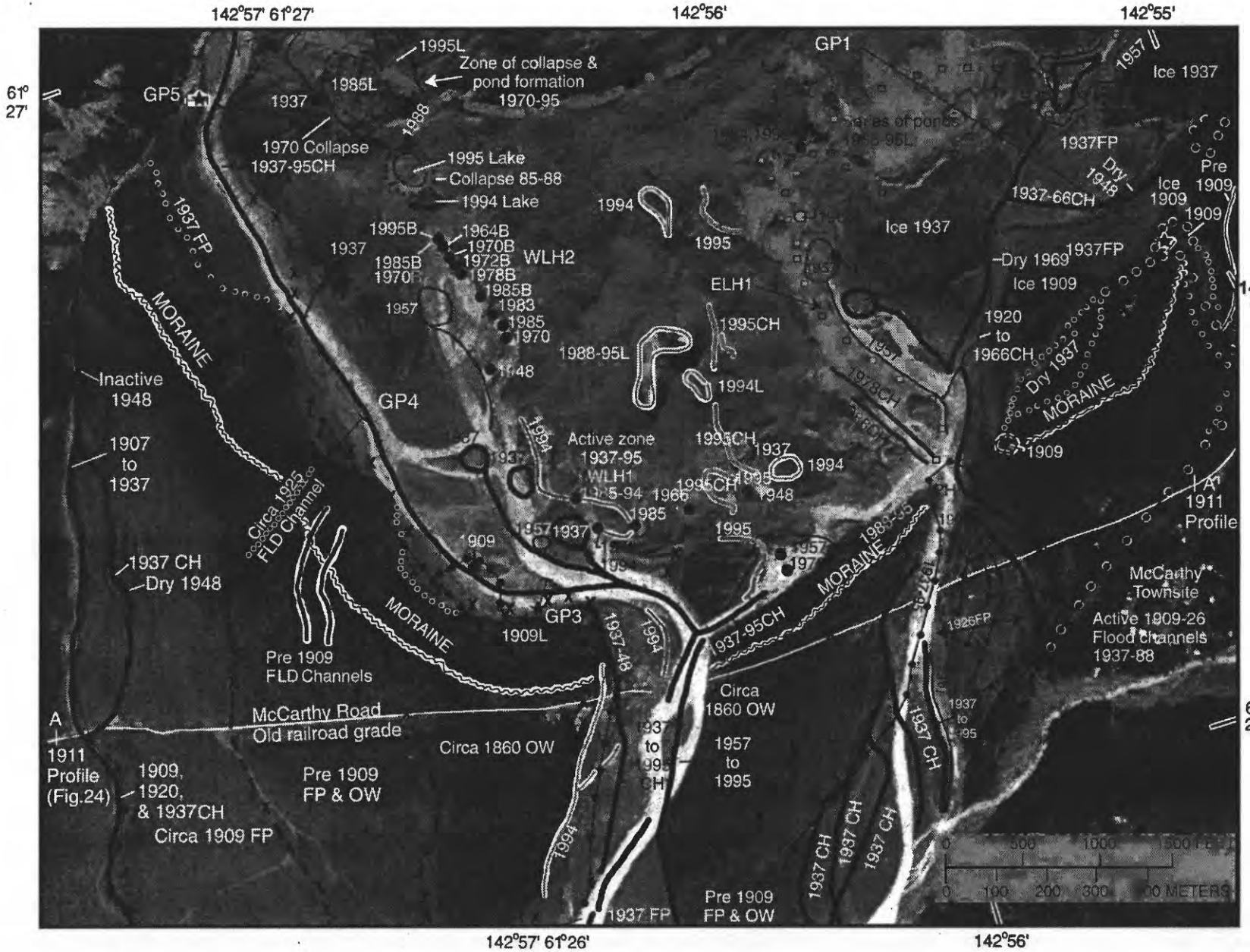


Figure 16. Kennicott Glacier and outwash history, southside.

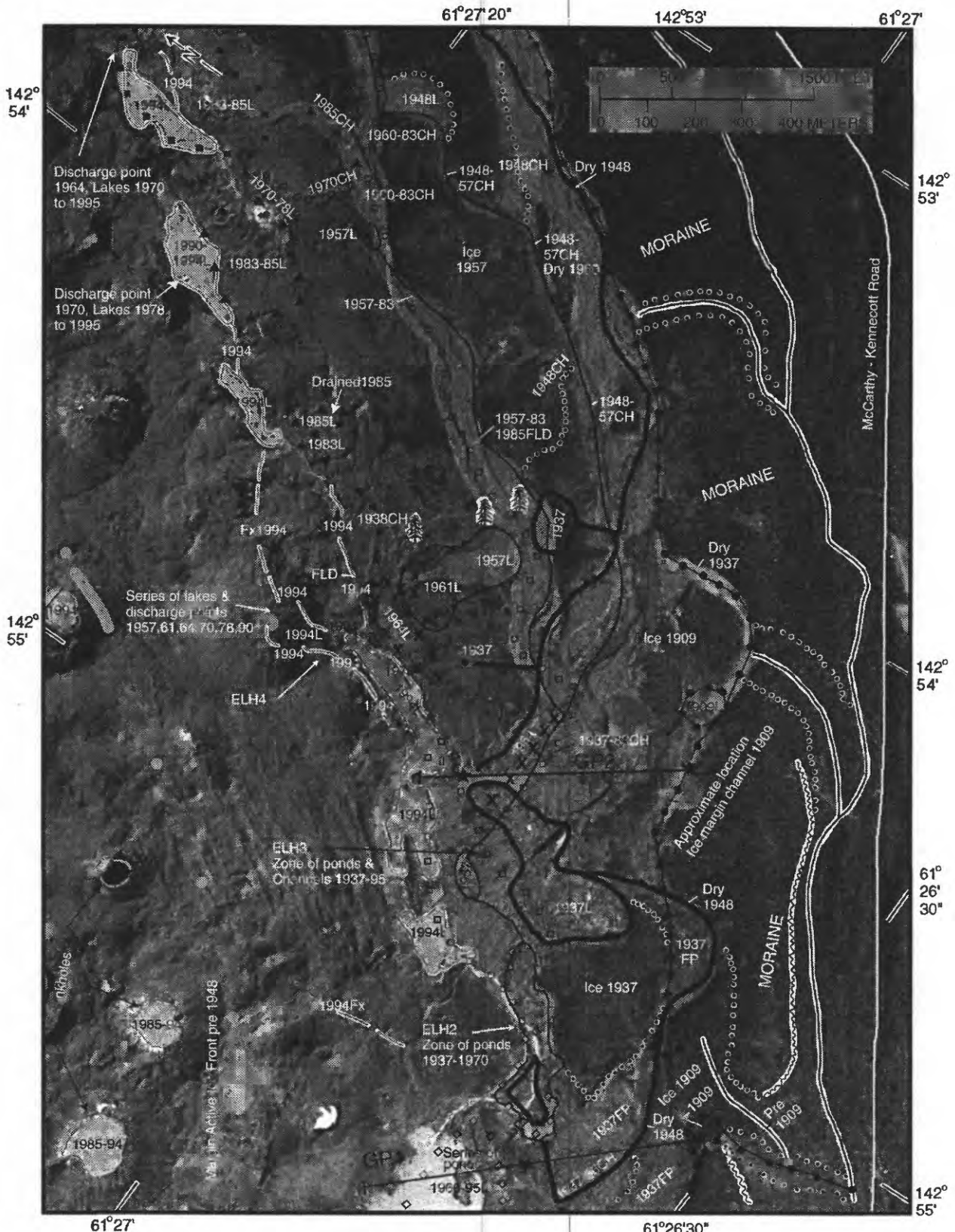


Figure 17. Kennicott Glacier and outwash history, lower east side.

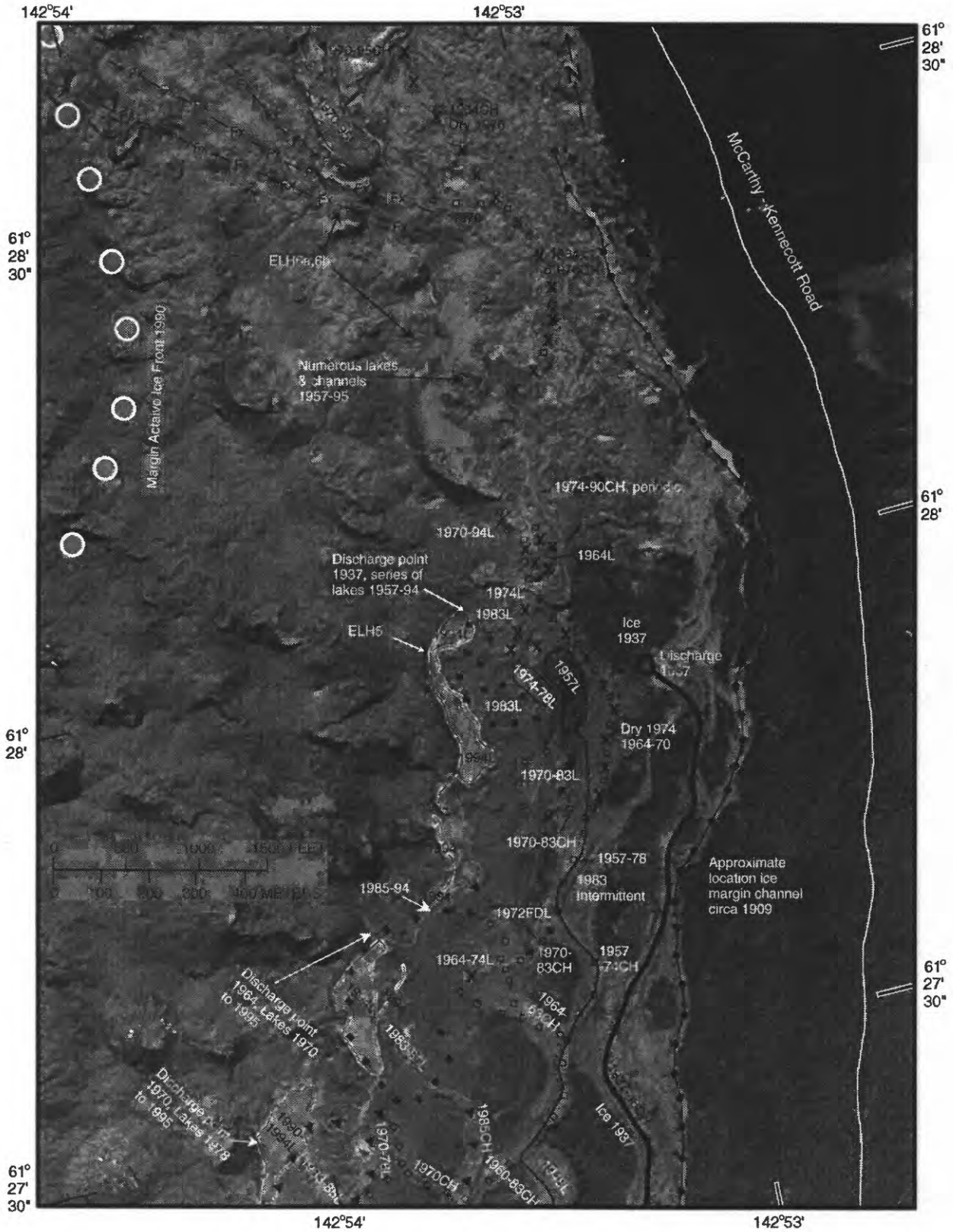


Figure 18. Kennicott Glacier and outwash history, upper east side.

Figure 19. Kennicott Glacier and outwash history, west side.

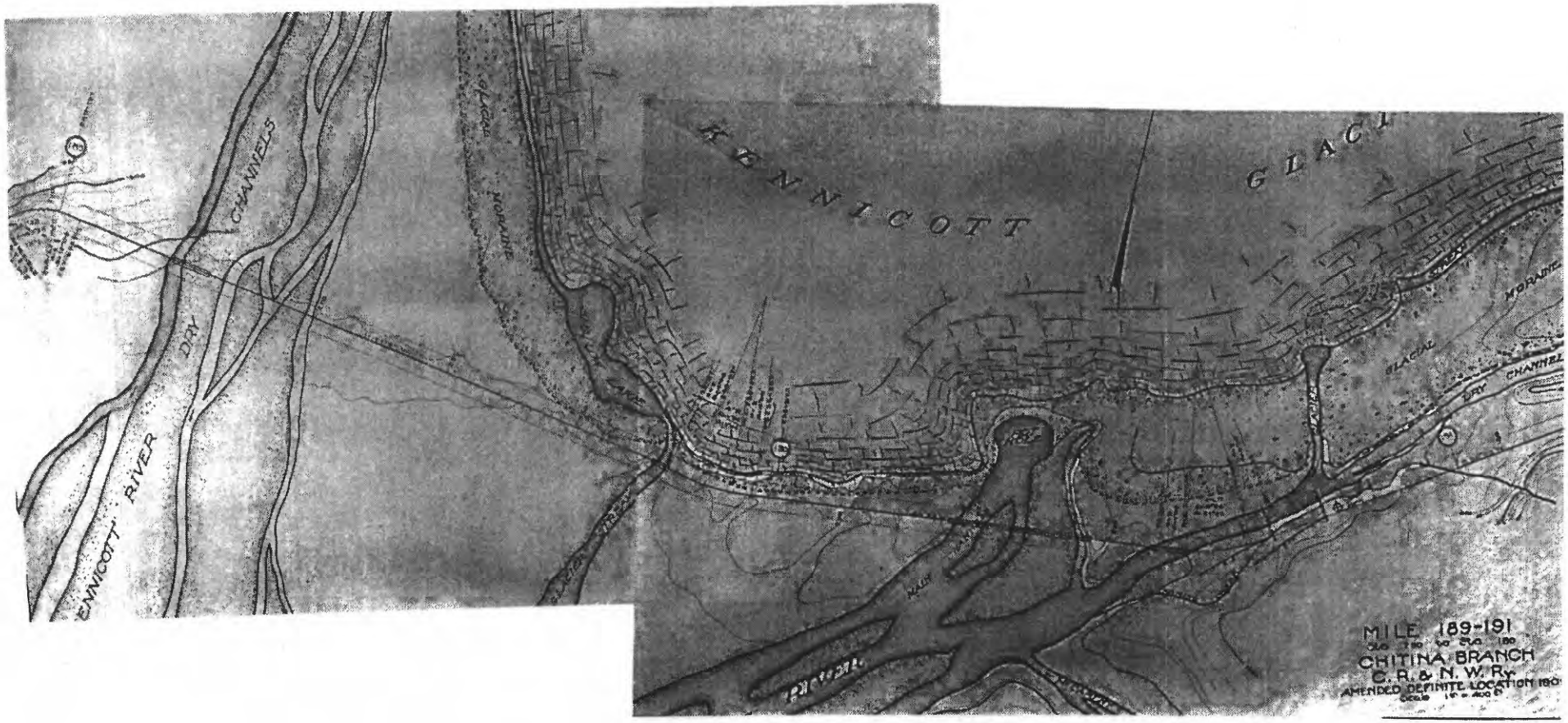
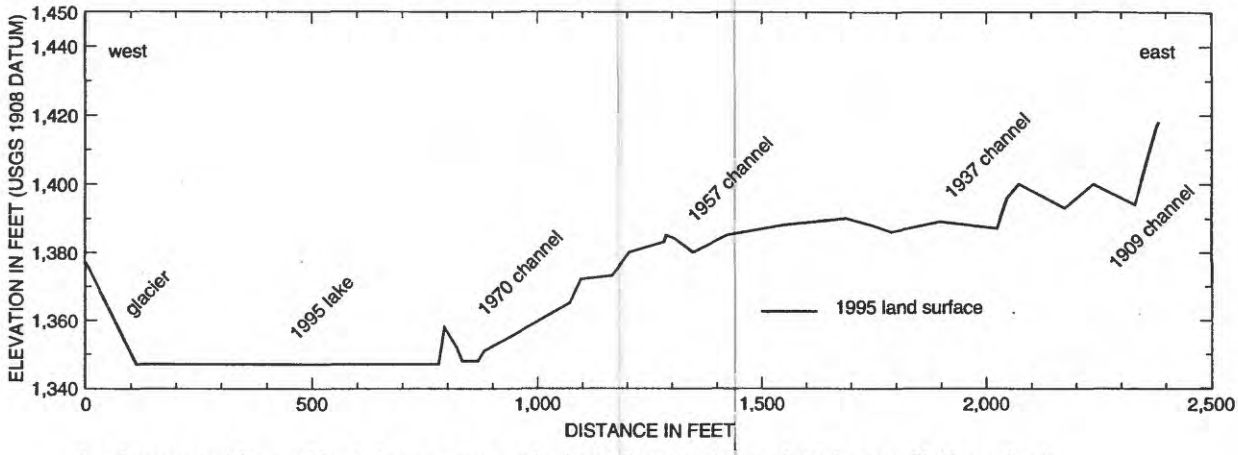
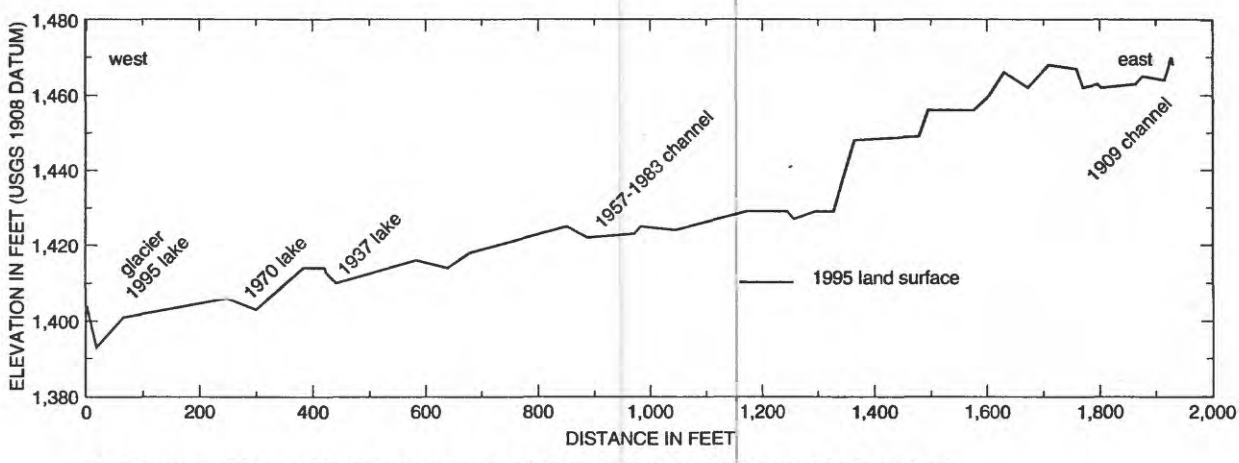


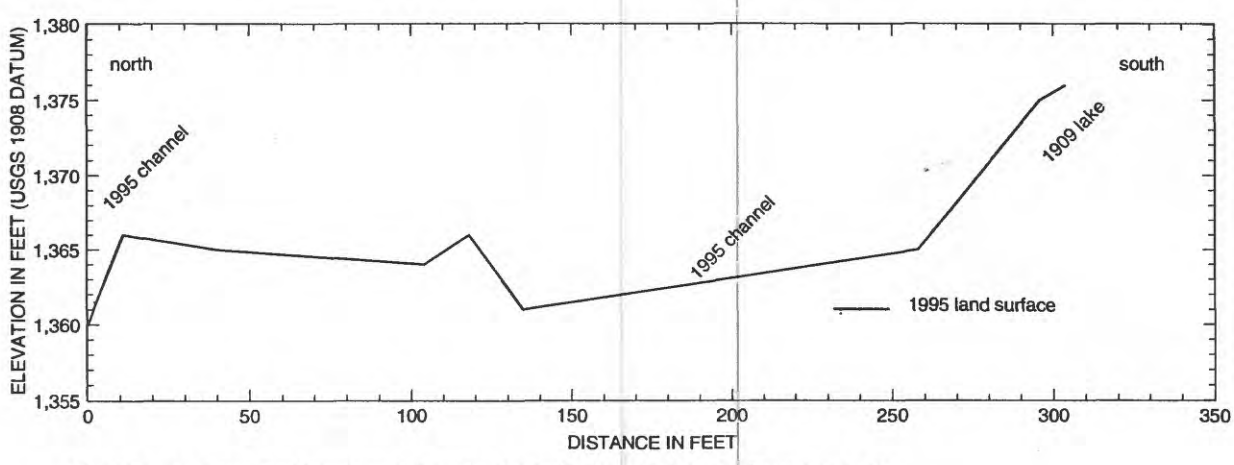
Figure 20. Copper River and Northwestern Railway 1909 survey plan view map.



A. Geomorphic profile 1, lower east side (see figures 16 and 17 for profile location).

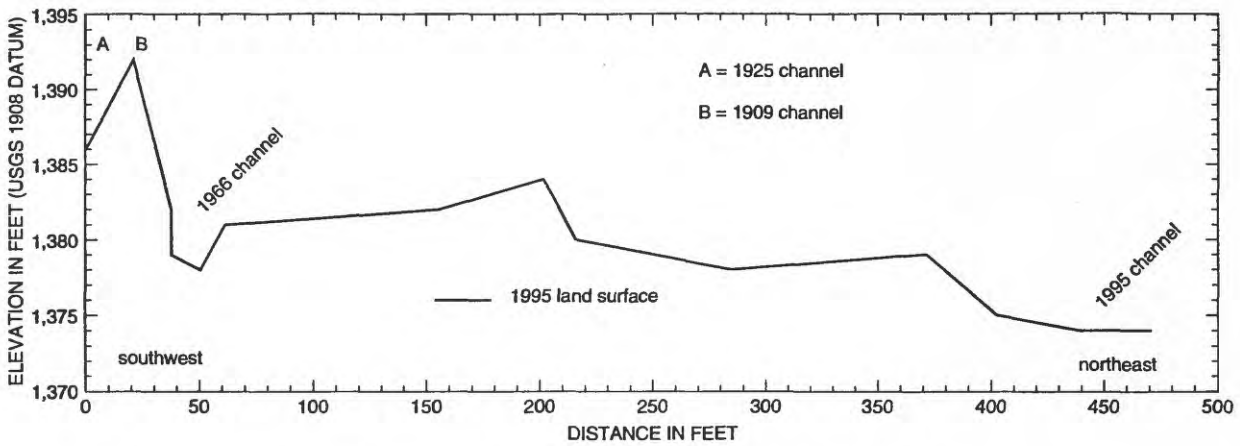


B. Geomorphic profile 2, upper east side (see figure 17 for profile location).

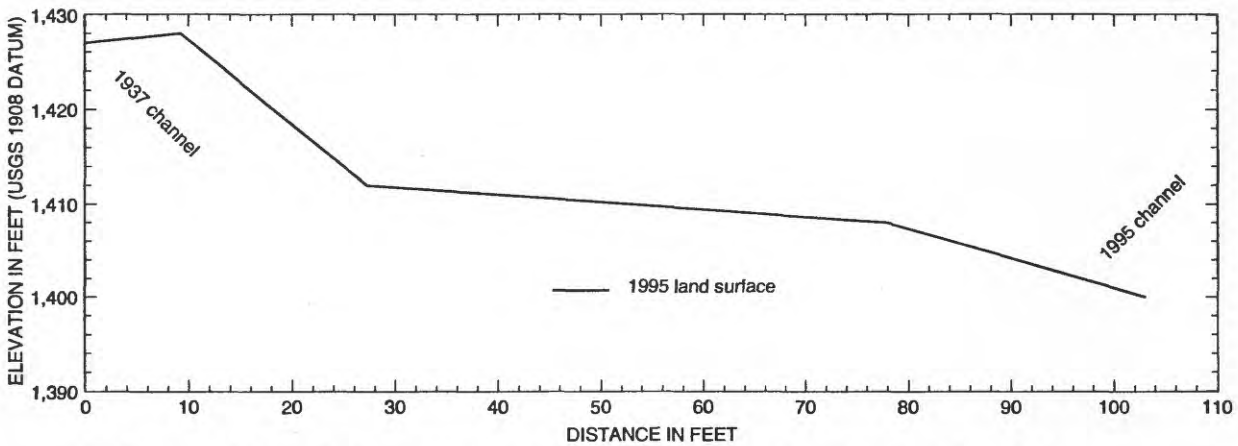


C. Geomorphic profile 3, south side (see figure 16 for profile location).

Figure 21. Geomorphic profiles of Kennicott Glacier outwash.



D. Geomorphic profile 4, lower west side (see figure 16 for profile location).



E. Geomorphic profile 5, upper west side (see figure 16 and 19 for profile location).

Figure 21. Continued.

Outwash Area Evolution

To predict future changes, the stream channel and lake/hole morphology from 1860 to 1995 for Kennicott Glacier and its outwash area has been reconstructed using historical photographs and documents (table 3; figs. 15-19). Ice-margin lakes, active stream channels, discharge points, **sinkholes**, and glacial and geomorphic features are plotted for the following years: about 1860, pre-1909, about 1909, 1937, 1957, 1970, 1990, 1994, and 1995. In addition, selected information for 1925, 1966, 1978 and the 1980's is plotted.

Physical conditions in Kennicott Glacier and its outwash area evolve as the glacier thins and retreats. Recognizing the stages in this evolutionary sequence provides a useful tool for predicting future drainage pattern changes and assessing potential flood hazards. A recurring evolution pattern appears, which is most obvious along the southeastern margin where the glacier's retreat is most extensive. This study identified four general stages of outwash area evolution: ***karst***, *pond*, *active channel,* and *abandoned channel*. These constitute a continuum of conditions. In many areas, the characteristics overlap and merge, and not all conditions may be present at any given

Table 3. Documentation for the reconstruction of the Kennicott Glacier and its outwash area

Source	Date
USGS map, Bulletin 374 (Moffit and Maddren, 1909)	1907
Copper River and Northwestern Railway survey maps	1909
United States Land Office (published 1920)	1912
Oblique aerial photography by Bradford Washburn	1937-38
Trimetrogon aerial photography	June 18, 1948
Aerial photography, USGS, scale 1:48,000	July 27, 1957
Oblique aerial photograph, USGS	August 8, 1960
Oblique aerial photograph, USGS	July, 1961
Oblique aerial photographs, USGS	August 24, 1964
Oblique aerial photograph, USGS	July 20, 1966
Oblique aerial photograph, USGS	August 27, 1969
Aerial photograph. Aeromap, Inc., scale 1:20,000	August 26, 1970
Aerial photograph. National Aeronautic and Space Administration, scale 1:60,000	July 21, 1972
Aerial photography, USGS, scale 1:12,000	September 1, 1974
Aerial photograph. Aeromap, Inc., scale 1:2,000	June 11, 1976
Aerial photograph. National Aeronautic and Space Administration, scale 1:60,000	August 1978
Aerial photograph. Aeromap, Inc., scale 1:12,000	August 19, 1983
Oblique aerial photograph, USGS	August 24, 1984
Aerial photograph, National Park Service, scale variable	September 12, 1985
Aerial photograph, National Park Service, scale variable	August 10, 1988
Aerial photograph, National Park Service, scale variable	August 22, 1990
Aerial photograph, University of Alaska Fairbanks, Office of Land	June 14, 1994
Oblique photographs, National Park Service	1994
Oblique photographs, National Park Service	1995

time. These four stages consist of a set of physical conditions that form and respond to ablation, glacial retreat, and complex supraglacial, englacial, and subglacial drainage controls. Small annual changes are common and catastrophic changes are known to occur, especially during outburst floods. A similar pattern of evolution is also observed in the lower reaches of the Kuskulana Glacier northwest of McCarthy (fig. 1) and Nadina Glacier (terminus, about 70 mi. northwest of McCarthy).

The *karst* stage occurs below the active parts of the glacier within the moraine-covered stagnant ice areas (figs. 16-19), in which tension fractures indicative of ice movement are absent. Characteristically, the karst stage contains small and large sinkholes, which are quasi-stationary. Initially, these features are circular in plan view, and cone shaped, but as their perimeters melt and collapse, they become elongated, which suggests linear englacial or subglacial channel controlling mechanisms. Small ponds occur within the karst areas, some of which evolve from sinkholes and others from collapse zones. During glacier-dammed lake outbursts, these sinkholes and ponds fill, which suggests a connection with the internal drainage system of Kennicott Glacier. Englacial and subglacial conduits are active in the karst stage. As melting progresses, caverns and passages form and expand. They persist from year to year. Discharge from west lake/hole 3 (WLH3, fig. 19)—which lies within the karst area—increases during outbursts, suggesting that it is connected to the glacier's internal drainage system, whereas west lake/hole 4 (WLH4, fig. 19), situated in the active glacier, has a constant discharge during outburst floods. The karst area acts like a large sponge during outburst floods. Large volumes of flood water are temporarily retained in the karst area, especially during the initial stages of an outburst when caverns and ponds are filling with water.

The *pond* stage occurs as Kennicott Glacier thins and retreats. Remnant karst sinkhole features persist and subglacial channels carry water between ice margin ponds. The ponds form embayments into the stagnant glacier ice along the ice-outwash margin and in the stagnant glacier ice adjacent to the margin. Most ponds are elongated (figs. 16-19) and change size and location over time. They eventually merge forming elongated ponds between the outwash gravel and glacier ice. Some of the lakes show dramatic stage changes during outbursts, suggesting that they are connected by englacial and subglacial channels. Ice-margin lakes, such as those observed near east lake/hole 4 (ELH4, fig. 17), have persisted as geomorphic features (1937, 1957, 1964, 1970, and 1990) and are connected to the internal drainage system of the glacier.

A transition to the *active channel* stage occurs as the ice-margin lakes connect, undercutting the ice margin or downcutting through outwash deposits. Between 1909 and 1995, the active channel position has migrated toward the center of the valley (figs. 16-18), and streambed elevation has declined (fig. 21). Active channels carry water for periods ranging from a few years to more than 25 years (fig. 16). Some active channels are eventually separated from the glacier margin by islands of moraine-covered ice, as noted for the 1909 and 1937 ice locations (figs. 16 and 18). Eventually, the elevation of the active channel becomes higher than that of the glacier margin ponds. Downcutting and migration of active channels may occur rapidly in unconsolidated outwash sediments. For example, a channel downcut approximately 20 ft into unconsolidated outwash sediments in the east lake/hole 4 area during the 1994 Hidden Creek Lake outburst flood (fig. 22).

The final stage of outwash area evolution is the *abandoned channel*. Catastrophic and small annual changes in the drainage system cause active channels to be abandoned. Abandoned channels are initially connected to bodies of water along the glacier margin. Englacial and subglacial channels become the new active conduits, lowering the pre-existing water-surface elevation which causes the older active channel to be bypassed. Initially, some of these abandoned channels carry flood water, but are eventually abandoned completely. The 1909 and 1937 channels along the eastern margin are examples of abandoned channels (figs. 16 and 18). Eventually abandoned channels are perched at elevations outside of any current flood hazard zone (fig. 21).

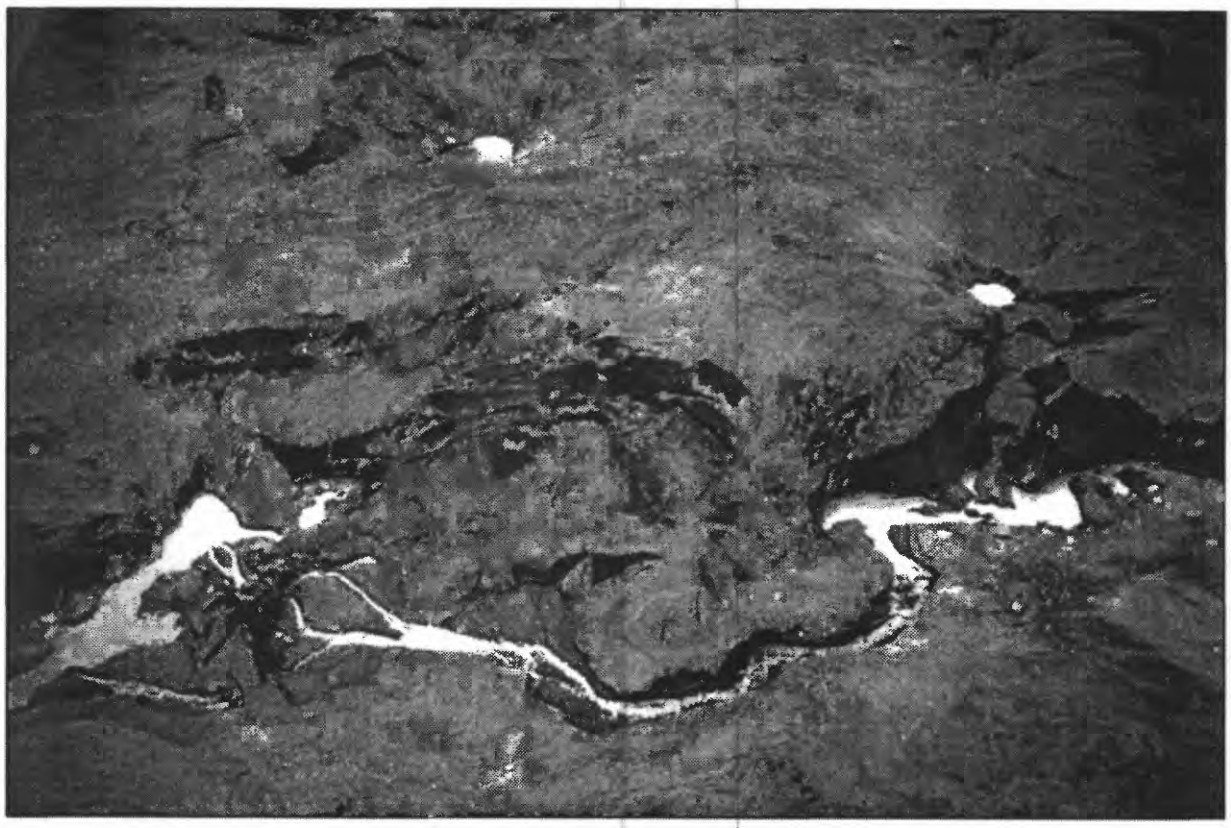


Figure 22. Channel downcutting near east lake/hole 4 resulting from the 1994 Hidden Creek Lake outburst flood.

Kennicott River

Source

The source of the Kennicott River is the Kennicott Glacier. The flow regime of the river is modified by increasing and decreasing snowmelt and icemelt, rainfall, lake outbursts, and groundwater inflow.

Outburst water from Hidden Creek Lake travels along undelineated englacial and subglacial conduits and issues from numerous locations along the margin of Kennicott Glacier. During outbursts, water boils out from beneath the glacier at discrete points. The "**pothole**," described and photographed in the early 1900's, is the most well-known example (fig. 20). It was located adjacent to the Copper River and Northwestern Railway bridge and was most active during the Hidden Creek Lake outbursts. The pothole and west lake/hole 2 were active in 1909; they have since remained active, but have migrated 2,000 ft up-glacier, and are likely to continue migrating up-glacier. Migration up-glacier of east lake/hole 4, and west lake/hole 2 could result in the capture of other active channels and increase the hydraulic efficiency of the glacier's internal drainage system. Shreve (1972) and Hooke (1989) conclude that increased hydraulic efficiency could result in sharper and higher discharge peaks.

Seven discharge sites were active during the 1994 and 1995 outbursts. Large volumes of water issued from the glacier at east lake/hole 6 (ELH6a, 6b, fig. 18) and west lake/hole 2 (WLH2, fig. 16) during the 1994 and 1995 outbursts. Flood water in 1994 and 1995 traveled through and adjacent to the karst zone along the eastern side and adjacent to the western margin of the Kennicott Glacier from west lake/hole 3 (WLH3, fig. 19).

Stage and Streamflow

Gages installed on the West and East Forks Kennicott River used a common datum established by GPS surveying techniques. On the West Fork Kennicott River, seasonal stage and streamflow data were obtained from 1992 to 1995 using the methods described by Rantz and others (1982). River stage was recorded at 30-minute intervals. Crest-stage gages were used to verify recorded maximum stage. On the East Fork Kennicott River, staff gages and a crest-stage gage were read daily in 1991 and periodically from 1992 through 1995. Frequency of staff-gage readings increased during floods.

Stage-discharge relations for both forks were developed by using current-meter discharge measurements during periods of low flow (Buchanan and Somers, 1969). For periods of medium to high flows, the relations were developed by using **slope-area** (Dalrymple and Benson, 1967; Fulford, 1994) and **step-backwater** (Davidian, 1984; Shearman and others, 1986; Shearman, 1990) indirect methods. It was not possible to measure flood water discharge directly using current meter methods because of safety concerns.

The Alaska Department of Transportation and Public Facilities (ADOT&PF) provided two topographic maps (1-foot contour interval) of the transportation corridor (which occupies the old Copper River and Northwestern Railway bed) and tram areas on the East and West Forks Kennicott River. The first map was based on a May 1994 survey made before the Hidden Creek Lake outburst flood, and the second was based on an October 1994 survey made after the outburst flood. Both ADOT&PF surveys used an arbitrary vertical datum. Channel cross-section information used for indirect discharge measurements on the West Fork Kennicott River was derived from the ADOT&PF maps and adjusted to the USGS 1908 datum. A summary of datum adjustments are listed in appendix 2.

Stage hydrographs (1992-95 water years) for the West Fork Kennicott River are shown in figure 23 (Schellekens and others, 1996). Maximum stage and corresponding discharge for selected events are presented in table 4. Combined East and West Fork Kennicott River discharge volumes from Hidden Creek Lake outburst floods averaged 2.1 billion cubic feet (appendix 5).

Annual maximum stages for the 1992-95 water years occurred during the Hidden Creek Lake outburst floods (fig. 23, table 4). The highest stage observed during this study was 1,353.16 ft at the West Fork Kennicott River gage and 1,363.82 ft at the East Fork Kennicott River gage. Rises in stage from Erie Lake outbursts are also evident, as are some rainfall events. Sharp peaks attributed to englacial or subglacial releases (Johnson, 1990) were evident during the summers of 1992 and 1993, but not during 1994 or 1995. Stage rises from other glacier-dammed lake failures, including Donoho, Gates, Bonanza, and Jumbo Lakes, are not evident. A gradual, but noticeable rise in stage on the West Fork Kennicott River is evident during the days preceding the Hidden Creek Lake outburst floods (fig. 23). The rise preceding the 1994 flood coincides well with the observed gradual drop in lake level at Hidden Creek Lake. Friend (1988) noted this same phenomenon during the 1986 outburst flood.

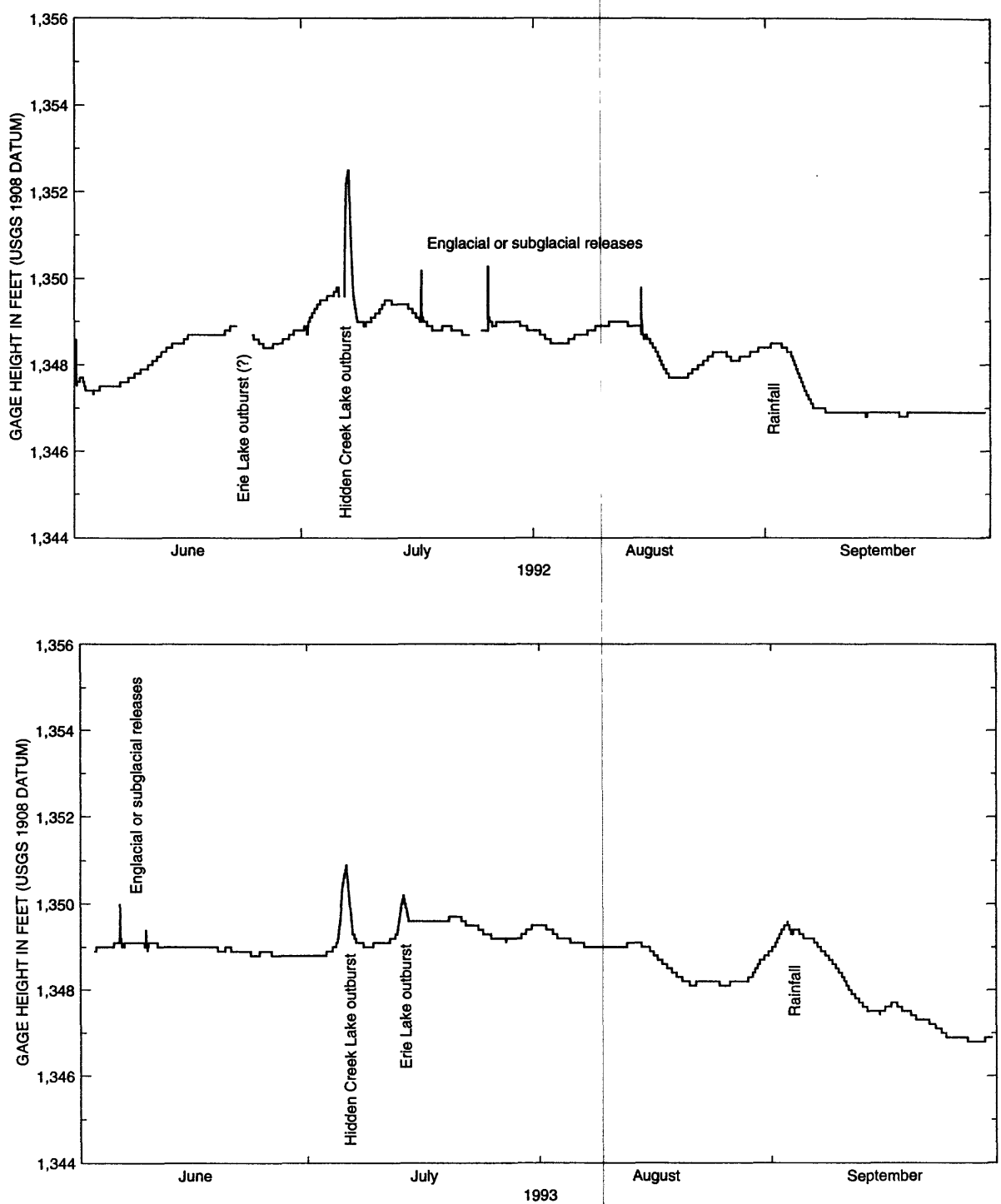
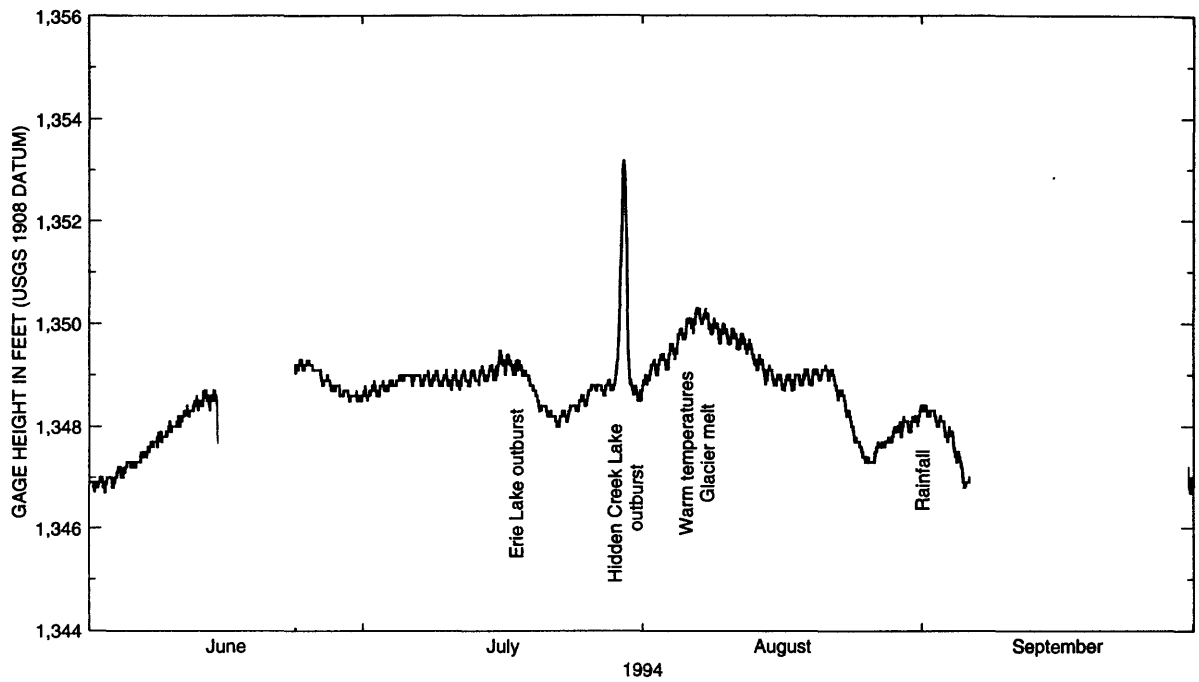


Figure 23. West Fork Kennicott River stage and explanation for peaks, June through September, 1992 to 1995.



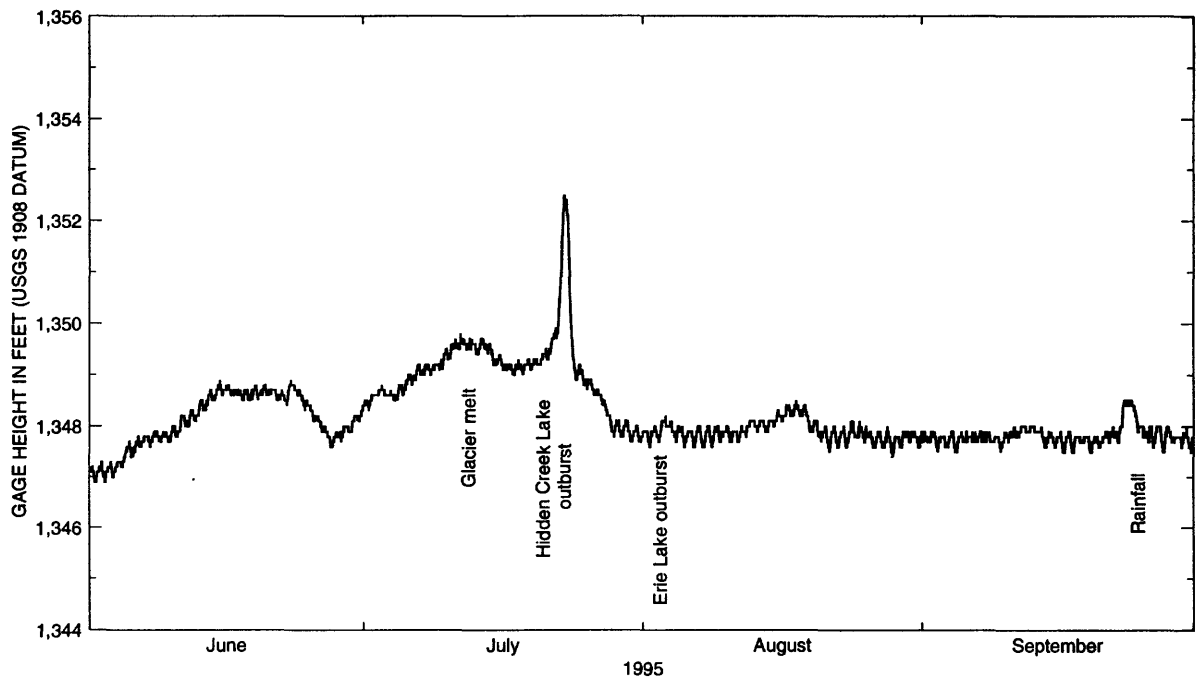


Figure 23. Continued.

Table 4. Maximum discharge and stage for selected hydrologic events on the East and West Forks Kennicott River, 1991 to 1995 water-years

[ft^3/s, cubic feet per second; ---, unknown; data from Schellekens and others, 1996]

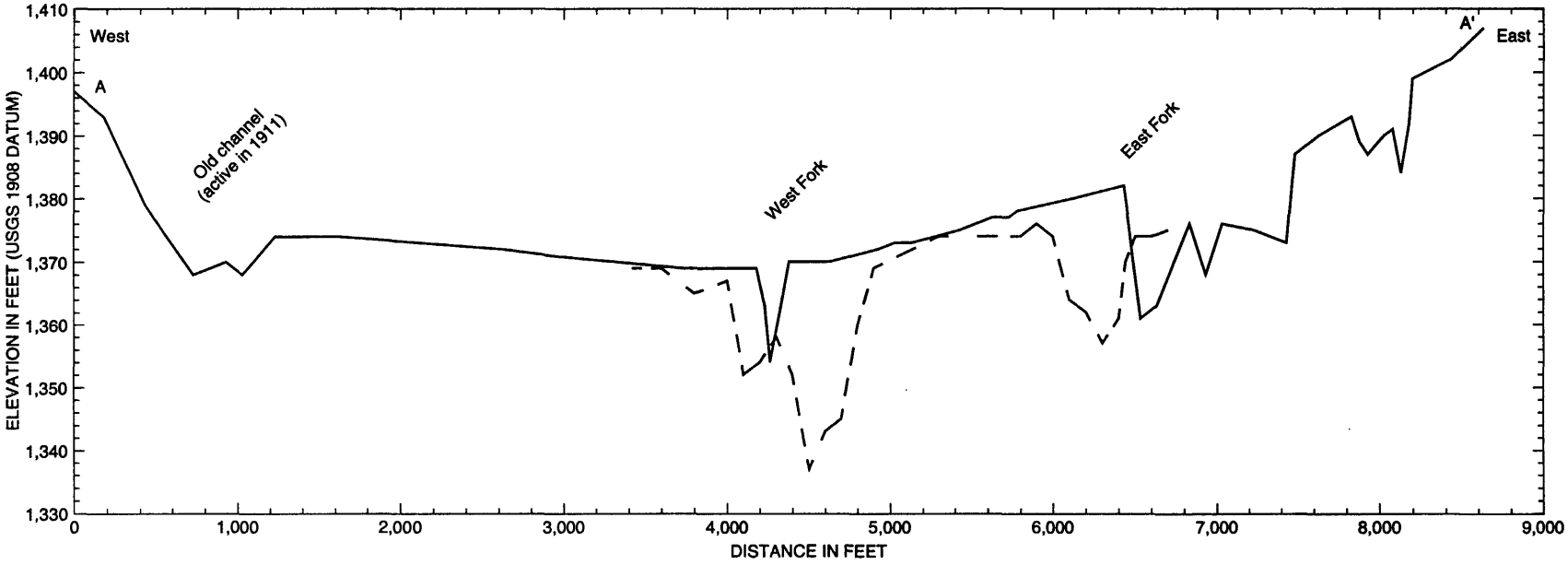
Date	Hydrologic event	West Fork		East Fork	
		Discharge (ft^3/s)	Stage (feet)	Discharge (ft^3/s)	Stage (feet)
August 4, 1991	Hidden Creek Lake outburst	20,000	1,352.22	4,500	1,363.82
July 7, 1992	Hidden Creek Lake outburst	23,200	1,352.51	3,820	1,363.16
July 17, 1992	Englacial or subglacial release	10,900	1,350.21	---	---
July 25, 1992	Englacial or subglacial release	11,100	1,350.27	---	---
June 6, 1993	Englacial or subglacial release	10,200	1,349.98	---	---
July 6, 1993	Hidden Creek Lake outburst	13,500	1,350.87	---	---
July 13, 1993	Erie Lake outburst	10,800	1,350.18	---	---
July 16, 1994	Erie Lake outburst	8,810	1,349.52	---	---
July 29, 1994	Hidden Creek Lake outburst	28,000	1,353.16	3,900	1,363.24
August 7, 1994	Rainfall	11,200	1,350.31	---	---
July 11, 1995	Warm; glacier melt	9,550	1,349.76	---	---
July 23, 1995	Hidden Creek Lake outburst	23,400	1,352.54	2,190	1,361.42

Historical maximum flood stages at the East and West Forks Kennicott River have been higher than those observed during this study. It is not known if historical flood discharges were larger or smaller than those observed during this study, because hydraulic properties have not been determined for historical floods.

River Channel Erosion, Aggradation, and Channel Migration

The lower terraces and active flood plain are composed of **alluvium** extending from the Kennicott Glacier terminus to the confluence with the Nizina River (MacKevett and Smith, 1972). These deposits consist of poorly sorted silt, sand, gravel, cobble, and boulder-sized material. **Glacial erratics** as large as 12 ft in diameter are common in the alluvium. An alluvial terrace lies on the western side of the West Fork active channel, as well as between the West and East Forks Kennicott River. These deposits are somewhat protected by a terminal moraine (fig. 16). Channel erosion, aggradation, and migration occur in response to thinning and retreat of Kennicott Glacier (figs. 16-19).

A profile taken along the Copper River and Northwestern Railway bed (fig. 24) shows the significant channel changes that have occurred between 1911, when the railroad survey was made, and 1994 when the ADOT&PF surveys were made.



VERTICAL EXAGGERATION X 40

EXPLANATION

—— 1911 survey, adjusted to USGS datum

- - 1994 ADOT&PF survey, adjusted to USGS 1908 datum

A - A' Line of profile shown in figure 16

Figure 24. Channel location and size in 1911 and in 1994 for the East and West Forks Kennicott River (profiles follow old railroad bed of the Copper River and Northwestern Railway).

An abandoned channel in the old alluvium terrace approximately 0.5 mi west of the West Fork Kennicott River (fig. 24) was active in 1911 (Danliquist, 1921) and remained active through at least 1937 (fig. 16). It is now perched approximately 40 ft above the active channel (fig. 21A). The West Fork Kennicott River currently occupies a much larger channel than the 1911 channel (fig. 24). The current channel has downcut nearly 20 ft and has migrated to the east. The East Fork Kennicott River currently occupies a much smaller channel than the 1911 channel and has migrated to the west. The East Fork Kennicott River main channel is well armored with boulders and has a smaller bed slope (0.004 ft/ft), making it more stable than the west channel, which consists of finer material and a steeper bed slope (0.012 ft/ft).

A capture channel between the East and West Forks Kennicott River formed during 1988 immediately upstream from the terminal moraine as the old ice under the glacier terminus melted, exposing the west-sloping subglacial terrain. This capture channel has captured progressively larger percentages of flow from the East Fork and added it to the West Fork each year during this study (table 5). The West Fork Kennicott River carried 68 percent of the total peak discharge in 1986 (prior to the formation of the capture channel) and 91 percent in 1995. During the summer of 1995, the East Fork Kennicott River was dry except during the Hidden Creek Lake outburst flood. This trend is likely to continue as the capture channel becomes more incised, eventually concentrating the entire Kennicott River flow into the West Fork.

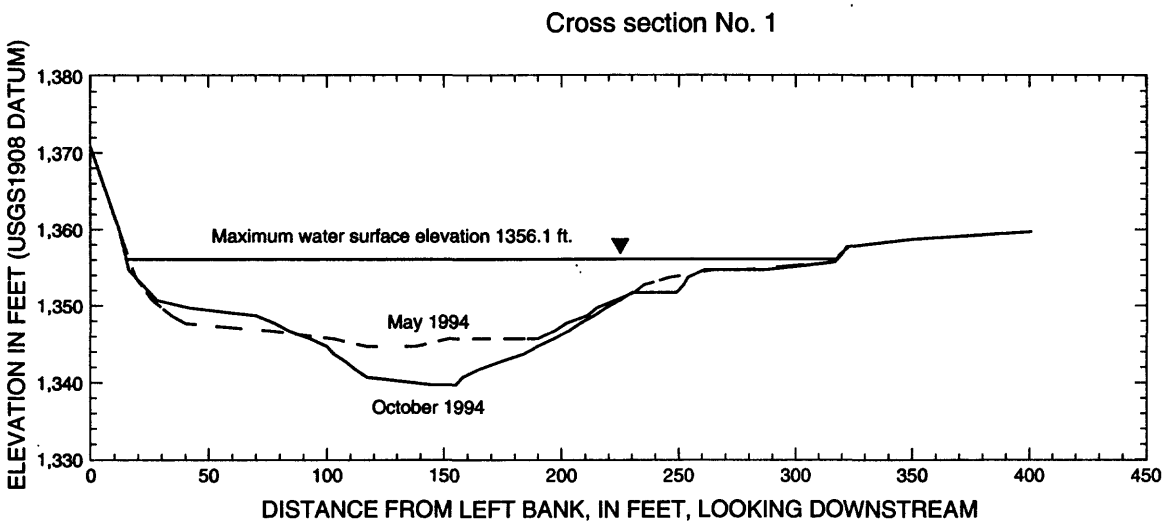
Table 5. Discharge for selected outburst floods and percentage of total discharge for the East and West Forks Kennicott River

Date	Outburst flood maximum discharge (cubic feet per second)			Percentage of total discharge	
	West Fork	East Fork	Combined	West Fork	East Fork
August 6, 1986[1]	12,100	5,600	17,700	68	32
August 4, 1991	20,000	4,500	24,500	82	18
July 7, 1992	23,200	3,820	27,000	86	14
July 29, 1994	28,000	3,900	31,900	88	12
July 23, 1995	23,400	2,190	25,600	91	9

[1]Data from Friend (1988)

An abrupt channel change was observed on the West Fork Kennicott River during the 1994 Hidden Creek Lake outburst flood (Edward LaChapelle, Randy Elliot, oral commun., 1994). Flow concentrated in the center of the channel upstream from the tram suddenly shifted toward the right bank. This sudden channel change was also noted on the stage record of the USGS gage. Plots of four cross sections (fig. 25) were made using the pre- and post Hidden Creek Lake outburst flood survey data from the ADOT&PF. The cross sections show that upstream from the tram, the **thalweg** moved toward the right bank and scoured approximately 6 ft; downstream from the tram, it moved more toward the center and filled approximately 5 ft (fig. 25). The right bank was severely scoured at all four cross sections. Cross-section locations are shown on figure 26.

The presence of **aufeis** in rivers can increase channel and bank erosion (Slaughter, 1990, p. 449). Aufeis formation is greatest during years when snowpack is low early in the winter (Johnson



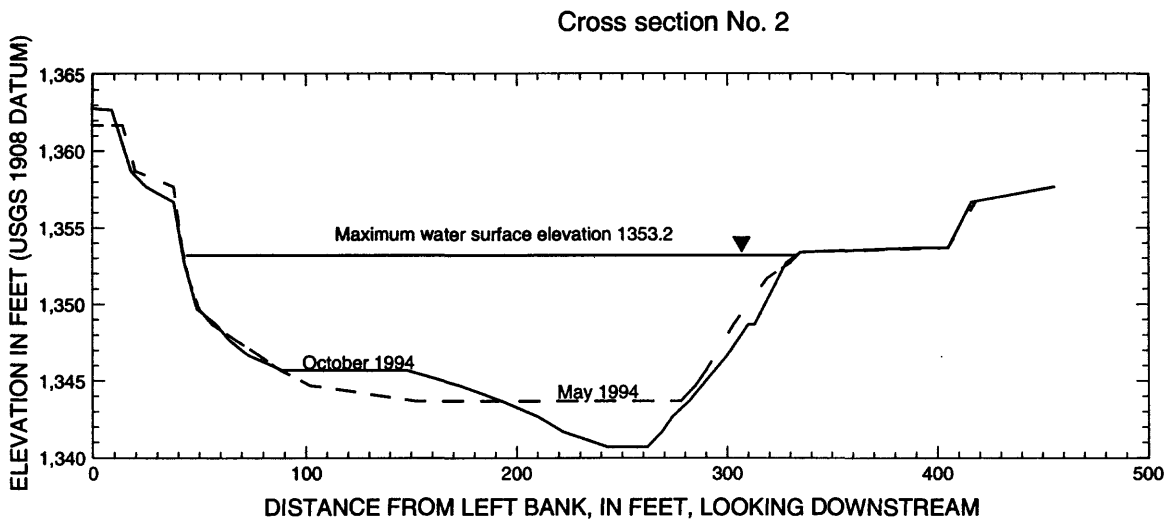
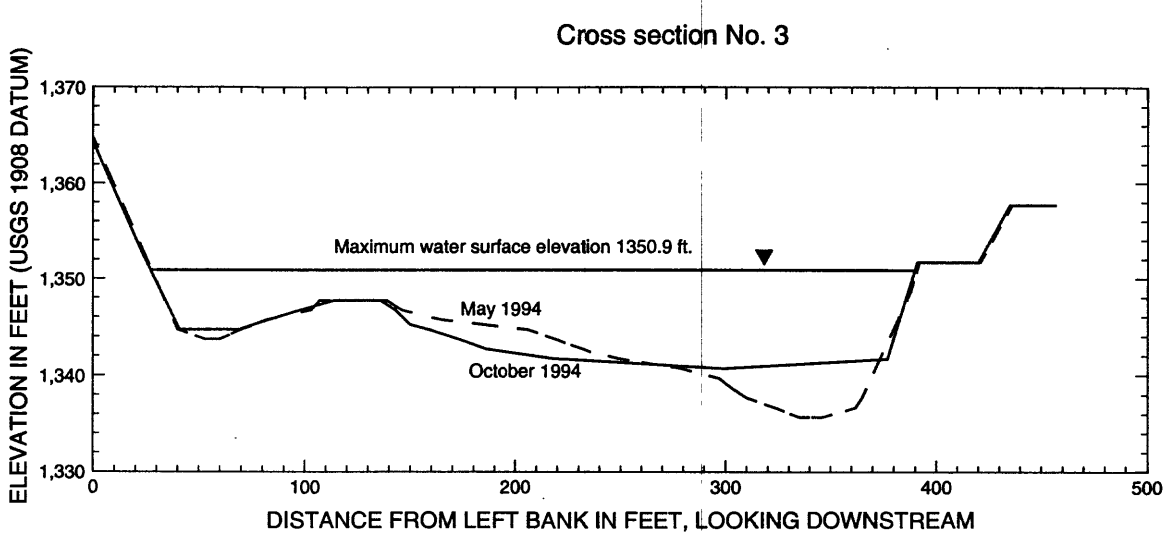


Figure 25. Pre- and post flood channel cross sections on the West Fork Kennicott River, Hidden Creek Lake outburst flood of July 29, 1994 (see figure 26 for cross-section locations).



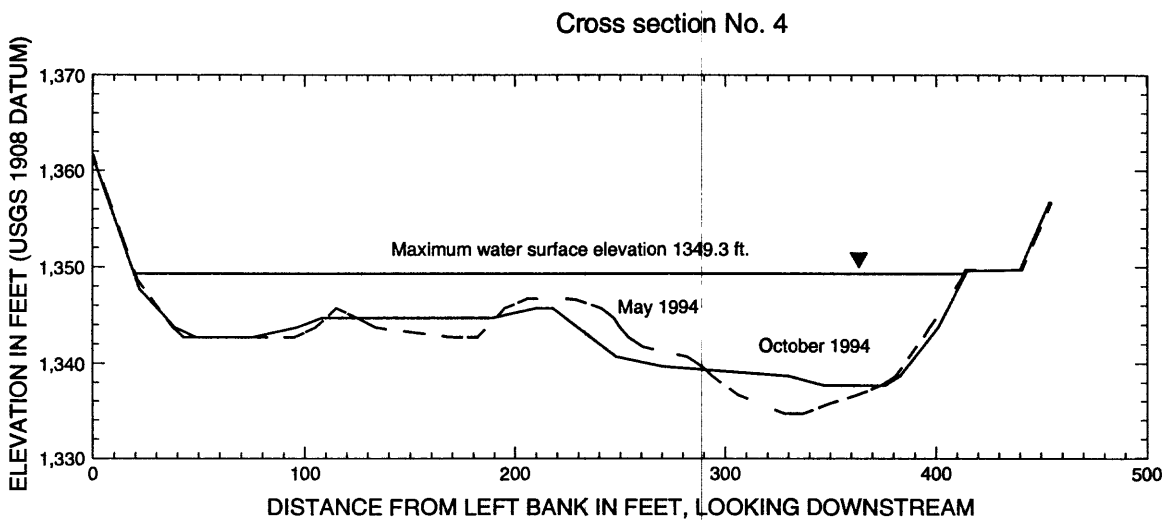


Figure 25. Continued.

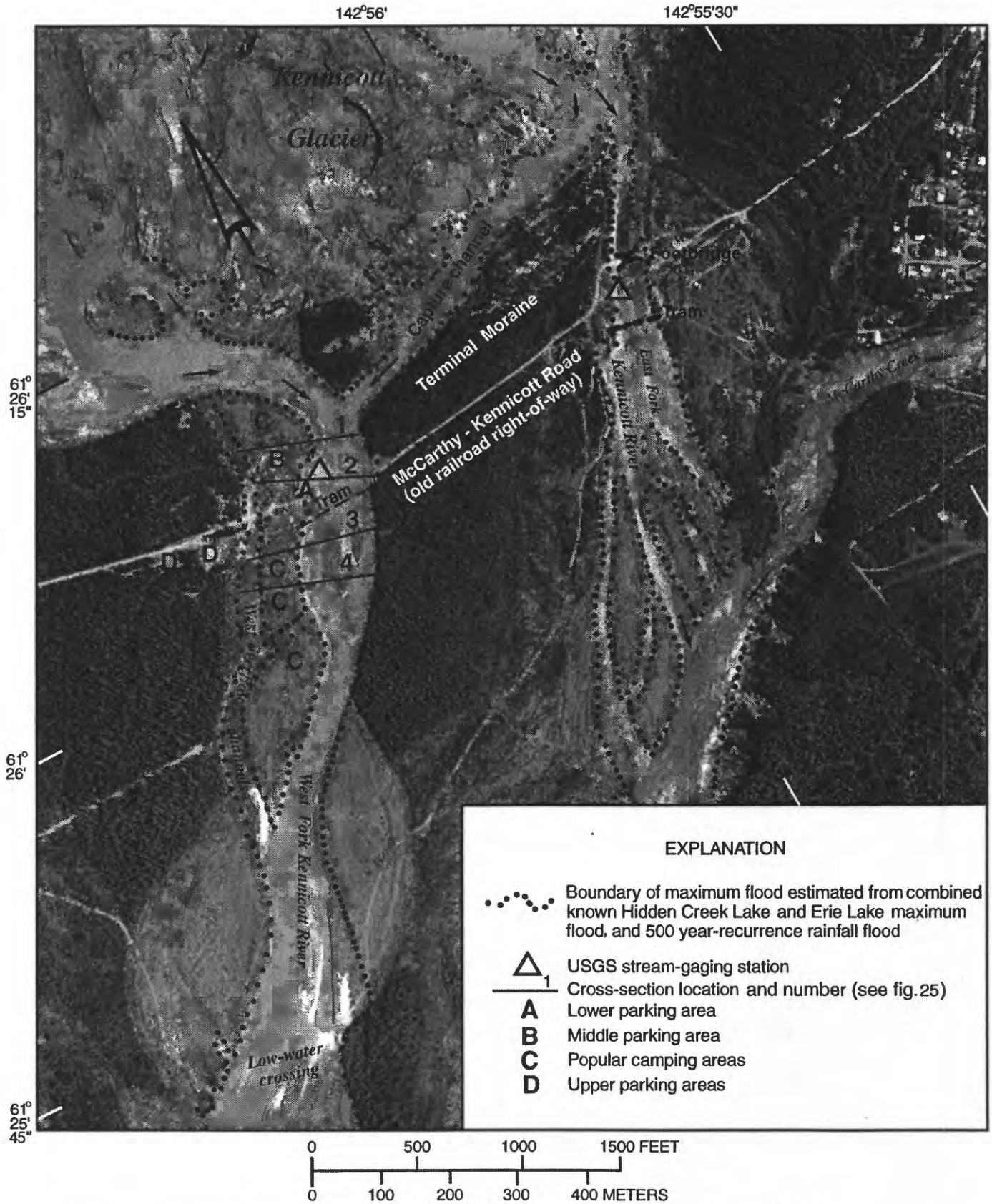


Figure 26. Kennicott Glacier terminus and Kennicott River at McCarthy, Alaska, June 14, 1994. (Aerial photograph from Aeromap.)

and Esch, 1977). No obvious correlation exists between aufeis and the rainfall of the previous summer or between aufeis and the winter severity as measured by cumulative freezing degree-days (Ashton, 1986, p. 300).

Snowpack in much of the Copper River Basin—which includes the Kennicott River Basin—was near record low water content as of February 1, 1996 (Natural Resources Conservation Service, 1996). A 6- to 8-foot-thick layer of aufeis formed during the 1995-96 winter in the West Fork Kennicott River. It extended from west lake/hole 2 (which issues water throughout the winter) to cross-section 4 downstream from the tram (fig. 26). Stream water was forced into the west overflow channels throughout the winter. Overflow channel erosion, however, was slight.

HYDROLOGIC HAZARDS

The Kennicott River Basin is prone to several natural hydrologic hazards including flooding from snowmelt or rainfall, glacier-dammed lake outburst flooding, stream erosion and sediment aggradation, and aufeis.

Flood Characteristics, 1991 to 1995

Numerous outburst floods, englacial or subglacial releases, and rainfall events (fig. 23) were recorded or observed at the West Fork Kennicott River stream-gaging station. Selected flood peak characteristics are presented in table 6.

The largest floods are caused by rapid draining of Hidden Creek Lake. The lower parking area and a small overflow channel west of the main West Fork Kennicott River channel conveyed some flow during the 1994 and 1995 Hidden Creek Lake floods.The data in table 6 show a noticeable gradual rise in river stage in the days prior to the Hidden Creek Lake outburst. This gradual rise ranged from 2 days in 1995 to 6 days in 1994. Analysis of stage hydrographs (fig. 23) shows other periods in which gradual stage rise occurred; therefore, a gradual stage rise is not an independent predictor of outburst floods. However, the stage of Hidden Creek Lake gradually declines a few days before the outburst. These observations used together may be a good tool to indicate imminent flood danger. Gradual stage rise, ranging from 0.5 to 3 days, in the West Fork Kennicott River also occurred immediately prior to Erie Lake outburst floods. Numerous "spike" peaks (less than 6 hours duration), probably caused by englacial or subglacial releases, occurred during 1992 and 1993. There were few or no gradual changes in stage prior to these releases.

The summary below shows that the duration of floods from the Hidden Creek Lake outburst is not directly dependent on the magnitude of the peak discharge, but controlled by the internal drainage of Kennicott Glacier:

Date	Maximum discharge West Fork Kennicott River (cubic feet per second)	Duration of flood (hours)
7-7-92	23,200	42
7-6-93	13,500	47
7-29-94	28,800	44

Table 6. Selected flood peak characteristics for the West Fork Kennicott River, 1991-95

Hydrologic event	Date of peak	Number of days of gradual stage rise[1]	Duration of main peak (hours)	Maximum rate of rise (feet per hour)	Change in stage from base to peak (feet)
Spike peak[2]	June 1, 1991	0	5	0.5	1.1
Outburst, Erie Lake	June 23, 1992	2	Unknown	Unknown	Unknown
Spike peak	July 1, 1992	0	3	0.3	0.3
Outburst, Hidden Creek Lake	July 7, 1992	4.5	42	0.2	3.0
Spike peak[2]	July 17, 1992	0	1	7.2	1.2
Spike peak[2]	July 25, 1992	1	1.5	7.2	1.4
Spike peak[2]	Aug. 15, 1992	0	3	5	1.0
Spike peak[2]	June 6, 1993	0	1.5	0.8	0.8
Spike peak[2]	June 9, 1993	0	1	0.7	0.4
Outburst, Hidden Creek Lake	July 6, 1993	4	47	0.2	1.4
Outburst, Erie Lake	July 13, 1993	1	30	0.7	0.6
Rainfall	Sept. 3, 1993	4	140	0.03	0.8
Outburst, Erie Lake	July 16, 1994	3	15	0.05	0.5
Outburst, Hidden Creek Lake	July 29, 1994	6	44	0.8	4.4
Rainfall	Aug. 7, 1994	Undefined	160	0.1	1.5
Outburst, Hidden Creek Lake	July 23, 1995	2	43	0.4	3.4
Outburst, Erie Lake	Aug. 3, 1995	0.5	36	0.04	0.4
Rainfall	Sept. 23, 1995	0.7	50	0.13	1.0

[1]Prior to rapid stage rise
[2]The short duration (less than 6 hours) spike peaks are probably caused by englacial or subglacial release

Durations of Erie Lake floods were highly variable, suggesting that the rate of lake draining is highly variable. Durations of spike peaks ranged from 1 to 5 hours. Durations of rainfall peaks were long (50 to 160 hours) compared with other events, probably because of long rainfall durations, and travel time of water from various points in the Kennicott basin.

The maximum rate of rise occurred with the spike peaks. The overall stage rise was small (0.3 to 1.4 ft), but sufficient to cause flooding in the lower parking area. However, the rise occurred so quickly and unpredictably that no flood warning might have been possible. Rate of rise for Hidden Creek Lake and Erie Lake outburst floods and rainfall events were more gradual, allowing more time to evacuate flood-prone areas. No changes in stage from spike peaks were observed on the

East Fork Kennicott River; however, spike peaks may have occurred that were not witnessed. Peak stages for the East Fork Kennicott River also occurred during Hidden Creek Lake outburst floods. Not enough data are available to determine whether a gradual rise in stage occurred before these floods. If the West Fork Kennicott River continues to carry a large percentage of the flow from Kennicott Glacier, it will be unlikely that gradual stage rises will occur on the East Fork Kennicott River. The East Fork will probably remain dry, or nearly dry immediately prior to the flood.

Potential Flood Magnitudes

The magnitudes of future floods in the Kennicott River may be significantly greater than those observed in 1986 (Friend, 1988) and from 1991 through 1995. If Erie Lake and Hidden Creek Lake drain simultaneously, the flood peak could be larger than those observed during this study period. A worst-case scenario would be simultaneous draining of Hidden Creek and Erie Lake coupled with a large rainfall. Potential flood magnitude for the combined flow of both forks of the Kennicott River can be estimated using existing discharge data for the Hidden Creek and Erie Lake outburst floods, and large regional floods estimated using regional flood-frequency equations (Jones and Fahl, 1994).

The recurrence interval is the average number of years within which a flood of a given magnitude will be equaled or exceeded. The frequency of a flood may also be stated in terms of probability of occurrence, which for large floods is the reciprocal of the recurrence interval. For example, a flood with a 50-year recurrence interval (Q_{50}) would have a probability of 0.02 or a 2 percent chance of being exceeded in any given year. The following flood-frequency equations were used to calculate the regional flood component. These equations, developed by Jones and Fahl (1994), used a regional multiple regression analysis of 109 peak-flow stations located over much of interior Alaska. They did not include a glacier component; however, many of the sites used to develop the equations were located in glaciated basins.

$$Q_{50} = 147A^{0.778}P^{0.544}(ST+1)^{-0.187}E^{-0.264}$$

$$Q_{100} = 185A^{0.765}P^{0.509}(ST+1)^{-0.179}E^{-0.257}$$

$$Q_{200} = 224A^{0.754}P^{0.480}(ST+1)^{-0.171}E^{-0.252}$$

$$Q_{500} = 275A^{0.742}P^{0.451}(ST+1)^{-0.160}E^{-0.245}$$

where A is the drainage area in square miles (352 mi^2 for combined East and West Forks);

P is mean annual precipitation, in inches (75 in. for the Kennicott basin; Jones and Fahl, 1994);

ST is the area of lakes in ponds, in percent (less than 1 percent for the Kennicott basin); and

E is the mean basin elevation, in feet (NGVD of 1929) (5,170 ft for the Kennicott basin).

The calculated combined peak discharges for the East and West Forks Kennicott River at various recurrence intervals, as well as the range of standard error of prediction are listed in table 7.

Table 7. Flood magnitude at 50-, 100-, 200- and 500-year recurrence intervals, and corresponding range of standard error of prediction.

Recurrence interval (years)	$Q_{regional}$ Flood discharge from regression equations (cubic feet per second)	Range of standard error of prediction (percent)
Q_{50}	15,400	-42 to 70
Q_{100}	16,400	-44 to 80
Q_{200}	17,200	-47 to 87
Q_{500}	18,400	-49 to 98

The difference between the calculated values for Q_{50} and Q_{500} is only 3,000 ft^3/s. Additionally, there is unquantifiable uncertainty in the magnitude of the lake outburst discharges and the gage stage-discharge rating error. The step-backwater model assumes a stable channel, which is not the case for the Kennicott River channel. Because of these uncertainties, a large regional flood of 18,000 ft^3/s was assumed for assessing hazard potential.

The combined discharge (Q_c) from the Hidden Creek and Erie Lake outbursts, and a large regional flood is estimated as follows:

$$Q_c = Q_{hcl - baseflow} + Q_{el - baseflow} + Q_{regional}$$

where $Q_{hcl - baseflow}$ is the maximum observed discharge peak from the Hidden Creek Lake outburst floods minus the baseflow (both forks combined);

$Q_{el - baseflow}$ is the maximum observed discharge peak from the Erie Lake outburst floods minus baseflow (both forks combined); and

$Q_{regional}$ is a large regional flood estimated using regression equations.

The baseflow component of the Hidden Creek Lake and Erie Lake outburst floods must be subtracted out because $Q_{regional}$ already includes the baseflow component for both East and West Fork Kennicott River. Q_c was determined by using the maximum flood discharge data from tables 5 and 7, and baseflow calculated from a hydrograph separation method that projects pre-peak baseflow across to the recession limb of the hydrograph at N days from the peak, where $N = A^{0.2}$ and A is the drainage area in square miles (Dunne and Leopold, 1978, p. 288). Baseflows used in this calculation were 7,000 ft^3/s for the Erie Lake flood, and 5,400 ft^3/s for the Hidden Creek Lake flood.

Q_c = 31,900 ft^3/s (Q_{hcl}, July 29, 1994) - 5,400 ft^3/s (baseflow) + 10,800 ft^3/s (Q_{el}, July 13, 1993) - 7,000 ft^3/s (baseflow) + 18,000 ft^3/s ($Q_{regional}$) = 48,300 ft^3/s.

Hazard Potentials

If the West Fork Kennicott River captures all the flow from the East Fork Kennicott River—as the present trend suggests will happen— the potential peak stage for combined Hidden Creek Lake and Erie Lake outbursts and regional floods can be estimated for the present channel geometry using step-backwater calculations (Shearman and others, 1986). Using an assumed combined discharge of 48,300 ft^3/s, maximum stage was calculated at four cross sections on the West Fork: two upstream from the tram, and two downstream (figs. 26 and 27).

Peak stages for the 1994 Hidden Creek Lake outburst flood are also plotted in figure 27. The 1994 flood was at **bankfull stage** for the main channel, with a minor quantity of overflow into the west overflow channel. A flood of 48,300 ft^3/s would cause sufficient flow in the west overflow channel to block access to or from the lower parking area (fig. 26). The area on the West Fork Kennicott River that would be submerged during the peak is shown in figure 26. If east lake/hole 4 and west lake/hole 2 continue to migrate up-glacier, sharper and higher discharge peaks may occur because of more efficient internal glacial drainage.

It is assumed that the East Fork Kennicott River as shown in figure 26 will continue to convey flood water in the near future. This hazard will diminish if the present trend of flow capture by the West Fork Kennicott River continues. The parts of the glacier terminus delineated as "flood hazard areas" are based on cross-section surveys and peak-flow observations made during the 1994 and 1995 outburst floods and on the boundary of the maximum evident outburst flood (Jones and Glass, 1993).

It is likely that the channel of the West Fork Kennicott River will continue to be unstable; this channel has been downcutting (fig. 24; fig. 25, cross sections 1 and 2). It is neither possible to predict if this trend will continue nor possible to determine if the channel will aggrade during flood-peak recessions. The tremendous volume of alluvial material on the lower part of Kennicott Glacier could cause channel aggradation. If this occurs, a larger area would be inundated and lateral migration of the channel might occur.

Lateral channel migration has occurred in the past (figs. 16 and 17), in response to thinning and retreat of the Kennicott Glacier terminus, and will likely continue in the future. Geomorphic evolution of the glacier and observations made in 1994 and 1995 suggest that the following scenario is likely to occur in the terminus outwash region (fig. 28).

Channels along the eastern margin of Kennicott Glacier will migrate westward. This migration may occur in a series of small steps or catastrophically during a flood. Future channel positions are depicted at times arbitrarily labeled "T1, T2, T3, and T4" (fig. 28). T1 through T3 are considered "probable" based on flow pattern observations made between 1991 and 1995. T4 is considered "possible," but depends on exact changes depicted with T1 through T3. The speed at which these changes occur depends on the magnitude of the outburst flood and on climatological conditions. At time T1, the channel position is expected to be approximately half way to the current confluence area. This will be followed by T2 and T3 channel positions farther to the west.

Water along the western margin of Kennicott Glacier is expected to bypass the existing channel and jump towards the center (time T2) of the valley. When this occurs, water issuing from west lake/hole 3 (fig. 19) will join with and pass directly through the west lake/hole 2 area (fig. 29). Eventually, all channels will merge to T4, and the confluence will migrate up-glacier. Changes in the glacier and outwash area will result in continued channel migration in the transportation corridor. Changes in englacial or subglacial drainage may cause glacier-dammed lakes to drain more rapidly, which would result in sharper, higher flood peaks (Shreve, 1972; Hooke, 1989).

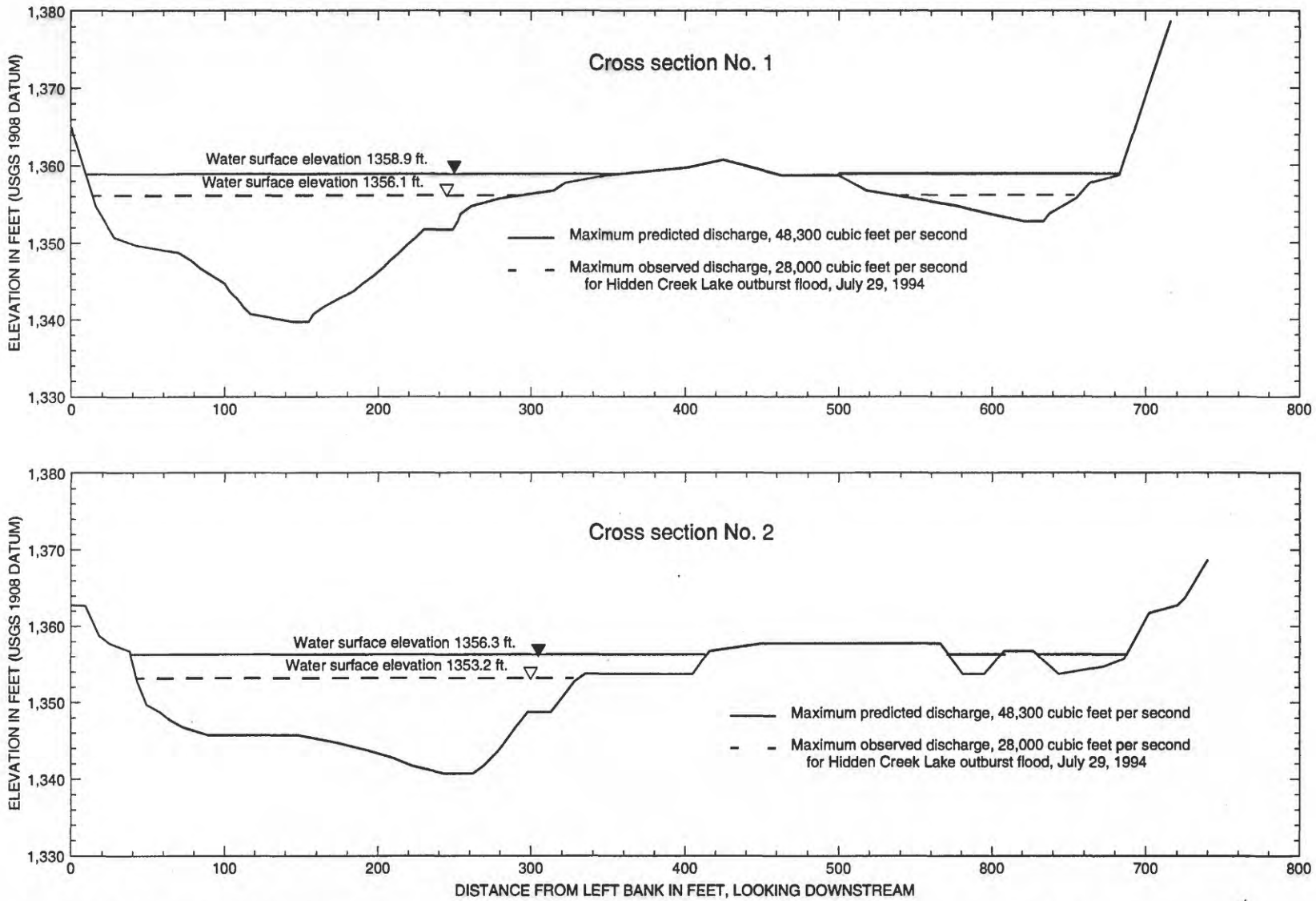
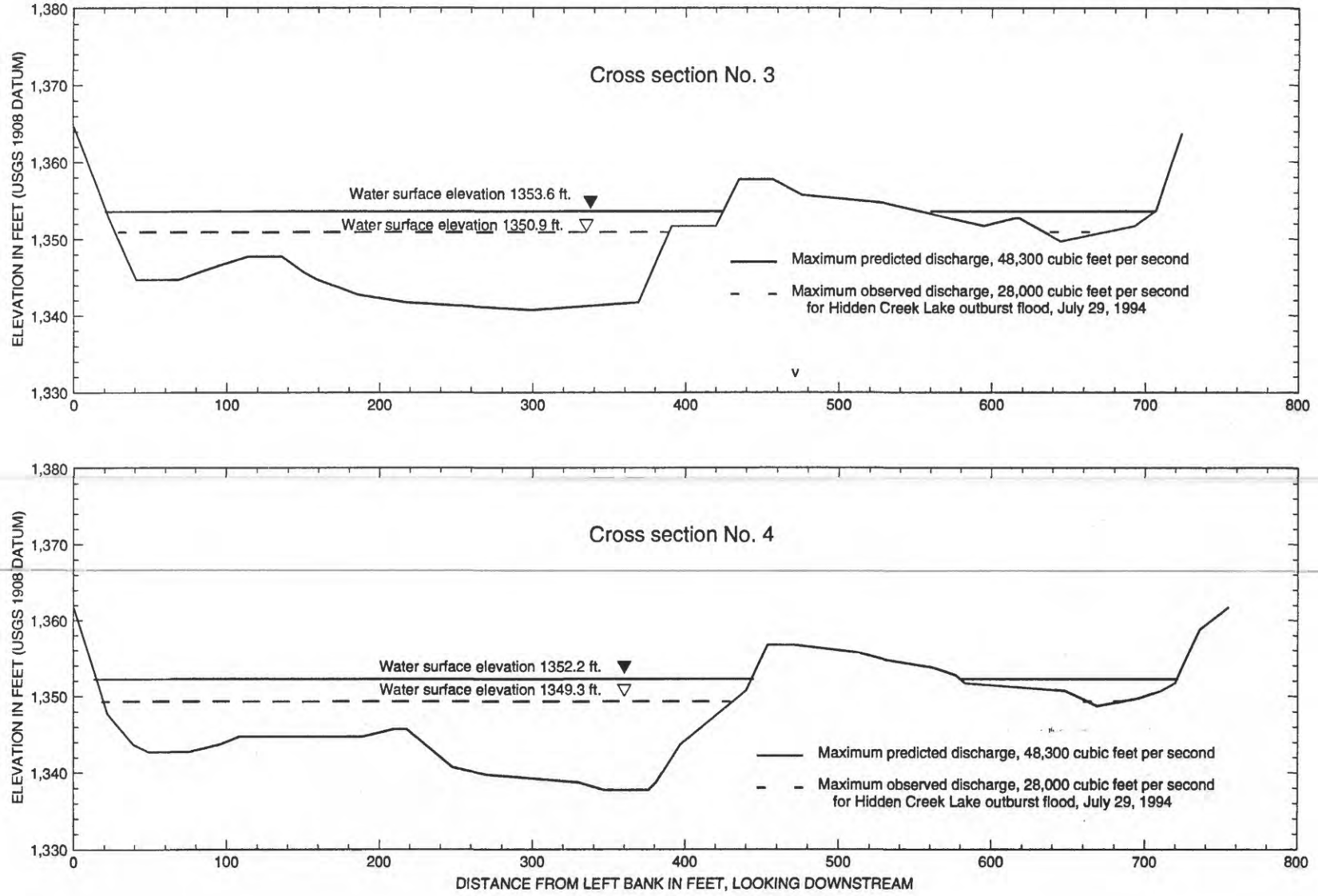


Figure 27. Water-surface elevations for maximum observed and maximum predicted discharges for the West Fork Kennicott River (see figure 26 for cross-section locations).



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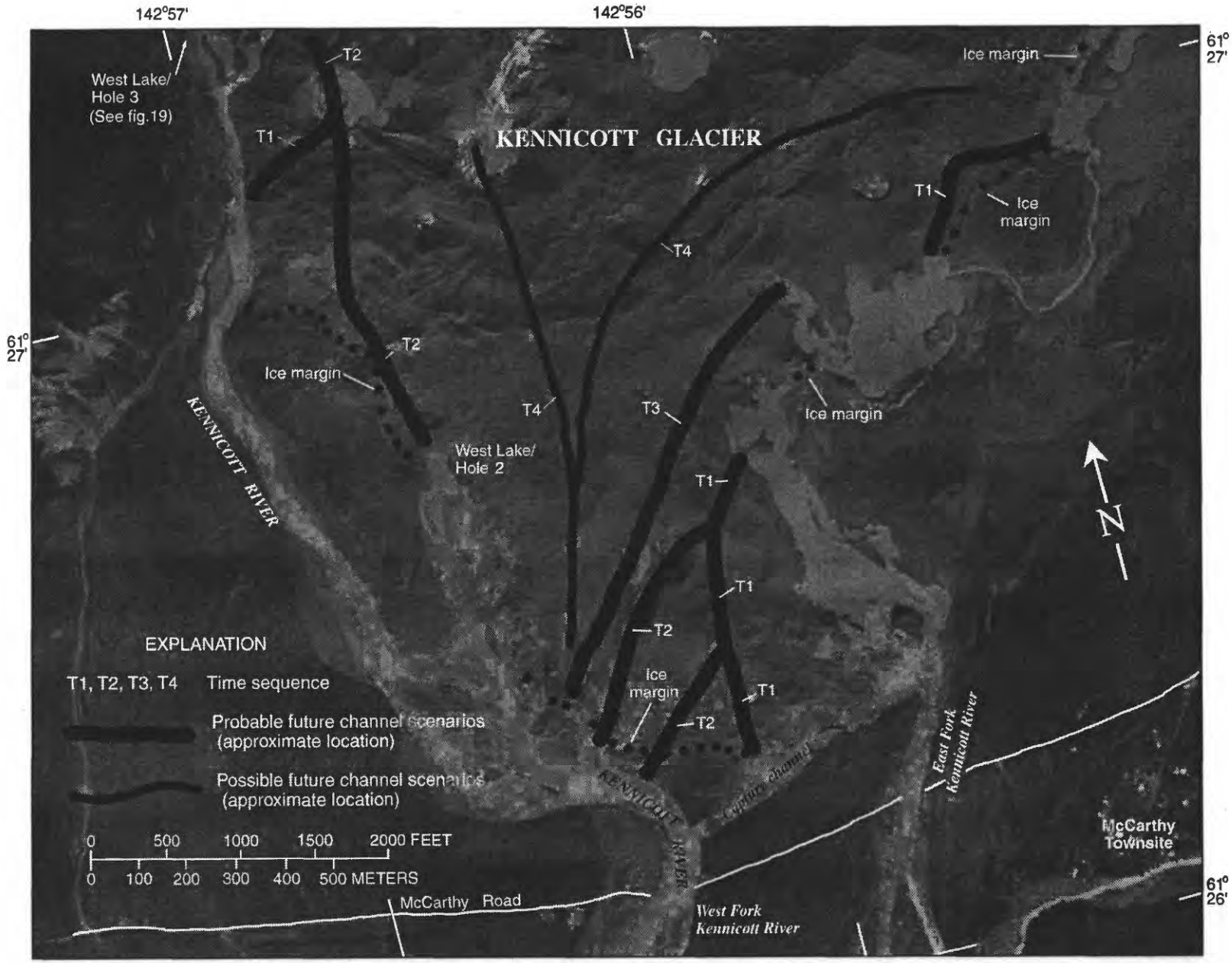

Figure 28. Kennicott Glacier and outwash, and future drainage scenario for the Kennicott River. (Aerial photograph base map, August 22, 1990.)

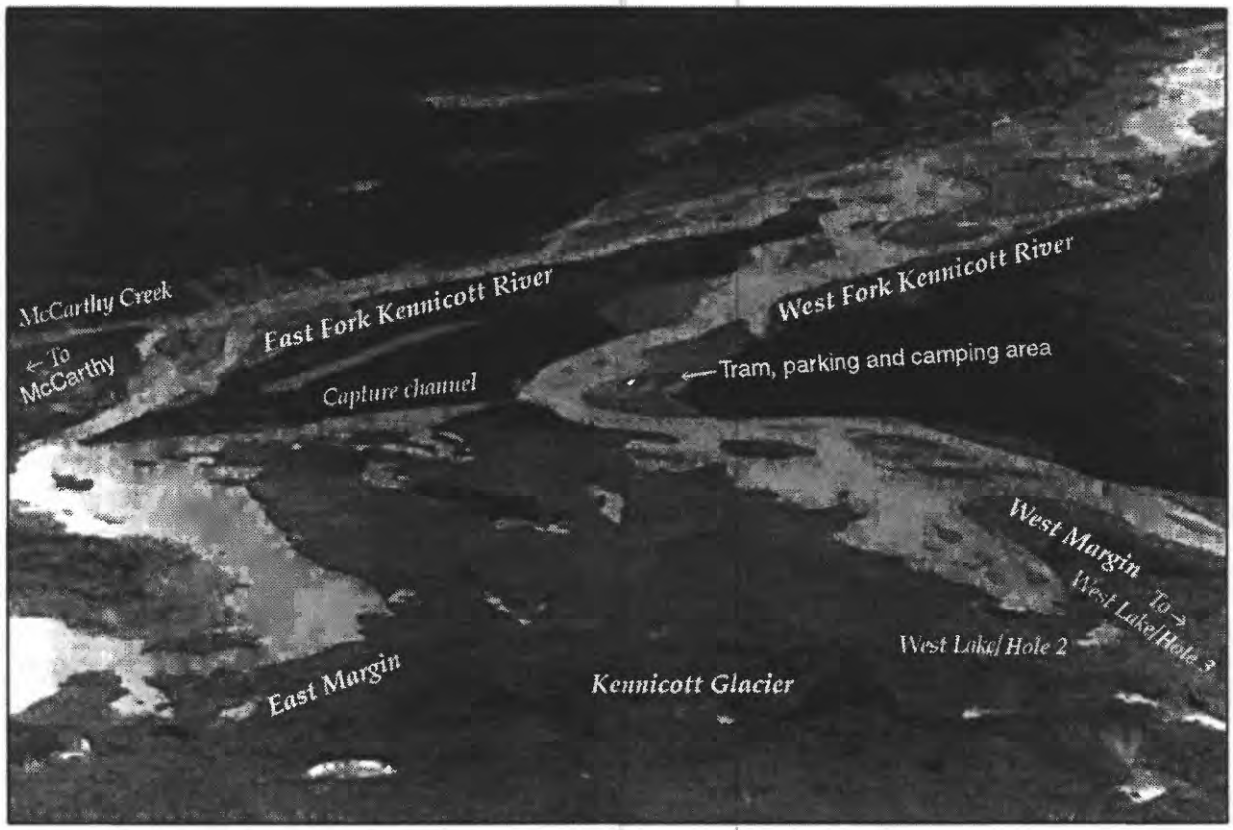

Figure 29. Kennicott Glacier terminus, July 23, 1995. (View is to southeast.)

Aufeis formation may block normal drainage channels and force water into alternate channels, such as the western overflow channels (fig. 26), causing erosion and channel migration. Large aufeis deposits may encroach on the lower parking areas and damage structures. If aufeis deposits move during breakup, the extra thickness can impose large ice loads on bridge piers (Ashton, 1986, p. 301).

FUTURE STUDIES

The largest floods will probably continue to be those caused by draining of Hidden Creek Lake, or by the combined draining of this lake and Erie Lake, and rainfall. Channel erosion, aggradation, and migration are also a hazard. The following efforts may aid in monitoring pre-flood conditions, and help predict future channel changes.

1. Periodic surveying of the geomorphic profiles (fig. 21) across the Kennicott Glacier terminus and the East and West Forks Kennicott River to monitor changes would help to predict future channel migration and flood hazards.
2. Mapping the underlying landforms of Kennicott Glacier from Hidden Creek Lake across to Erie Lake and down to the glacier terminus using ice-penetrating radar would provide valuable insight concerning future channel migration and possible changes of locations where flow issues from Kennicott Glacier.

3. Installing recording stream-gaging stations with satellite telemetry on the East and West Forks Kennicott River would provide near real-time river stage data, which could be used to predict and monitor floods. Making periodic discharge measurements would verify and update the stage-discharge relationships, aid in determining flood magnitudes, verify flood-water capture by the West Fork, and monitor channel changes.
4. Monitoring Hidden Creek Lake could determine when the lake is beginning to drain. Indicators of imminent outburst flooding are (a) stationary or declining lake stage, (b) large ice blocks actively calving off the ice-dam front, (c) formation of a clean ice washline along the ice-dam front or margin, (d) presence of rafted slush ice and small icebergs on the lakeshore, and (e) ice-dam fractures and escarpments. Identifying physical features at the 3,000-foot elevation level along the lakeshore that are easily seen from low-flying aircraft would help predict outbursts. Documenting the dates of the annual Hidden Creek Lake outbursts would help bracket timing of outbursts.
5. Measuring peak lake stage annually from existing control at Hidden Creek Lake would document changes over time.
6. Developing a relation between maximum stage at Hidden Creek Lake and total outburst flood volume would help assess flood hazard potential.

SUMMARY

Knowledge of hydrologic conditions and hazards is necessary for evaluating proposed activities in the Kennicott River Basin. Hydrologic hazards include rainfall-induced floods; glacier-dammed lake outburst floods; channel erosion, aggradation, and migration; and aufeis formation. Draining of ice-dammed lakes causes the largest floods in the Kennicott basin.

Hidden Creek Lake is the largest glacier-dammed lake in the basin, and drains on an annual basis. The maximum annual lake level is declining with time, and outburst floods in recent years have been occurring at earlier dates than previously documented. The decline in maximum lake level does not necessarily mean that maximum lake volume is decreasing. Annual lake volumes remain unquantified because of changes in the following: ice-dam position, percentage of icebergs, volume of water underlying the glacier between the ice margin and ice dam, and lake basin morphology. The following indicators can be used to forecast imminent draining of Hidden Creek Lake: lake stage near or above the level of recent maximum stages, stationary or declining lake stage, evidence of recent calving of large ice blocks from the ice margin, formation of a "clean ice" washline along the ice margin, slush ice and small icebergs stranded on the lakeshore, and fresh fractures and escarpments in the ice margin region.

Other glacier-dammed lakes in the Kennicott River Basin are Erie, Donoho, Gates, Jumbo, and Bonanza. Outburst floods from Erie Lake—but not from the other lakes—are evident in hydrographs of the Kennicott River. Outburst flood water from Hidden Creek Lake refills Donoho and Jumbo Lakes indicating a complex englacial and subglacial drainage system.

The most recent maximum advance of Kennicott Glacier occurred about 1860. The glacier terminus has retreated 2,000 ft since 1909, and the active stream channel/ice margin has dropped more than 70 ft. As the glacier thins and retreats, a recurring succession—karst, pond, active channel, and abandoned channel—occurs. This succession is most obvious along the southeast margin

where the retreat has been most extensive. Recognizing these four stages in this evolutionary sequence provides a tool for predicting future drainage patterns and assessing potential flood hazards.

Water issues from Kennicott Glacier at several points and forms two main river channels: the West and East Forks Kennicott River. Historical data indicate that outburst floods from Hidden Creek Lake are larger than rainfall-induced floods or floods from other glacier-dammed lake outbursts. The West and East Forks Kennicott River channels are prone to erosion, aggradation, and migration. The most significant channel changes occur during the Hidden Creek Lake outburst floods. The West Fork Kennicott River has downcut 20 ft at the railroad grade since 1911, and is much larger today than it was in 1911. The East Fork Kennicott River has migrated westward, leaving behind abandoned channels, and now carries less flow than it has historically. A capture channel diverts water from the East Fork Kennicott River to the West Fork Kennicott River. The West Fork carries a larger percentage of flood flow each year. If this trend continues, the East Fork channel will eventually be abandoned.

River stage was observed to gradually rise beginning 4 to 6 days prior to the Hidden Creek Lake outburst floods. This observation coupled with evidence of slow draining of Hidden Creek Lake may be useful as a warning tool. Englacial and subglacial releases caused the most rapid stage rises in the Kennicott River; the overall changes in stage are small, but occurred rapidly.

A potential flood magnitude of 48,300 ft^3/s was estimated by combining known maximum discharges from Hidden Creek and Erie Lake outburst floods with a large regional flood. The flood hazard zone in the transportation corridor was delineated using channel geometry surveyed in October 1994. Channel erosion or aggradation may increase or decrease the size of the flood hazard zone.

As Kennicott Glacier continues to thin and retreat, the inner glacier drainage may become more efficient, possibly leading to sharper and higher flood peaks. Aufeis formation may cause channel and bank erosion and may damage bridge piers and structures near the Kennicott River.

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GLOSSARY

Ablation. The combined processes of melt, runoff,and evaporation by which a glacier loses mass.

Alluvium. A general term for all detrital deposits resulting from the operations of river, including sediments laid down in riverbeds, flood plains, fans, and at the foot of mountains.

Arcuate. Bent or curved in the form of a bow.

Aufeis. A mass of ice that forms by overflow and subsequent freezing of sheets of surface water or emerging ground water.

Bankfull stage. The stage at which the channel just begins to overflow the flood plain (Hedman and Osterkamp, 1982, p. 4). The reference level for this section (bankfull stage) is variously defined by breaks in bank slope, by the edges of the flood plain, or the lower limits of permanent vegetation.

Dacite. A fine-grained extrusive rock.

Dropstone. An oversized stone in laminated sediment that depresses the underlying laminae and may be covered by "draped" laminae. Most dropstones originate through ice-rafting.

En echelon. In an overlapping or staggered arrangement.

Englacial. Within glacier ice.

Glacial erratic. A rock fragment carried by a glacier and deposited at some distance from the outcrop from which it was derived.

Karst. As used in this report, karst refers to the portion of glaciers characterized by closed depressions, sinkholes, caves, and under-glacier drainage.

Lake/hole. As used in this report, lake/hole refers to a point where water issues from the glacier margin, or at one time did issue, from the glacier. When occupied with water, a lake is formed; when drained, a dry hole is left.

Moraine. Drift deposited chiefly by direct glacial action and having constructional topography independent of control by the surface on which the drift lies.

Outburst flood. A sudden, often annual, outburst of water from a glacier or glacier-dammed lake, sometimes resulting in a catastrophic flood.

Plastic deformation. Permanent deformation of the shape or volume of a substance, without rupture.

Pothole. As used in this report, pothole refers to the historical main point of issue for outburst flood water. Water "boiled out of these holes during outburst flooding," according to historical records.

Sinkhole. As used in this report, a circular depression, commonly funnel shaped, on the karst portion of the glacier. Drainage is englacial or subglacial.

Slope-area method. Method for computing water discharge using Manning equation for conditions of uniform flow in which the water-surface profile and energy gradient are parallel to the streambed, and the area, hydraulic radius, and depth remain constant throughout the reach.

Step-backwater method. Method for computing water-surface profiles using the energy equation in a series of subreaches for conditions of steady uniform flow in which the flow at both end cross sections is either all supercritical or all subcritical, the slope is small enough so that normal depth can be considered to be vertical depth, and the water surface across the cross section is level.

Strandline. Horizontal terrace, formed by wave action, that marks previous lake stages.

Subglacial. Beneath glacier ice.

Supraglacial. On the glacier surface.

Thalweg. Line joining the deepest points of a stream channel.

Trim line. Line marking the former margin of a glacier.

APPENDIX 1

Summary of historical data and references for Hidden Creek Lake

HIDDEN CREEK LAKE GRAPH DATA [PS(M), estimated or measured peak stage, in meters; EPS(FT), estimated peak stage, in feet; MPS(FT), measured peak stage, in feet]

SITE	YEAR	MONTH	DAY	DD-MMM	DATE	STATUS	NOTES	SOURCE	S_NOTES	PS(M)	EPS(FT)	MPS(FT)
HIDDEN CRK LK	1900					FILLING						
HIDDEN CRK LK	1901					FILLING						
HIDDEN CRK LK	1902					FILLING						
HIDDEN CRK LK	1903					FILLING						
HIDDEN CRK LK	1904					FILLING						
HIDDEN CRK LK	1905					FILLING						
HIDDEN CRK LK	1906					FILLING						
HIDDEN CRK LK	1907					FILLING						
HIDDEN CRK LK	1908					FILLING						
HIDDEN CRK LK	1909					FILLING						
HIDDEN CRK LK	1910					FILLING						
HIDDEN CRK LK	1911					FILLING						
HIDDEN CRK LK	1912					FILLING						
HIDDEN CRK LK	1913					FILLING						
HIDDEN CRK LK	1914					FILLING						
HIDDEN CRK LK	1915					FILLING						
HIDDEN CRK LK	1916					FILLING						
HIDDEN CRK LK	1917					FILLING						
HIDDEN CRK LK	1918					FILLING						
HIDDEN CRK LK	1919	6	25	175	06/25/19	FILLING	YEAR/DATE?,STAGE>94,DATE EST @ L.JUNE	PHOTO	PRE-1938 PHOTO,E.HOLLARD-KENNECOTT,KID	924.5		3033
HIDDEN CRK LK	1920	7	20	201	07/20/20	FILLING	YEAR/DATE?,STAGE>94,DATE EST @M/L.JULY	PHOTO	PRE-1938 PHOTO,C.HODGES-KENNECOTT,KID	934.6		3066
HIDDEN CRK LK	1921					FILLING						
HIDDEN CRK LK	1922					FILLING						
HIDDEN CRK LK	1923					FILLING						
HIDDEN CRK LK	1924					FILLING						
HIDDEN CRK LK	1925					FILLING						
HIDDEN CRK LK	1926					FILLING						
HIDDEN CRK LK	1927					FILLING						
HIDDEN CRK LK	1928	6	16	166	06/16/28	FILLING	SKETCH FIELD NOTES, WATER LEVEL DEPICTED	USGS	F. MOFFIT FIELD NOTES, BK#639 P105			
HIDDEN CRK LK	1929					FILLING						
HIDDEN CRK LK	1930					FILLING						
HIDDEN CRK LK	1931					FILLING						
HIDDEN CRK LK	1932					FILLING						
HIDDEN CRK LK	1933					FILLING						
HIDDEN CRK LK	1934					FILLING						
HIDDEN CRK LK	1935					FILLING						
HIDDEN CRK LK	1936					FILLING						
HIDDEN CRK LK	1937					FILLING						
HIDDEN CRK LK	1938					FILLING						
HIDDEN CRK LK	1939					FILLING						
HIDDEN CRK LK	1940					FILLING						
HIDDEN CRK LK	1941					FILLING						
HIDDEN CRK LK	1942					FILLING						
HIDDEN CRK LK	1943					FILLING						
HIDDEN CRK LK	1944					FILLING						
HIDDEN CRK LK	1945					FILLING						
HIDDEN CRK LK	1946					FILLING						
HIDDEN CRK LK	1947					FILLING						
HIDDEN CRK LK	1948	6	18	169	06/18/48	FILLING	ICEBERS & SLUSH NEAR GLACIER	PHOTO	TRIMET#241RT-72PL-C-8M164-72RS-16JUNE48-ACR-1B			
HIDDEN CRK LK	1949					FILLING						
HIDDEN CRK LK	1950					FILLING						
HIDDEN CRK LK	1951	7	10	191	07/10/51	FILLING	STAGE DEPICTED, 1950? PERCHED BERGS	PHOTO	ALASKA ICE-DAMMED LAKES, K. STONE, 1963	922.3		3026
HIDDEN CRK LK	1952					FILLING						
HIDDEN CRK LK	1953					FILLING						
HIDDEN CRK LK	1954					FILLING						
HIDDEN CRK LK	1955					FILLING						
HIDDEN CRK LK	1956					FILLING						
HIDDEN CRK LK	1957	8	1	213	08/01/57	FILLING	APPRX DATE, HIGHEST KNOWN STAGE	PHOTO	A.POST, 4.11 AUG, 1957			
HIDDEN CRK LK	1958					FILLING						
HIDDEN CRK LK	1959					FILLING						
HIDDEN CRK LK	1960					FILLING						
HIDDEN CRK LK	1961					FILLING						
HIDDEN CRK LK	1962					FILLING						
HIDDEN CRK LK	1963					FILLING						
HIDDEN CRK LK	1964					FILLING						
HIDDEN CRK LK	1965					FILLING						
HIDDEN CRK LK	1966					FILLING						
HIDDEN CRK LK	1967					FILLING						
HIDDEN CRK LK	1968					FILLING						
HIDDEN CRK LK	1969					FILLING						
HIDDEN CRK LK	1970					FILLING						

HIDDEN CREEK LAKE GRAPH DATA

									PS(M)	EPS(FT)	MPS(FT)
HIDDEN CRK LK	1971				FILLING						
HIDDEN CRK LK	1972	7	21	202	07/21/72 FILLING	STAGE REACHES/EXCEEDS WILLOW RM	PHOTO	NASA/JCS,M#209,FL#24-81,COL(#23-81,CIR)	924.3		3033
HIDDEN CRK LK	1973				FILLING						
HIDDEN CRK LK	1974	8	11	223	08/11/74 FILLING	LAKE LEVEL DEPICTED	SLIDE	G.WINLKER, USGS			
HIDDEN CRK LK	1975				FILLING						
HIDDEN CRK LK	1976				FILLING						
HIDDEN CRK LK	1977				FILLING						
HIDDEN CRK LK	1978				FILLING						
HIDDEN CRK LK	1979				FILLING						
HIDDEN CRK LK	1980	8	7	219	08/07/80 FILLING	PRE-RELEASE??, FOOT BRIDGE STANDING	OBSERVATION	E. LACHAPELLE BRIDGE STANDING, PER COMM.			
HIDDEN CRK LK	1981	7	1	182	07/01/81 FILLING	PRE-RELEASE, FOOT BRIDGE STANDING	J. HANNAH	BRIDGE STANDING, PER. COMM			
HIDDEN CRK LK	1982	7	6	187	07/06/82 FILLING	APPEARS FULL	PHOTO	OBLIUQE, NPS:WASO-MMB 1983 RPT			
HIDDEN CRK LK	1983				FILLING						
HIDDEN CRK LK	1984				FILLING						
HIDDEN CRK LK	1985	7	27	208	07/27/85 FILLING	LARGE LAKE	TM IMAGE	LANDSAT PATH 65, ROW 7			
HIDDEN CRK LK	1986	7	27	208	07/27/86 FILLING	LAKE LEVEL VISIBLE	PHOTO	NPS, L. HOVIS FIELD SURVEY OF SITE			
HIDDEN CRK LK	1987				FILLING						
HIDDEN CRK LK	1988				FILLING						
HIDDEN CRK LK	1989				FILLING						
HIDDEN CRK LK	1990				FILLING						
HIDDEN CRK LK	1991				FILLING						
HIDDEN CRK LK	1992	7	2	183	07/02/92 FILLING	WATER LEVEL TO ROCK GL, PLOT H2O LEVEL	SLIDE	ROSENKRANS, DATE WITHIN 1 or 2 days			
HIDDEN CRK LK	1993	6	24	174	06/24/93 FILLING	WATER LEVEL NEAR ROCK GL, PLOT H2O LEVEL	PRINTS (2)	ROSENKRANS	912.8		2995
HIDDEN CRK LK	1994	7	16	197	07/16/94 FILLING	09:15, -2M WASHLINE ON GLACIER	REPORT	R. ELCONIN, AERIAL OBSERVATION			
HIDDEN CRK LK	1995	7	20	201	07/20/95 FILLING	LAKE STAGE INCREASING	PHOTO	TIME LAPSE CAMERA			
HIDDEN CRK LK	1860				OUTBURST	HIGHEST CONTINOUS STRANDLINE, CIRCA 1860?	SURVEY	USGS FIELD SURVEY, NUMEROUS SPOT EL.	960.8	3152	
HIDDEN CRK LK	1861				OUTBURST						
HIDDEN CRK LK	1862				OUTBURST						
HIDDEN CRK LK	1863				OUTBURST						
HIDDEN CRK LK	1864				OUTBURST						
HIDDEN CRK LK	1865				OUTBURST						
HIDDEN CRK LK	1866				OUTBURST						
HIDDEN CRK LK	1867				OUTBURST						
HIDDEN CRK LK	1868				OUTBURST						
HIDDEN CRK LK	1869				OUTBURST						
HIDDEN CRK LK	1870				OUTBURST						
HIDDEN CRK LK	1871				OUTBURST						
HIDDEN CRK LK	1872				OUTBURST						
HIDDEN CRK LK	1873				OUTBURST						
HIDDEN CRK LK	1874				OUTBURST						
HIDDEN CRK LK	1875				OUTBURST						
HIDDEN CRK LK	1876				OUTBURST						
HIDDEN CRK LK	1877				OUTBURST						
HIDDEN CRK LK	1878				OUTBURST						
HIDDEN CRK LK	1879				OUTBURST						
HIDDEN CRK LK	1880				OUTBURST						
HIDDEN CRK LK	1881				OUTBURST						
HIDDEN CRK LK	1882				OUTBURST						
HIDDEN CRK LK	1883				OUTBURST						
HIDDEN CRK LK	1884				OUTBURST						
HIDDEN CRK LK	1885				OUTBURST						
HIDDEN CRK LK	1886				OUTBURST						
HIDDEN CRK LK	1887				OUTBURST						
HIDDEN CRK LK	1888				OUTBURST						
HIDDEN CRK LK	1889				OUTBURST						
HIDDEN CRK LK	1890				OUTBURST						
HIDDEN CRK LK	1891				OUTBURST						
HIDDEN CRK LK	1892				OUTBURST						
HIDDEN CRK LK	1893				OUTBURST						
HIDDEN CRK LK	1894				OUTBURST						
HIDDEN CRK LK	1895				OUTBURST						
HIDDEN CRK LK	1896				OUTBURST						
HIDDEN CRK LK	1897				OUTBURST						
HIDDEN CRK LK	1898				OUTBURST						
HIDDEN CRK LK	1899				OUTBURST						
HIDDEN CRK LK	1900				OUTBURST						
HIDDEN CRK LK	1901				OUTBURST						
HIDDEN CRK LK	1902				OUTBURST						
HIDDEN CRK LK	1903				OUTBURST						
HIDDEN CRK LK	1904				OUTBURST						
HIDDEN CRK LK	1905				OUTBURST						
HIDDEN CRK LK	1906				OUTBURST						

HIDDEN CREEK LAKE GRAPH DATA

										PS(M)	EPS(FT)	MPS(FT)
HIDDEN CRK LK	1979					OUTBURST						
HIDDEN CRK LK	1980					OUTBURST						
HIDDEN CRK LK	1981	7	19	200	07/19/81	OUTBURST	FLOOD OBSERVED AND BRIDGE COLLAPSED	PHOTO	G. GREENE, PER. COMM AND PHOTO JUL/81			
HIDDEN CRK LK	1982					OUTBURST				922.2	3026	
HIDDEN CRK LK	1983	8	7	219	08/07/83	OUTBURST	FLOOD EVENT OBSERVED, EARLY IN MONTH	R. ELLIOT	OBSERVATION,PER. COMM. (VERBAL)			
HIDDEN CRK LK	1984	8	26	238	08/26/84	OUTBURST	FLOOD EVENT, CONFLICTING REPORTS	NOTES	WMC DATA, B. HECHT .COMM (VERBAL-DEFINATE)	921.7		3024
HIDDEN CRK LK	1985	8	16	228	08/16/85	OUTBURST	BIG FLOOD, CLEAR CRK 1M DEEP W/RAINS	NOTES	D. DOAK, PER COMM (LETTER)			
HIDDEN CRK LK	1986	8	6	218	08/06/86	OUTBURST	PEAK STAGE RECORDED ON 1974 AERIAL PHOTO	FRIEND	MS THESIS & PER. CONVERSATION	915.8	3005	
HIDDEN CRK LK	1987					OUTBURST						
HIDDEN CRK LK	1988	7	23	204	07/23/88	OUTBURST	EVENT OBSERVED IN MCCARTHY	NOTES	B. HECHT, PER COMM.			
HIDDEN CRK LK	1989	7	19	200	07/19/89	OUTBURST	RIVER VERY HIGH	NOTES	D. DOAK, PER COMM. (LETTER)			
HIDDEN CRK LK	1990	7	4	185	07/04/90	OUTBURST		USGS	DRAFT REPORT,JONES, TABLE #2	916.1		3006
HIDDEN CRK LK	1991	8	3	215	08/03/91	OUTBURST		USGS	DRAFT REPORT STAN JONES TABLE #2			
HIDDEN CRK LK	1992	7	6	187	07/06/92	OUTBURST	50% VOLUME,STRANDED BERGS,PEAK 92 STAGE	PHOTO	G. GREEN DATED PHOTO	915.1	3002	
HIDDEN CRK LK	1993	7	5	186	07/05/93	OUTBURST	PEAK DISCHARGE AT TRAM 7/6/93	STAGE GAGE	USGS STAGE RECORD AT KENNICOTT TRAM	912.8		2995
HIDDEN CRK LK	1994	7	29	210	07/29/94	OUTBURST	OUTBURST EVENT 10:00 AM STAGE DOWN 35'?	PHOTO	AERIAL OBSERVATION, ROSENKRANS	920.8	3021	
HIDDEN CRK LK	1995	7	23	204	07/23/95	OUTBURST	WATERLEVEL @ TOP TERMINAL MORAINE 9:00	PHOTO	ROSENKRANS, AERIAL OBSERVATION & NOTES	916.1	3006	
HIDDEN CRK LK	1900					POST/OUTB						
HIDDEN CRK LK	1901					POST/OUTB						
HIDDEN CRK LK	1902					POST/OUTB						
HIDDEN CRK LK	1903					POST/OUTB						
HIDDEN CRK LK	1904					POST/OUTB						
HIDDEN CRK LK	1905					POST/OUTB						
HIDDEN CRK LK	1906					POST/OUTB						
HIDDEN CRK LK	1907					POST/OUTB						
HIDDEN CRK LK	1908					POST/OUTB						
HIDDEN CRK LK	1909					POST/OUTB						
HIDDEN CRK LK	1910					POST/OUTB						
HIDDEN CRK LK	1911					POST/OUTB						
HIDDEN CRK LK	1912					POST/OUTB						
HIDDEN CRK LK	1913					POST/OUTB						
HIDDEN CRK LK	1914					POST/OUTB						
HIDDEN CRK LK	1915					POST/OUTB						
HIDDEN CRK LK	1916	9	12	255	09/12/16	POST/OUTB	STRANDED BERGS, STRANDLINE VISIBLE	USGS	F. MOFFIT, BULL #894 PLATE #5A			
HIDDEN CRK LK	1917					POST/OUTB						
HIDDEN CRK LK	1918					POST/OUTB						
HIDDEN CRK LK	1919					POST/OUTB						
HIDDEN CRK LK	1920					POST/OUTB						
HIDDEN CRK LK	1921					POST/OUTB						
HIDDEN CRK LK	1922					POST/OUTB						
HIDDEN CRK LK	1923					POST/OUTB						
HIDDEN CRK LK	1924					POST/OUTB						
HIDDEN CRK LK	1925					POST/OUTB						
HIDDEN CRK LK	1926					POST/OUTB						
HIDDEN CRK LK	1927					POST/OUTB						
HIDDEN CRK LK	1928					POST/OUTB						
HIDDEN CRK LK	1929					POST/OUTB						
HIDDEN CRK LK	1930					POST/OUTB						
HIDDEN CRK LK	1931					POST/OUTB						
HIDDEN CRK LK	1932					POST/OUTB						
HIDDEN CRK LK	1933					POST/OUTB						
HIDDEN CRK LK	1934					POST/OUTB						
HIDDEN CRK LK	1935					POST/OUTB						
HIDDEN CRK LK	1936					POST/OUTB						
HIDDEN CRK LK	1937	8	14	226	08/14/37	POST/OUTB	ICE DAM FRACTURES @ MARGIN OF PHOTO	PHOTO	B. WASHBURN, #570			
HIDDEN CRK LK	1938					POST/OUTB						
HIDDEN CRK LK	1939					POST/OUTB						
HIDDEN CRK LK	1940					POST/OUTB						
HIDDEN CRK LK	1941					POST/OUTB						
HIDDEN CRK LK	1942					POST/OUTB						
HIDDEN CRK LK	1943					POST/OUTB						
HIDDEN CRK LK	1944					POST/OUTB						
HIDDEN CRK LK	1945					POST/OUTB						
HIDDEN CRK LK	1946					POST/OUTB						
HIDDEN CRK LK	1947					POST/OUTB						
HIDDEN CRK LK	1948					POST/OUTB						
HIDDEN CRK LK	1949					POST/OUTB						
HIDDEN CRK LK	1950					POST/OUTB	1950? PERCHED BERGS DEPICTED IN 1951 PHOTO	PHOTO	ALASKA ICE-DAMMED LAKES ,K.STONE, 1963	929.8		3051
HIDDEN CRK LK	1951					POST/OUTB						
HIDDEN CRK LK	1952					POST/OUTB						
HIDDEN CRK LK	1953					POST/OUTB						
HIDDEN CRK LK	1954					POST/OUTB						

HIDDEN CREEK LAKE GRAPH DATA

										PS(M)	EPS(FT)	MPS(FT)
HIDDEN CRK LK	1907					OUTBURST						
HIDDEN CRK LK	1908					OUTBURST						
HIDDEN CRK LK	1909					OUTBURST	POTHOLE RELEASED EARLY IN 1909	USGS	USGS BULL #448 PAGE 14			
HIDDEN CRK LK	1910					OUTBURST						
HIDDEN CRK LK	1911	9	15	258	09/15/11	OUTBURST	ICY LK BROKE,BRIDGE DAMAGE,POTHOLE ACTIV	PUBLISHED	COPPER SPIKE, PAGE 128			
HIDDEN CRK LK	1912					OUTBURST						
HIDDEN CRK LK	1913					OUTBURST						
HIDDEN CRK LK	1914					OUTBURST						
HIDDEN CRK LK	1915					OUTBURST						
HIDDEN CRK LK	1916					OUTBURST				945.9	3103	
HIDDEN CRK LK	1917					OUTBURST						
HIDDEN CRK LK	1918					OUTBURST						
HIDDEN CRK LK	1919					OUTBURST				924.5		3033
HIDDEN CRK LK	1920					OUTBURST				934.6		3066
HIDDEN CRK LK	1921	9	16	259	09/16/21	OUTBURST	POTHOLE GEYSER 40' HIGH, LESS THAN PAST	PUBLISHED	MCCARTHY WEEKLY NEWS 9/17/21			
HIDDEN CRK LK	1922	9	2	245	09/02/22	OUTBURST	POTHOLE BREAKS 2 WEEKS EARLY	PUBLISHED	MCCARTHY WEEKLY NEWS 9/9/22			
HIDDEN CRK LK	1923	8	20	232	08/20/23	OUTBURST	NEW POTHOLE ATOP GLACIER, DATE EST. (8/16-8/2	PUBLISHED	MCCARTHY WEEKLY NEWS 8/23/23			
HIDDEN CRK LK	1924					OUTBURST						
HIDDEN CRK LK	1925	9	7	250	09/07/25	OUTBURST	BRIDGE DAMAGE, BROKE OUT NUNEROUS PLACE	PUBLISHED	MCCARTHY WEEKLY NEWS 9/12/25			
HIDDEN CRK LK	1926	8	29	241	08/29/26	OUTBURST	BREAKOUT NOT AS SPECTACULAR AS USUAL	PUBLISHED	MCCARTHY WEEKLY NEWS 9/4/26			
HIDDEN CRK LK	1927					OUTBURST	USUALLY RELEASED IN AUGUST PRIOR TO 1928	USGS	BULL #984. F. MOFFIT PLATE 5A			
HIDDEN CRK LK	1928					OUTBURST						
HIDDEN CRK LK	1929					OUTBURST						
HIDDEN CRK LK	1930					OUTBURST						
HIDDEN CRK LK	1931					OUTBURST						
HIDDEN CRK LK	1932					OUTBURST						
HIDDEN CRK LK	1933	8	28	240	08/28/33	OUTBURST	"POTHOLE BROKE, FOOT KENNICOTT GL."	DATABANK	USWB CLIMATE DATA, L. YEHLE			
HIDDEN CRK LK	1934					OUTBURST						
HIDDEN CRK LK	1935					OUTBURST						
HIDDEN CRK LK	1936					OUTBURST						
HIDDEN CRK LK	1937					OUTBURST						
HIDDEN CRK LK	1938					OUTBURST						
HIDDEN CRK LK	1939					OUTBURST						
HIDDEN CRK LK	1940					OUTBURST						
HIDDEN CRK LK	1941					OUTBURST						
HIDDEN CRK LK	1942					OUTBURST						
HIDDEN CRK LK	1943					OUTBURST						
HIDDEN CRK LK	1944					OUTBURST						
HIDDEN CRK LK	1945					OUTBURST						
HIDDEN CRK LK	1946					OUTBURST						
HIDDEN CRK LK	1947					OUTBURST						
HIDDEN CRK LK	1948					OUTBURST						
HIDDEN CRK LK	1949					OUTBURST						
HIDDEN CRK LK	1950					OUTBURST				928.9		3051
HIDDEN CRK LK	1951					OUTBURST				922.3		3026
HIDDEN CRK LK	1952					OUTBURST						
HIDDEN CRK LK	1953					OUTBURST						
HIDDEN CRK LK	1954					OUTBURST						
HIDDEN CRK LK	1955					OUTBURST						
HIDDEN CRK LK	1956					OUTBURST						
HIDDEN CRK LK	1957	8	4	216	08/04/57	OUTBURST	STRANDLINE,PARTLY DRAINED?,PERCHED BERGS	PHOTO	W. FIELD IGY-RPT, L. VIERECK #LV-57-B151	936.1	3071	
HIDDEN CRK LK	1958					OUTBURST						
HIDDEN CRK LK	1959					OUTBURST						
HIDDEN CRK LK	1960					OUTBURST						
HIDDEN CRK LK	1961					OUTBURST						
HIDDEN CRK LK	1962	8	14	226	08/14/62	OUTBURST	RELEASE STARTED 8/13 FINISHED 8/14	PHOTO	L. YEHLE , NOTES AND OBSERVATION			
HIDDEN CRK LK	1963					OUTBURST						
HIDDEN CRK LK	1964					OUTBURST	.			929.9		3051
HIDDEN CRK LK	1965					OUTBURST						
HIDDEN CRK LK	1966					OUTBURST						
HIDDEN CRK LK	1967					OUTBURST						
HIDDEN CRK LK	1968					OUTBURST	FLOOD ON CHITINA R OBSERVED	POST/MAYO	USGS HA-#455, REF. (PER COMM MCKECHNIE)			
HIDDEN CRK LK	1969					OUTBURST				923.3		3029
HIDDEN CRK LK	1970					OUTBURST				925.4		3036
HIDDEN CRK LK	1971					OUTBURST						
HIDDEN CRK LK	1972					OUTBURST				924.3		3033
HIDDEN CRK LK	1973					OUTBURST						
HIDDEN CRK LK	1974	8	16	228	08/16/74	OUTBURST	FLOOD EVENT AND LAKE OBSERVED	PHOTO	G. MULL, SLIDES AND OBSERVATIONS COMM.	922.8	3028	
HIDDEN CRK LK	1975	8	6	218	08/06/75	OUTBURST	LAKE DRAINING,>50%FULL,STRANDED BERGS	PHOTO	USGS,#75M4-1/2,OBLIQUE,1:20179,B&W	924.9	3035	
HIDDEN CRK LK	1976					OUTBURST				925.5	3037	
HIDDEN CRK LK	1977					OUTBURST						
HIDDEN CRK LK	1978	8	10	222	08/10/78	OUTBURST	LARGE FLOOD	J. MILLER	OBSERVATION, VERBAL COMM.	925.3		3036

HIDDEN CREEK LAKE GRAPH DATA

									PS(M)	EPS(FT)	MPS(FT)
HIDDEN CRK LK	1955					POST/OUTB					
HIDDEN CRK LK	1956					POST/OUTB					
HIDDEN CRK LK	1957					POST/OUTB					
HIDDEN CRK LK	1958					POST/OUTB					
HIDDEN CRK LK	1959					POST/OUTB					
HIDDEN CRK LK	1960					POST/OUTB					
HIDDEN CRK LK	1961					POST/OUTB					
HIDDEN CRK LK	1962					POST/OUTB					
HIDDEN CRK LK	1963					POST/OUTB					
HIDDEN CRK LK	1964	8	24	236	08/24/64	POST/OUTB	POST RELEASE, STRANDLINE,	PHOTO	USGS,K642-76, OBLIQUE	929.9	3051
HIDDEN CRK LK	1965					POST/OUTB					
HIDDEN CRK LK	1966					POST/OUTB					
HIDDEN CRK LK	1967	9	1	244	09/01/67	POST/OUTB	STRANDED BERGS, FALL COLORS, NO SNOW	SLIDE	G. BURDICK (G.GREENE COLLECTION, NOV-67)		
HIDDEN CRK LK	1968					POST/OUTB					
HIDDEN CRK LK	1969	8	27	239	08/28/69	POST/OUTB	POST RELEASE, PERCHED BERGS	PHOTO	A. POST,69R3-201,B&W,DISTANT OBLIQUE	923.3	3029
HIDDEN CRK LK	1970	8	26	238	08/26/70	POST/OUTB	POST RELEASE, ICEBERG STRANDLINE	PHOTO	AEROMAP ROLL#70-23APT FL/FR(5-17&4-19)	925.4	3036
HIDDEN CRK LK	1971					POST/OUTB					
HIDDEN CRK LK	1972					POST/OUTB					
HIDDEN CRK LK	1973	10	6	279	10/06/73	POST/OUTB	HIGHWATER MARK EAST CHANNEL	M.MILES	AKDOT DATED PHOTO		
HIDDEN CRK LK	1974	9	4	247	09/04/74	POST/OUTB	POST RELEASE,SMALL LAKE,REFILLING?	PHOTO	USGS,EL-13000',#74V106-110,B&W		
HIDDEN CRK LK	1975	8	16	228	08/16/75	POST/OUTB	WASHED OUT KENNICOTT R. BRIDGE APPROACH	M.MILES	AKDOT RECORDS		
HIDDEN CRK LK	1976	7	22	203	07/22/76	POST/OUTB	IMM. POST RELEASE, LK MUD MARK, SMALL LK	PHOTO	USGS,#76M1-121,OBLIQUE,1:20179,B&W		
HIDDEN CRK LK	1977	8	6	218	08/06/77	POST/OUTB	RELEASED PRIOR AUG 5/6, BRIDGE DAMAGE	G. GREENE	VERBAL COMM.		
HIDDEN CRK LK	1978	8	28	240	08/28/78	POST/OUTB	DRAINAGE HOLE VISIBLE	PHOTO	NASA,#FL104B-7957&8,1;60000,CIR	925.3	3036
HIDDEN CRK LK	1979					POST/OUTB					
HIDDEN CRK LK	1980					POST/OUTB					
HIDDEN CRK LK	1981					POST/OUTB					
HIDDEN CRK LK	1982	7	31	212	07/31/82	POST/OUTB	PEAK STAGE LINE VISIBLE, POST RELEASE	N.OLMSTED	PHOTOS AND PER COMM. SITE VISITED 7/82		
HIDDEN CRK LK	1983					POST/OUTB					
HIDDEN CRK LK	1984	8	31	243	08/31/84	POST/OUTB	POST RELEASE, SOME PERCHED ICEBERGS	PHOTO	USGS,84R3, OBLIQUE	921.7	3024
HIDDEN CRK LK	1985					POST/OUTB					
HIDDEN CRK LK	1986	9	6	249	09/06/86	POST/OUTB	DRAIN HOLES,BEACHED BERGS	PHOTO	NPS,12WRST-3-45-29&30,1:12000,CIR		
HIDDEN CRK LK	1987					POST/OUTB					
HIDDEN CRK LK	1988					POST/OUTB					
HIDDEN CRK LK	1989					POST/OUTB					
HIDDEN CRK LK	1990	8	13	225	08/13/90	POST/OUTB	SMALL LAKE, POST RELEASE	SLIDE	C. PRELLER & L.MAYO FLIGHT	916.1	3006
HIDDEN CRK LK	1991	8	5	217	08/05/91	POST/OUTB		USGS	DRAFT REPORT STAN JONES TABLE #2		
HIDDEN CRK LK	1992	7	7	188	07/07/92	POST/OUTB	PEAK DISCHARGE AT TRAM	STAGE GAGE	USGS KENNICOTT RIVER STAGE RECORD		
HIDDEN CRK LK	1993	7	6	187	07/06/93	POST/OUTB	VISUAL CONFIRMATION, ALOT OF BERGS	SLIDE	GROUND,OBLIQUE,HUMMEL TRIP		
HIDDEN CRK LK	1994	7	30	211	07/30/94	POST/OUTB	RELEASE OVER, PRIOR TO 9:00AM	PHOTO	AERIAL OBSERVATION, ROSENKRANS		
HIDDEN CRK LK	1995	7	24	205	07/24/95	POST/OUTB	NO WATER,ICE CRACKING AND NOISY 10:00	PHOTO	ROSENKRANS, OBSERVATION		

APPENDIX 2

Location and description of survey monuments

SURVEY DATUMS

A common datum was established throughout the basin. Horizontal control was established using the North American Datum of 1927. All elevation data presented in this report are referenced to U.S. Geological Survey monument "K," elevation stamped 1,414 ft, 1908. This monument is located on the east side of McCarthy. Global position satellite and total station survey techniques were used to establish vertical datum at Hidden Creek Lake, the Kennicott Glacier terminus area, and the Kennicott River. Survey monuments established at Hidden Creek Lake and Kennicott River are described below. Vertical datums used by the Alaska Department of Transportation and Public Facilities (ADOT&PF)(1994), and the University of Alaska (1995) were different from the datum used for this report.

Kennicott and Hidden Creek Lake Survey Monuments

Monument name	Monument description
K	Base. USGS benchmark K, est. 1908, elev. given at 1414 ft (430.99 meters), located in the town of McCarthy, Alaska
KENW	Wooden stake located on the right bank West Fork Kennicott River 60 ft southwest from tram concrete platform. Established September 17, 1991.
KENE	Wooden stake located on centerline of old rail bed, on right bank approximately 100 ft south from road. Established May 31, 1991.
AIR1	Temporary reference mark used to run GPS survey to Hidden Creek Lake. Temporary due to airport construction.
HID1, 2, and 3	Established at Hidden Creek valley airstrip to determine elevation via GPS.
WILLOW	Monument established July 1994. Tablet installed August 28, 1994. Located on small rock outcrop north of Hidden Creek Lake.
VALLEY	Tablet installed August 28, 1994. Monument is located on valley floor along north bank of Hidden Creek
HIDDEN	Tablet installed August 28, 1994. Monument is located on flat rock in valley bottom. May be difficult to find because of iceberg deposition.
ROCK	Wooden stake located on rock glacier on south side of Hidden Creek Lake. Established August 29, 1994. Tablet was not installed because of snowfall on August 29 and 30.
BOULDER	Tablet installed on August 30 on top of large boulder near "A" frame west of airstrip.

Survey data for monuments at Hidden creek Valley were established using GPS techniques and a single known starting point, U.S. Geological Survey monument "K" in McCarthy. Elevation errors of the Hidden Creek Valley monuments are probably plus or minus 3 feet (1 meter), relative to monument "K." Elevation errors of Hidden Creek Valley monuments relative to each other, are plus or minus 1 foot (0.3 meter).

Monument Name	Latitude (North)	Longitude (West)	Northing (feet)	Easting (feet)	Zone	Elevation (feet)
K	61 25 57.583	142 55 10.549	22351104	1304520	07	1414
AIR-1	61 26 35.148	142 53 41.286	22354790	1308970	07	1512
KENW	6126 03.044	142 56 35.065	22351780	1300429	07	1359
KENE	6126 05.407	142 55 55.326	22351963	1302368	07	1370
HID-1	61 33 26.708	143 08 53.538	22397932	1266020	07	3125
HID-2	61 33 27.294	143 08 43.862	22397976	1266491	07	3117
HID-3	61 33 29.326	143 08 50.520	22398193	1266175	07	3123
VALLEY	61 33 31.130	143 07 03.125	22398205	1271380	07	3024
HIDDEN	31 33 38.190	143 06 51.922	22398905	1271945	07	3009
WILLOW	61 33 39.149	143 07 10.447	22399031	1271052	07	3117
ROCK	61 33 28.577	143 06 33.691	22397901	1272795	07	3155
BOULDER	61 33 29.739	143 09 08.023	22398262	1265329	07	3175

To obtain meters, multiply feet by 3.281.

Marks were painted on bedrock near the WILLOW monument for tape-down references to obtain lake-surface elevation. They are:

- Blue cross immediately southwest of WILLOW monument. Elevation: 3031 feet.
- Blue painted rock below blue cross. Elevation: 3004 feet.

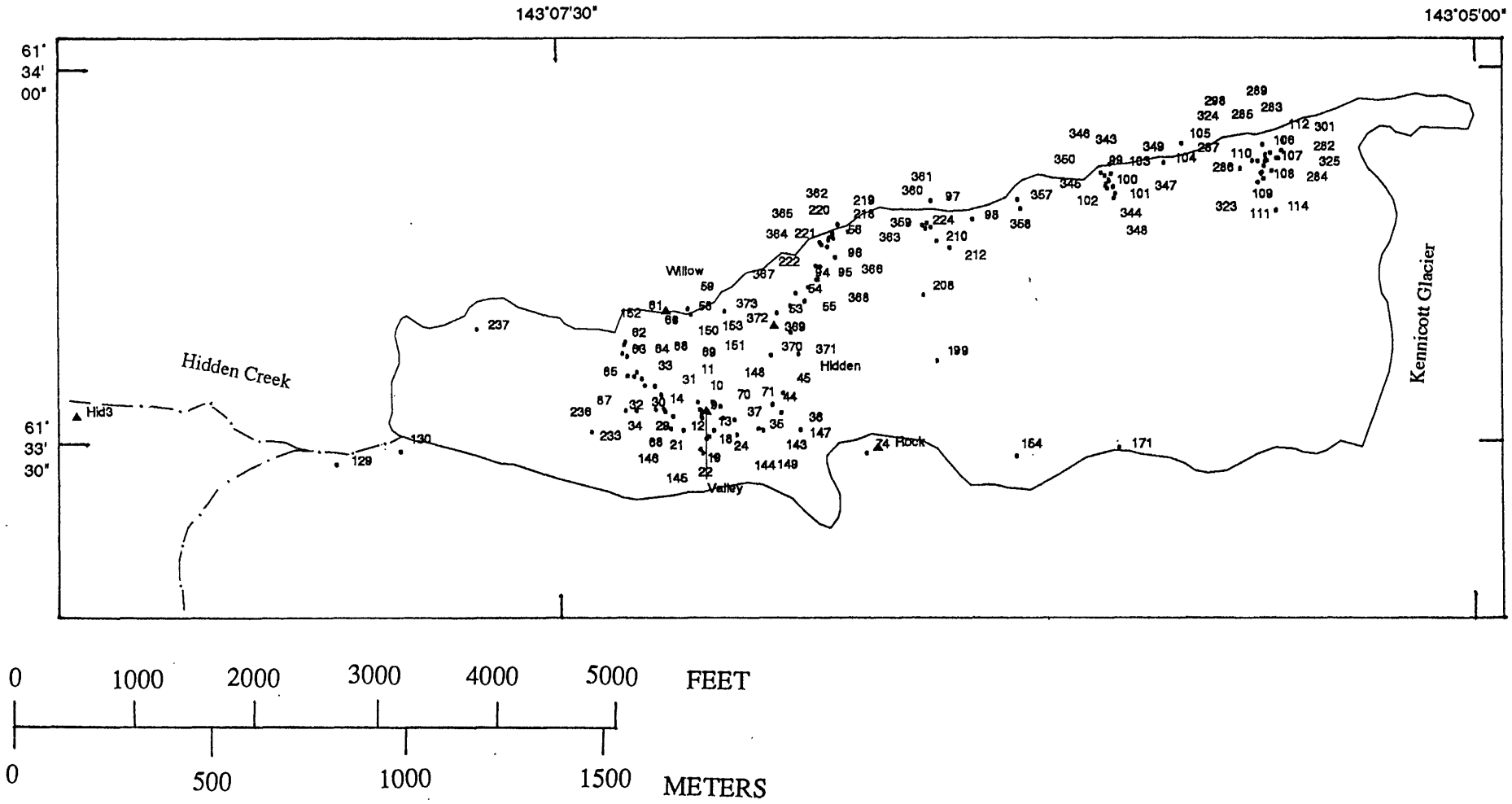
To adjust Alaska Department of Transportation and Public Facilities survey datum of 1994 to USGS datum of 1908, add 3.92 feet.

To adjust University of Alaska Fairbanks (Aeromap, Inc.) survey datum of 1994 to USGS datum of 1908, add approximately 15.5 feet.

APPENDIX 3

Hidden Creek Lake data survey, 1994 and 1995

BLANK



Lake surface taken from July 27, 1957 aerial photograph (USGS, scale 1:48,000)

▲ Monument, established 1994; See appendix 2 for coordinates and descriptions

• Survey points, August 1994 and 1995; See Table A3 for coordinates and site descriptions

Figure A3-1. Hidden Creek Lake survey monument, lake stage, dropstone deposits, and iceberg data-point locations.

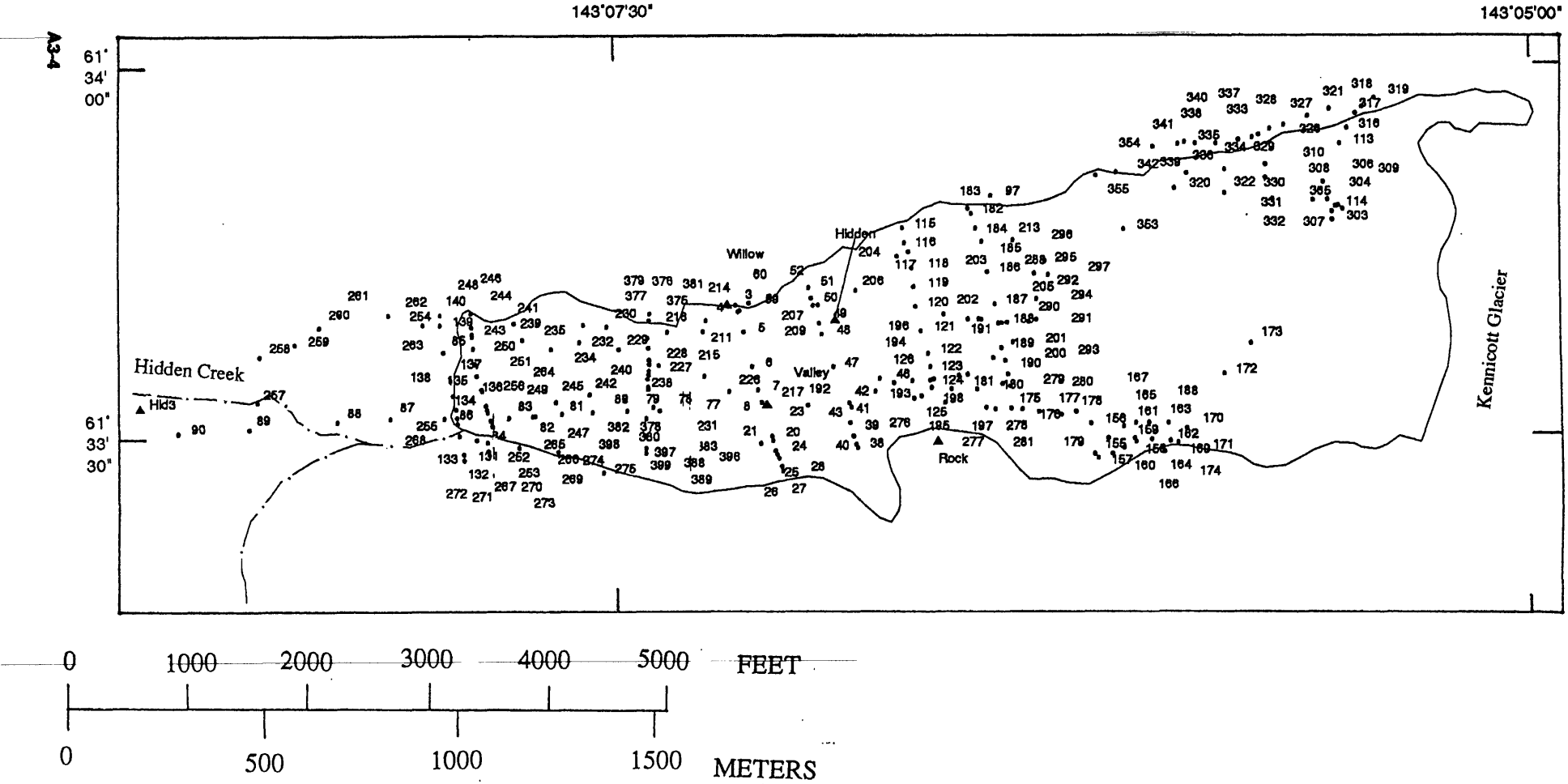


Figure A3-2. Hidden Creek Lake survey monument and geomorphic data-point locations.

Table A3. Hidden Creek Lake survey data, 1994 and 1995.
(see figures A3-1 and A3-2 for survey point location)

Survey point	Easting (feet)	Northing (feet)	Elevation (feet)	Easting (meters)	Northing (meters)	Elevation (meters)	Remarks
1	1271945	22398905	3009	387670	6826853	917	Hidden monument
2	1270813	22397507	3008	387325	6826427	916.8	Hidden monument -invert
3	1271115	22399023	3053	387417	6826889	930.6	Geomorphic profile
4	1271141	22398970	3023	387425	6826873	921.5	Geomorphic profile
5	1271184	22398800	3025	387438	6826821	922.1	Geomorphic profile
6	1271253	22398514	3024	387459	6826734	921.7	Geomorphic profile
7	1271302	22398324	3024	387474	6826676	921.7	Geomorphic profile
8	1271335	22398222	3025	387484	6826645	922	Geomorphic profile
9	1271322	22398212	3022	387480	6826642	921.2	Paleo high-water mark
10	1271332	22398209	3021	387483	6826641	920.8	Paleo high-water mark
11	1271305	22398275	3028	387475	6826661	923	Top of rock
12	1271335	22398193	3016	387484	6826636	919.3	Paleo high-water mark
13	1271335	22398163	3010	387484	6826627	917.3	Lake level, 7-16-94 1245 pm
14	1271338	22398144	3003	387485	6826621	915.4	Hidden Creek pws, 8-30-94
15	1271345	22398091	3006	387487	6826605	916.3	Topographical definition
16	1271351	22398055	3010	387489	6826594	917.3	Topographical definition
17	1271351	22398035	3012	387489	6826588	918.1	Topographical definition
18	1271378	22397970	3020	387497	6826568	920.4	Paleo high-water mark
19	1271401	22397989	3017	387504	6826574	919.6	Debris line
20	1271417	22397940	3020	387509	6826559	920.5	Geomorphic profile
21	1271325	22397884	3026	387481	6826542	922.2	Blue rock #2, top of rock
22	1271348	22397851	3020	387488	6826532	920.4	Paleo debris line, excellent
23	1271424	22397907	3019	387511	6826549	920.2	Geomorphic profile
24	1271447	22397825	3019	387518	6826524	920	debris line, 7-27-94, excellent
25	1271460	22397792	3020	387522	6826514	920.3	Geomorphic profile
26	1271473	22397763	3025	387526	6826505	922	Debris line, 7-27-94
27	1271499	22397694	3046	387534	6826484	928.3	Geomorphic profile
28	1271506	22397658	3058	387536	6826473	932	Geomorphic profile
29	1271191	22398042	3023	387440	6826590	921.3	Paleo debris
30	1271082	22398055	3027	387407	6826594	922.5	Paleo debris
31	1271102	22398160	3017	387413	6826626	919.6	Debris, 1994, from iceberg
32	1271030	22398219	3016	387391	6826644	919.3	Debris, 1994, flagged
33	1270958	22398216	3020	387369	6826643	920.4	Debris line, 7-27-94, excellent

Survey point	Easting (feet)	Northing (feet)	Elevation (feet)	Easting (meters)	Northing (meters)	Elevation (meters)	Remarks			
34	1270800	22398206	3027	387321	6826640	922.5	Debris line, 7-27-94, excellent			
35	1271807	22398052	2995	387628	6826593	912.9	Marked, 7-09-94			
36	1272152	22398045	2980	387733	6826591	908.4	Marked, 6-28-94			
37	1271627	22398006	3001	387573	6826579	914.7	6-24-93, air photo			
38	1272129	22397845	3022	387726	6826530	921.1	Geomorphic profile			
39	1272119	22397874	3007	387723	6826539	916.5	Geomorphic profile			
40	1272093	22397943	2999	387715	6826560	914.2	Geomorphic profile, 16 ft. from stream			
41	1272067	22398052	2984	387707	6826593	909.5	Geomorphic profile			
42	1272077	22398180	3001	387710	6826632	914.8	Hidden Creek channel, left bank			
43	1272057	22398216	3004	387704	6826643	915.7	Geomorphic profile			
44	1271926	22398252	3010	387664	6826654	917.4	Lake stage, 7-16-94			
45	1272014	22398347	3007	387691	6826683	916.6	Ice berg #2, 1986 photo			
46	1272313	22398413	3001	387782	6826703	914.7	Geomorphic profile			
47	1271926	22398511	3009	387664	6826733	917	Geomorphic profile			
48	1271834	22398780	3008	387636	6826815	916.8	Geomorphic profile			
49	1271811	22398872	3011	387629	6826843	917.6	Geomorphic profile			
50	1271758	22399020	3013	387613	6826888	918.4	Geomorphic profile			
51	1271745	22399079	3025	387609	6826906	922.1	Geomorphic profile			
52	1271722	22399164	3051	387602	6826932	930	Geomorphic profile			
53	1271965	22399003	3005	387676	6826883	915.8	Peak stage, 1986			
54	1272122	22399167	3005	387724	6826933	915.8	Ice berg #1, 1986 photo			
55	1272195	22399102	3003	387746	6826913	915.2	Stage, 7-2-92, from aerial photo			
56	1272431	22399653	3060	387818	6827081	932.6	Tape-down point			
57	1271945	22398905	3008	387670	6826853	916.9	HIDDEN monument (checks O.K.)			
58	1271256	22398993	3021	387460	6826880	920.7	7-27-94 peak stage			
59	1271227	22399036	3031	387451	6826893	923.8	Blue "X"; down-lake from WILLOW			
60	1271227	22399042	3036	387451	6826895	925.3	Tape-down point #2			
61	1271132	22398957	3024	387422	6826869	921.6	Ice berg #1, 7-22-76			
62	1270712	22398767	3034	387294	6826811	924.6	Ice berg #1, 8-26-70			
63	1270685	22398675	3036	387286	6826783	925.3	Ice berg #1, 8-78			
64	1270728	22398652	3036	387299	6826776	925.2	Ice berg #2, 9-4-74			
65	1270731	22398495	3036	387300	6826728	925.3	Ice berg #1, 9-4-74			
66	1270787	22398488	3034	387317	6826726	924.8	Ice berg #2, 8-78			
67	1270849	22398472	3034	387336	6826721	924.7	Ice berg #2, 8-20-70			
68	1270876	22398416	3027	387344	6826704	922.6	Pre-94 debris line, prism at 6.3 ft.			
69	1271007	22398334	3023	387384	6826679	921.5	Peak stage, 7-27-94, prism at 7.7 ft.			
70	1271430	22398278	3021	387513	6826662	920.7	Peak stage, 7-27-94, 10 a.m.			
71	1271492	22398235	3021	387532	6826649	920.7	Peak stage, 7-27-94, 10:15 a.m.			

Survey point	Easting (feet)	Northing (feet)	Elevation (feet)	Easting (meters)	Northing (meters)	Elevation (meters)	Remarks			
72	1272795	22397901	3155	387929	6826547	961.7	ROCK monument			
73	1269964	22398514	3154	387066	6826734	961.4	ROCK monument (invert shot)			
74	1272700	22397851	3040	387900	6826532	926.5	Top of glacier			
75	1270777	22398734	3040	387314	6826801	926.6	Rock #3			
76	1271912	22398258	3013	387660	6826656	918.3	Rock			
77	1270781	22398170	3036	387315	6826629	925.2	Longitudinal profile			
78	1270492	22398153	3041	387227	6826624	927	Longitudinal profile			
79	1270219	22398153	3046	387144	6826624	928.3	Longitudinal profile			
80	1269934	22398140	3052	387057	6826620	930.2	Longitudinal profile			
81	1269675	22398127	3058	386978	6826616	931.9	Longitudinal profile			
82	1266778	22398107	3061	386095	6826610	933	Longitudinal profile			
83	1269232	22398094	3066	386843	6826606	934.5	Longitudinal profile			
84	1268973	22397917	3071	386764	6826552	935.9	Lake stage,7-29-57 from air photo			
85	1268694	22398639	3072	386679	6826772	936.2	Lake stage,7-29-57 from air photo			
86	1268700	22398091	3072	386681	6826605	936.4	Longitudinal profile, prism at 7.2 ft.			
87	1268251	22398091	3080	386544	6826605	938.8	Longitudinal profile, prism at 6.6 ft.			
88	1267814	22398065	3088	386411	6826597	941.3	Longitudinal profile, prism at 5.2 ft.			
89	1267080	22398009	3103	386187	6826580	945.9	Longitudinal profile			
90	1266489	22397983	3118	386007	6826572	950.3	Longitudinal profile, end			
91	1271945	22398905	3009	387670	6826853	917.1	HIDDEN monument			
92	1273648	22396897	3008	388189	6826241	916.9	HIDDEN, invert shot			
93	1273648	22396897	3008	388189	6826241	916.9	HIDDEN, invert check shot			
94	1272224	22399216	3000	387755	6826948	914.5	Stage, 7-2-92, aerial photo			
95	1272293	22399282	2997	387776	6826968	913.3	Stage, 6-24-93, aerial photo			
96	1272457	22399462	2995	387826	6827023	912.9	Stage, 7-9-94, from photo			
97	1273238	22399925	3099	388064	6827164	944.4	Tape down point #3			
98	1273582	22399768	3038	388169	6827116	926	Peak stage, 8-6-75, aerial photo			
99	1274646	22400151	3045	388493	6827233	928.2	Peak stage, 8-6-75, strand line			
100	1274682	22400056	3020	388504	6827204	920.6	Peak stage, 7-27-94			
101	1274747	22399941	2979	388524	6827169	908	Lake level, 7-29-94 10:30 am			
102	1274682	22400043	3019	388504	6827200	920	Ice berg #3, 9-4-74 photograph			
103	1274705	22400092	3025	388511	6827215	921.9	Stage, 8-6-75, from photograph			
104	1275161	22400233	3080	388650	6827258	938.8	Possible strandline			
105	1275312	22400391	3154	388696	6827306	961.3	Old trail or strandline ?			
106	1275974	22400378	3055	388898	6827302	931.1	Highest elevation for time lapse camera			
107	1276014	22400250	3022	388910	6827263	921.2	Stage, 7-24-94, 12:15 pm			
108	1275984	22400099	2988	388901	6827217	910.8	Stage, 7-4-94, 1730, Walder and Driedger			
109	1275971	22400151	3004	388897	6827233	915.6	Blue painted rock (reference)			

Survey point	Easting (feet)	Northing (feet)	Elevation (feet)	Easting (meters)	Northing (meters)	Elevation (meters)	Remarks
110	1275964	22400142	2999	388895	6827230	914.1	Stage, 7-9-94, 5:17 pm
111	1275938	22400066	2976	388887	6827207	906.9	Stage, 7-29-94, 1028 am,lake draining)
112	1276138	22400414	3084	388948	6827313	939.9	Moraine, top of stake
113	1276119	22400358	3061	388942	6827296	933	Geomorphic profile
114	1276086	22399840	2907	388932	6827138	886.1	Stage, 7-29-94, 5:30 p.m.
115	1272500	22399656	3053	387839	6827082	930.5	Geomorphic profile
116	1272519	22399535	3007	387845	6827045	916.6	Geomorphic profile
117	1272552	22399459	2990	387855	6827022	911.4	Geomorphic profile
118	1272579	22399325	2989	387863	6826981	911	Geomorphic profile
119	1272592	22399170	2996	387867	6826934	913.2	Geomorphic profile
120	1272608	22399010	2995	387872	6826885	912.7	Geomorphic profile
121	1272654	22398803	2993	387886	6826822	912.1	Geomorphic profile
122	1272716	22398619	2993	387905	6826766	912.3	Geomorphic profile
123	1272733	22398511	2992	387910	6826733	912	Geomorphic profile
124	1272729	22398399	2981	387909	6826699	908.5	Geomorphic profile
125	1272743	22398340	2967	387913	6826681	904.4	Geomorphic profile
126	1272661	22398268	2951	387888	6826659	899.5	Geomorphic profile
127	1266020	22397934	3125	385864	6826557	952.4	HID 1 monument
128	1266000	22398455	3125	385858	6826716	952.4	Invert shot on HID 1 monument
129	1268326	22397769	3083	386567	6826507	939.6	Upper limits of lake sediments
130	1268855	22397881	3074	386728	6826541	936.9	Upper limits of lake sediments
131	1268864	22397750	3086	386731	6826501	940.5	Geomorphic profile
132	1268864	22397799	3073	386731	6826516	936.5	Geomorphic profile
133	1268825	22397950	3073	386719	6826562	936.5	Geomorphic profile
134	1268812	22398048	3069	386715	6826592	935.3	Geomorphic profile
135	1268805	22398098	3066	386713	6826607	934.4	Geomorphic profile
136	1268799	22398166	3069	386711	6826628	935.4	Geomorphic profile
137	1268773	22398278	3069	386703	6826662	935.3	Geomorphic profile
138	1268750	22398403	3072	386696	6826700	936.3	Geomorphic profile
139	1268668	22398862	3074	386671	6826840	936.9	Geomorphic profile
140	1268668	22398947	3097	386671	6826866	944	Geomorphic profile, prism at 5.8 ft.
141	1265331	22398262	3175	385654	6826657	967.6	BOULDER monument
142	1267020	22398124	3174	386169	6826615	967.5	BOULDER monument (invert shot)
143	1271847	22398042	2992	387640	6826590	911.9	Stage, 7-8-95
144	1271696	22397920	3003	387594	6826553	915.2	Debris line, 1995
145	1271440	22398042	3007	387516	6826590	916.4	Debris line, 1996
146	1271040	22398196	3017	387394	6826637	919.6	Debris line, 1997
147	1271994	22398186	3005	387685	6826634	916	Ice berg, 7-23-95

Survey point	Easting (feet)	Northing (feet)	Elevation (feet)	Easting (meters)	Northing (meters)	Elevation (meters)	Remarks			
148	1271607	22398127	3002	387567	6826616	914.9	Ice berg, 7-23-96			
149	1271512	22398144	3003	387538	6826621	915.4	Debris line, 1995			
150	1270830	22398724	3032	387330	6826798	924.1	Stage, 7-72, NASA			
151	1270954	22398406	3031	387368	6826701	923.7	Stage, 7-72, NASA			
152	1270702	22398747	3034	387291	6826805	924.6	Ice berg, 8-26-70			
153	1270807	22398524	3036	387323	6826737	925.4	Ice berg, 8-26-70			
154	1273937	22397819	2999	388277	6826522	913.9	8/25/95			
155	1274094	22397792	3056	388325	6826514	931.5	Topographical definition			
156	1274065	22398042	2961	388316	6826590	902.6	Topographical definition			
157	1274124	22397760	3078	388334	6826504	938.2	Topographical definition			
158	1274242	22397792	3083	388370	6826514	939.6	Topographical definition			
159	1274206	22397920	3011	388359	6826553	917.6	Topographical definition			
160	1274337	22397845	3080	388399	6826530	938.7	Topographical definition			
161	1274334	22398019	2978	388398	6826583	907.7	Topographical definition			
162	1274422	22397920	3048	388425	6826553	929	Topographical definition			
163	1274432	22397894	3065	388428	6826545	934.3	Topographical definition			
164	1274436	22397894	3065	388429	6826545	934.24	Topographical definition			
165	1274436	22398048	2975	388429	6826592	906.7	Topographical definition			
166	1274564	22397911	3054	388468	6826550	930.7	Topographical definition			
167	1274541	22398048	2978	388461	6826592	907.7	Topographical definition			
168	1274705	22398045	2979	388511	6826591	907.9	Topographical definition			
169	1274718	22397901	3049	388515	6826547	929.4	Topographical definition			
170	1274924	22398006	2986	388578	6826579	910.1	Topographical definition			
171	1274783	22397888	3050	388535	6826543	929.7	Exotic block			
172	1275167	22398452	2919	388652	6826715	889.7	Topographical definition			
173	1275394	22398705	2924	388721	6826792	891.1	Topographical definition			
174	1274672	22397815	3101	388501	6826521	945.1	Paleo strand line			
175	1273409	22398166	2973	388116	6826628	906.2	Edge of terrace			
176	1273494	22398160	2971	388142	6826626	905.6	Edge of terrace			
177	1273635	22398137	2969	388185	6826619	905	Edge of terrace			
178	1273819	22398114	2961	388241	6826612	902.4	Edge of terrace			
179	1273940	22398144	2958	388278	6826621	901.7	Edge of terrace			
180	1273274	22398160	2974	388075	6826626	906.5	Edge of terrace			
181	1273199	22398173	2973	388052	6826630	906.1	Edge of terrace			
182	1273044	22399817	3097	388005	6827131	944	Geomorphic profile			
183	1273071	22399774	3072	388013	6827118	936.3	Geomorphic profile			
184	1273113	22399653	3007	388026	6827081	916.6	Geomorphic profile			
185	1273163	22399544	2978	388041	6827048	907.5	Geomorphic profile			

Survey point	Easting (feet)	Northing (feet)	Elevation (feet)	Easting (meters)	Northing (meters)	Elevation (meters)	Remarks
186	1273208	22399292	2977	388055	6826971	907.4	Geomorphic profile
187	1273268	22399029	2977	388073	6826891	907.4	Geomorphic profile
188	1273297	22398865	2964	388082	6826841	903.3	Geomorphic profile
189	1273330	22398665	2977	388092	6826780	907.4	Geomorphic profile
190	1273356	22398560	2967	388100	6826748	904.3	Geomorphic profile
191	1273376	22398449	2947	388106	6826714	898.1	Geomorphic profile
192	1271716	22398196	3016	387600	6826637	919.1	Edge of terrace
193	1272277	22398308	2999	387771	6826671	914.2	Edge of terrace
194	1272431	223983016	2999	387818	68266692	913.9	Edge of terrace
195	1272582	22398396	2991	387864	6826698	911.7	Edge of terrace
196	1272759	22398409	2979	387918	6826702	907.9	Edge of terrace
197	1272969	22398439	2970	387982	6826711	905.2	Edge of terrace
198	1273044	22398445	2967	388005	6826713	904.2	Edge of terrace
199	1273284	22398609	2978	388078	6826763	907.6	Stage, 7-3-95 1200 pm
200	1273258	22398580	2978	388070	6826754	907.8	Edge of terrace
201	1273415	22398708	2975	388118	6826793	906.6	Terrace point
202	1273327	22398869	2962	388091	6826842	902.8	Ravine
203	1273133	22398901	2970	388032	6826852	905.1	Ravine
204	1272460	22399420	2989	387827	6827010	910.9	Base of scree slope
205	1272844	22398944	2981	387944	6826865	908.6	Ravine
206	1272113	22399144	3005	387721	6826926	915.9	Base of scree slope
207	1271798	22399023	3011	387625	6826889	917.8	Base of scree slope
208	1273172	22399151	2978	388044	6826928	907.6	Stage, 7-3-95 1200 pm
209	1271401	22399082	3022	387504	6826907	921.2	Base of scree slope
210	1273284	22399594	2978	388078	6827063	907.6	Stage, 7-3-95 1200 pm
211	1271151	22398977	3024	387428	6826875	921.7	Base of bedrock
212	1273395	22399538	2978	388112	6827046	907.6	Stage, 7-3-95 1200 pm
213	1273418	22399554	2983	388119	6827051	909.3	Cairn, 6-30-95
214	1270872	22398898	3033	387343	6826851	924.5	Base of scree slope
215	1270849	22398803	3032	387336	6826822	924	Base of scree slope
216	1270557	22398800	3040	387247	6826821	926.5	Base of scree slope
217	1271381	22398206	3025	387498	6826640	921.9	Edge of terrace
218	1272556	22399672	3066	387856	6827087	934.6	Pre-1938 JP
219	1272470	22399732	3103	387830	6827105	945.9	Ice berg, 9-12-16
220	1272398	22399623	3048	387808	6827072	929	Peak stage, 8-16-74
221	1272326	22399390	3009	387786	6827001	917	Ice berg, 7-82
222	1272286	22399394	3020	387774	6827002	920.6	Peak stage, 1982
223	1271053	22399033	3118	387398	6826892	950.2	WILLOW monument

Survey point	Easting (feet)	Northing (feet)	Elevation (feet)	Easting (meters)	Northing (meters)	Elevation (meters)	Remarks			
224	1273192	22399695	3010	388050	6827094	917.4	Peak stage, 8-16-74			
225	1271381	22398206	3025	387498	6826640	921.9	VALLEY monument			
226	1271069	22398308	3028	387403	6826671	923	Terrace			
227	1270863	22398436	3034	387340	6826710	924.6	Terrace			
228	1270479	22398524	3041	387223	6826737	926.9	Terrace			
229	1270154	22398659	3050	387124	6826778	929.5	Terrace			
230	1270052	22398849	3052	387093	6826836	930.2	Base of scree slope			
231	1270758	22398173	3037	387308	6826630	925.7	Edge of terrace			
232	1269859	22398862	3055	387034	6826840	931.2	Base of scree slope			
233	1270712	22398206	3032	387294	6826640	924.1	Ice berg, 7-72			
234	1269822	22398718	3055	387023	6826796	931	Terrace			
235	1269586	22398662	3058	386951	6826779	932.1	Terrace			
236	1270429	22398032	3041	387208	6826587	927	Stage, 1974 w..			
237	1269488	22398878	3060	386921	6826845	932.7	Stage, pre-1938 jp..			
238	1270436	22398183	3042	387210	6826633	927.2	Edge of terrace			
239	1269350	22398741	3062	386879	6826803	933.3	Edge of terrace			
240	1270193	22398245	3048	387136	6826652	928.9	Edge of terrace			
241	1269281	22398875	3065	386858	6826844	934.1	Base of scree slope			
242	1269904	22398288	3052	387048	6826665	930.3	Edge of terrace			
243	1268933	22398787	3071	386752	6826817	936	Base of scree slope			
244	1268933	22398787	3071	386752	6826817	936	Base of scree slope			
245	1269629	22398226	3058	386964	6826646	932.1	Edge of terrace			
246	1268923	22398960	3106	386749	6826870	946.6	Geomorphic profile			
247	1269455	22398111	3061	386911	6826611	932.9	Edge of terrace			
248	1268927	22398846	3078	386750	6826835	938.2	Geomorphic profile			
249	1269238	22398098	3066	386845	6826607	934.4	Edge of terrace			
250	1268930	22398787	3071	386751	6826817	935.9	Geomorphic profile			
251	1268930	22398767	3065	386751	6826811	934.3	Geomorphic profile			
252	1269068	22397825	3068	386793	6826524	935.2	Geomorphic profile			
253	1269078	22397789	3085	386796	6826513	940.3	Geomorphic profile			
254	1268946	22398668	3066	386756	6826781	934.6	Geomorphic profile			
255	1269061	22397891	3070	386791	6826544	935.6	Geomorphic profile			
256	1268953	22398541	3067	386758	6826742	934.7	Geomorphic profile			
257	1267148	22398232	3101	386208	6826648	945.2	Exotic block			
258	1267168	22398603	3105	386214	6826761	946.4	Base of scree slope			
259	1267460	22398701	3100	386303	6826791	944.7	Base of scree slope			
260	1267664	22398846	3092	386365	6826835	942.3	Base of scree slope			
261	1267824	22398954	3087	386414	6826868	940.8	Base of scree slope			

Survey point	Easting (feet)	Northing (feet)	Elevation (feet)	Easting (meters)	Northing (meters)	Elevation (meters)	Remarks			
262	1268238	22398947	3080	386540	6826866	938.7	Base of scree slope			
263	1268523	22398865	3074	386627	6826841	936.8	Base of scree slope			
264	1268969	22398445	3066	386763	6826713	934.6	Geomorphic profile			
265	1269009	22398331	3066	386775	6826678	934.4	Geomorphic profile			
266	1269015	22398321	3062	386777	6826675	933.1	Geomorphic profile			
267	1269048	22398199	3062	386787	6826638	933.4	Geomorphic profile			
268	1269058	22398163	3061	386790	6826627	932.8	Geomorphic profile			
269	1269061	22398144	3062	386791	6826621	933.2	Geomorphic profile			
270	1269084	22398075	3062	386798	6826600	933.2	Geomorphic profile			
271	1269101	22398035	3063	386803	6826588	933.7	Geomorphic profile			
272	1269104	22398025	3068	386804	6826585	935.2	Geomorphic profile			
273	1269320	22397851	3065	386870	6826532	934.2	Base of scree slope			
274	1269645	22397819	3060	386969	6826522	932.6	Base of scree slope			
275	1270023	22397645	3067	387084	6826469	934.7	Base of scree slope			
276	1272601	22398248	2956	387870	6826653	900.9	Hidden Creek, left edge of water			
277	1272857	22398216	2942	387948	6826643	896.7	Hidden Creek, left edge of water			
278	1273120	22398324	2926	388028	6826676	891.9	Hidden Creek, left edge of water			
279	1273333	22398367	2917	388093	6826689	889.1	Hidden Creek, left edge of water			
280	1273395	22398347	2914	388112	6826683	888.2	Hidden Creek, left edge of water			
281	1272910	22398327	2959	387964	6826677	902	Topographic definition			
282	1276132	22400332	3051	388946	6827288	929.8	Ice berg, 8-24-64			
283	1276106	22400270	3031	388938	6827269	923.7	Peak stage, 1982			
284	1276092	22400270	3029	388934	6827269	923.3	Ice berg, 8-27-69			
285	1275997	22400296	3033	388905	6827277	924.5	Pre-1938 stage, "Icy" Lake			
286	1275889	22400247	3025	388872	6827262	922	Peak stage, 8-16-74			
287	1275791	22400184	3013	388842	6827243	918.3	Ice berg, 8-31-84			
288	1273044	22398901	2974	388005	6826852	906.5	Gully			
289	1276001	22400263	3025	388906	6827267	922	Peak stage, 8-16-74			
290	1273159	22398898	2968	388040	6826851	904.7	Gully			
291	1273369	22398875	2958	388104	6826844	901.5	Gully			
292	1273550	22398882	2951	388159	6826846	899.4	Gully			
293	1273612	22398898	2961	388178	6826851	902.4	Topographic definition			
294	1273615	22399069	2971	388179	6826903	905.6	Topographic definition			
295	1273596	22399282	2956	388173	6826968	900.8	Gully			
296	1273684	22399380	2971	388200	6826998	905.6	Topographic definition			
297	1273710	22399266	2948	388208	6826963	898.4	Gully			
298	1275938	22400243	3023	388887	6827261	921.3	Ice berg, 8-26-70			
299	1273770	22399643	2984	388226	6827078	909.6	Topographical definition			

Survey point	Easting (feet)	Northing (feet)	Elevation (feet)	Easting (meters)	Northing (meters)	Elevation (meters)	Remarks
300	1274045	22399745	2982	388310	6827109	908.8	Topographical definition
301	1276050	22400165	3007	388921	6827237	916.6	Peak stage, 7-23-95
302	1274294	22399774	2995	388386	6827118	912.7	Topographical definition
303	1276060	22399725	2862	388924	6827103	872.2	Terminal moraine
304	1276145	22399814	2888	388950	6827130	880.1	Terminal moraine
305	1276056	22399794	2884	388923	6827124	879.1	Terminal moraine
306	1276112	22399846	2905	388940	6827140	885.3	Terminal moraine
307	1276024	22399892	2929	388913	6827154	892.7	Terminal moraine
308	1275902	22399886	2910	388876	6827152	886.8	Terminal moraine
309	1275964	22399981	2917	388895	6827181	889.1	Terminal moraine
310	1275984	22400040	2971	388901	6827199	905.4	Terminal moraine
311	1276024	22400129	2999	388913	6827226	914.2	Terminal moraine
312	1276060	22400197	3018	388924	6827247	919.7	Terminal moraine
313	1276096	22400276	3031	388935	6827271	923.8	Terminal moraine
314	1276112	22400322	3050	388940	6827285	929.6	Terminal moraine
315	1276165	22400407	3084	388956	6827311	940	Terminal moraine
316	1276181	22400489	3124	388961	6827336	952.2	Terminal moraine
317	1276250	22400614	3157	388982	6827374	962.2	Terminal moraine
318	1276302	22400670	3172	388998	6827391	966.9	Terminal moraine
319	1276404	22400739	3182	389029	6827412	969.8	Terminal moraine
320	1274757	22399987	2991	388527	6827183	911.6	Topographical definition
321	1276033	22400647	3148	388916	6827384	959.6	Trail
322	1275170	22399945	2954	388653	6827170	900.3	Topographical definition
323	1276040	22400312	3037	388918	6827282	925.5	Peak stage, 7-22-76
324	1275994	22400240	3018	388904	6827260	919.8	Peak stage, 8-6-75
325	1275987	22400204	3008	388902	6827249	916.8	Ice berg, 9-7-74
326	1275853	22400588	3154	388861	6827366	961.3	Trail
327	1275656	22400516	3156	388801	6827344	962	Trail
328	1275545	22400480	3154	388767	6827333	961.2	Trail
329	1275449	22400430	3153	388738	6827318	961	Trail
330	1275505	22400184	3033	388755	6827243	924.3	Topographical definition
331	1275508	22400073	2984	388756	6827209	909.6	Topographical definition
332	1275564	22399899	2894	388773	6827156	882.2	Topographical definition
333	1275449	22400430	3153	388738	6827318	960.9	Trail
334	1275400	22400411	3153	388723	6827312	961	Trail
335	1275285	22400388	3154	388688	6827305	961.2	Trail
336	1275170	22400142	3039	388653	6827230	926.1	Topographical definition
337	1275095	22400358	3154	388630	6827296	961.2	Trail

Survey point	Easting (feet)	Northing (feet)	Elevation (feet)	Easting (meters)	Northing (meters)	Elevation (meters)	Remarks			
338	1274924	22400358	3152	388578	6827296	960.8	Trail			
339	1274856	22400112	3031	388557	6827221	923.8	Topographical definition			
340	1274833	22400368	3150	388550	6827299	960	Trail			
341	1274783	22400355	3152	388535	6827295	960.8	Trail			
342	1274573	22400329	3126	388471	6827287	952.8	Trail			
343	1274672	22400125	3036	388501	6827225	925.4	Ice berg, 8-26-70			
344	1274760	22399978	2988	388528	6827180	910.6	Lake stage, 6-24-93			
345	1274698	22400024	3009	388509	6827194	917.1	Ice berg, 8-31-84			
346	1274705	22400083	3021	388511	6827212	920.8	Ice berg, 8-27-69			
347	1274711	22400079	3019	388513	6827211	920.2	Peak stage, 8-16-74			
348	1274747	22400033	3002	388524	6827197	915.1	Peak stage, 7-23-95			
349	1274728	22400145	3044	388518	6827231	927.8	Wash line			
350	1274714	22400224	3080	388514	6827255	938.6	Wash line			
351	1274462	22399896	3020	388437	6827155	920.3	Topographical definition			
352	1274268	22399850	3025	388378	6827141	922	Topographical definition			
353	1274331	22399646	2937	388397	6827079	895.1	Base of scree slope			
354	1274268	22400119	3138	388378	6827223	956.5	Trail			
355	1274104	22400092	3128	388328	6827215	953.5	Trail			
356	1274091	22400129	3148	388324	6827226	959.6	Wash line			
357	1273950	22399928	3051	388281	6827165	929.8	Ice berg, 7-10-51			
358	1273973	22399856	3026	388288	6827143	922.3	Lake stage, 7-10-51			
359	1273238	22399705	3011	388064	6827097	917.6	Peak stage, 7-23-95			
360	1273205	22399741	3026	388054	6827108	922.3	Ice berg, 7-10-51			
361	1273166	22399725	3024	388042	6827103	921.7	Ice berg, 8-31-84			
362	1272395	22399607	3041	387807	6827067	926.8	Peak stage, 8-16-74			
363	1272431	22399659	3066	387818	6827083	934.6	Pre-1938 lake stage,			
364	1272434	22399617	3042	387819	6827070	927.1	Ice berg, 8-24-64			
365	1272323	22399587	3045	387785	6827061	928.1	Peak stage, 8-6-75			
366	1272385	22399551	3021	387804	6827050	920.8	Ice berg, 8-26-70			
367	1272339	22399567	3035	387790	6827055	925.1	Lake stage, 7-72 NASA			
368	1272306	22399282	2995	387780	6826968	912.7	Peak stage, 6-24-93			
369	1272073	22399062	3006	387709	6826901	916.1	Ice berg, 8-13-90			
370	1272080	22398842	3004	387711	6826834	915.7	Ice berg, 8-13-91			
371	1272139	22398668	3003	387729	6826781	915.2	Ice berg, 8-13-92			
372	1271916	22398659	3007	387661	6826778	916.6	Peak stage, 7-23-95			
373	1271532	22399020	3017	387544	6826888	919.5	Topographical definition			
374	1271319	22399131	3047	387479	6826922	928.6	Pre-1938 stage			
375	1270403	22398954	3097	387200	6826868	943.9	Geomorphic profile			

Survey point	Easting (feet)	Northing (feet)	Elevation (feet)	Easting (meters)	Northing (meters)	Elevation (meters)	Remarks			
376	1270400	22398898	3079	387199	6826851	938.5	Geomorphic profile			
377	1270390	22398750	3042	387196	6826806	927.1	Geomorphic profile			
378	1270397	22398668	3044	387198	6826781	927.9	Geomorphic profile			
379	1270400	22398570	3043	387199	6826751	927.5	Geomorphic profile			
380	1270400	22398534	3035	387199	6826740	925	Geomorphic profile			
381	1270397	22398478	3035	387198	6826723	925.1	Geomorphic profile			
382	1270397	22398452	3036	387198	6826715	925.4	Geomorphic profile			
383	1270387	22398413	3035	387195	6826703	924.9	Geomorphic profile			
384	1270387	22398406	3037	387195	6826701	925.6	Geomorphic profile			
385	1270387	22398390	3037	387195	6826696	925.5	Geomorphic profile			
386	1270393	22398363	3033	387197	6826688	924.5	Geomorphic profile			
387	1270393	22398360	3029	387197	6826687	923.2	Geomorphic profile			
388	1270393	22398347	3029	387197	6826683	923.2	Geomorphic profile			
389	1270397	22398331	3031	387198	6826678	923.71	Geomorphic profile			
390	1270400	22398311	3036	387199	6826672	925.2	Geomorphic profile			
391	1270387	22398262	3036	387195	6826657	925.2	Geomorphic profile			
392	1270380	22398232	3036	387193	6826648	925.4	Geomorphic profile			
393	1270380	22398229	3038	387193	6826647	926	Geomorphic profile			
394	1270377	22398216	3038	387192	6826643	925.9	Geomorphic profile			
395	1270377	22398203	3043	387192	6826639	927.6	Geomorphic profile			
396	1270377	22398088	3044	387192	6826604	927.7	Geomorphic profile			
397	1270374	22397950	3042	387191	6826562	927.3	Geomorphic profile			
398	1270374	22397845	3042	387191	6826530	927.1	Geomorphic profile			
399	1270374	22397806	3041	387191	6826518	926.9	Geomorphic profile			
400	1270374	22397806	3041	387191	6826518	926.9	Geomorphic profile			

APPENDIX 4

Summary of historical data and references for outburst lakes in the Kennicott basin

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KENNICOTT BASIN OUTBURST LAKES: ALL DATA

SITE	YEAR	MONTH	DAY	DATE	STATUS	NOTES	SOURCE	S_NOTES
4TH JULY LAKE	48	6	16	06/16/48	FULL	ICE MARGIN LAKE	PHOTO	TRIMET#301RT-72PL-C-8M164-72RS-16JUNE48-ACR
4TH JULY LAKE	57	7	29		FULL	NO BERGS	PHOTO	USGS,M230-7813&4,1:40000,B&W
4TH JULY LAKE	57	7	29		FULL	NO DISCHARGE, LARGE DEPRESSION NEAR LAKE	PHOTO	USGS,M230-7847&8,1:40000,B&W
4TH JULY LAKE	64	8	24		FULL	STAGE AT LEVEL PREBREECH TO THE WEST	PHOTO	POST,K642-77,B7W,OBLIQUE
4TH JULY LAKE	70	8	26	08/26/70	FILLING	BREECHED, DRAINS WESTWARD	PHOTO	AEROMAP ROLL#70-23APT FL/FR(3-11)
4TH JULY LAKE	72	7	21	07/21/72	FILLING	PRIOR W.SIDE BREECH, V FULL	PHOTO	NASA/JCS,M#209,FL#24-78,COLOR
4TH JULY LAKE	78	8	0		FULL		PHOTO	NASA,ENLARGEMENT,FL105#7525,1:32500,B&W
4TH JULY LAKE	90	8	22		FILLING	LAKE DRAINS PRIOR TO FILLING?	PHOTO	NPS,R1-90(#7884-86)1:48000,COLOR
4TH JULY LAKE	93	7	15		FILLING		SLIDE	ROSENKRANS
4TH JULY LAKE	94	3	31		LOW STAGE	ICE, BREECH ON WEST SIDE, UNCONNECTED	OBSERVATION	ROSENKRANS, OVERFLIGHT
4TH JULY LAKE	94	5	13	05/13/94	FILLING	TWO SMALL LAKES PERCHED ON ICE NEARBY	OBSERVATION	FLIGHT NOTES AND PHOTO
4TH JULY LAKE	94	6	5	06/05/94	STATIC	BREECHED, DRAINS TO THE WEST	PHOTO	OBSERVATION, ROSENKRANS
BONANZA LAKE 1	57	7	29		EMPTY		PHOTO	USGS,M230-7847&8,1:40000,B&W
BONANZA LAKE 1	57	7	29		EMPTY	DRAIN HOLE VISIBLE, LAKE PART OF II?	PHOTO	USGS,M230-7904&5,1:40000,B&W
BONANZA LAKE 1	66	7	20	07/20/66	EMPTY	H2O DRAIN POINT	PHOTO	AEROMAP ROLL#66-16,FL/FR(9-3)
BONANZA LAKE 1	70	8	26	08/26/70	EMPTY	FORMING, POST RELEASE	PHOTO	AEROMAP ROLL#70-23APT FL/FR(3-10)
BONANZA LAKE 1	72	7	21	07/21/72	EMPTY	DRAINED	PHOTO	NASA/JCS,M#209,FL#19-218,COLOR
BONANZA LAKE 1	74	8			EMPTY		SLIDE	VC#825-27
BONANZA LAKE 1	74	9	1	09/01/74	EMPTY	NO H2O OBSERVED	PHOTO	USGS, 74V3-110, B&W, OBLIQUE
BONANZA LAKE 1	75	5			FILLING		SLIDE	VC,V9#2264-3
BONANZA LAKE 1	76	6	11	06/11/76	FORMING?	SMALL DEPRESSION? RECEIVES H2O	PHOTO	AEROMAP FL#76-7(2-2&3-3)
BONANZA LAKE 1	76	7			EMPTY		SLIDE	VC,VOL9#4004-34
BONANZA LAKE 1	78	8	0		EMPTY		PHOTO	NASA,ENLARGEMENT,FL105#7525,1:32500,B&W
BONANZA LAKE 1	78	8	25		EMPTY		PHOTO	NASA,ENLARGEMENT,FL105B#7087,1:19000,CIR
BONANZA LAKE 1	83	8	19	08/19/83	EMPTY	DRAIN HOLE AND CHANNEL	PHOTO	83-CO3257,FL#14X,FR,#7
BONANZA LAKE 1	85	9	12		EMPTY		PHOTO	MCCARTHY RD,#14-7,1:12000,COLOR
BONANZA LAKE 1	86	6	29		EMPTY		PHOTO	NPS,R#5&6(193-195),1;16000,CIR
BONANZA LAKE 1	86	9	6		EMPTY		PHOTO	NPS-12WRST-3-42-56&7,1:12000,CIR
BONANZA LAKE 1	88	6	28		EMPTY	PERCHED LK @ S END, PRERELEASE EL 1930'?	PHOTO	NPS,R#1-88(1215&6),1:500',B&W
BONANZA LAKE 1	89	8	10		EMPTY		PHOTO	NPS,BONANZA PK#1&2,1:40000,COLOR
BONANZA LAKE 1	89	8	10		EMPTY		MAP	NPS KENNECOTT CLAIMS, 1:2400, 10'C
BONANZA LAKE 1	90	8	22		EMPTY	BONANZA CRK DRAINS INTO HOLE	PHOTO	NPS,1-90(#7858-60,73-76)1:48000,COLOR
BONANZA LAKE 1	92	7	0		EMPTY		SLIDE	ROSENKRANS
BONANZA LAKE 1	92	7	2		EMPTY		SLIDE	ROSENKRANS
BONANZA LAKE 1	93	7	15		EMPTY		SLIDES	ROSENKRANS
BONANZA LAKE 1	94	3	31		EMPTY	NO ICE	OBSERVATION	ROSENKRANS, OVERFLIGHT
BONANZA LAKE 1	94	5	13	05/13/94	FILLING	MOD. STAGE, MUDDY WATER	PHOTO	ROSENKRANS, NOTES
BONANZA LAKE 1	94	5	24	05/24/94	DRAINING	STAGE DECREASING @18:30	NOTES	OBSERVATION, M. MCDONALD
BONANZA LAKE 1	94	5	26	05/26/94	DRAINING	STAGE DROPPING	NOTES	OBSERVATION, M. MCDONALD
BONANZA LAKE 1	94	5	30	05/30/94	EMPTY	OBSERVED 6/1	NOTES	OBSERVATION, M. MCDONALD
BONANZA LAKE 1	94	6	4	06/04/94	EMPTY	DRAINING H20	PHOTO	OBSERVATION, ROSENKRANS
BONANZA LAKE 1	94	7	15	07/15/94	EMPTY	NO ACTIVITY WHILE ERIE IS DRAINING	PHOTO	OBSERVATION,ROSENKRANS
BONANZA LAKE 1	95	4	3		EMPTY		OBSERVATION	AERIAL OBSERVATION, ROSENKRANS
BONANZA LAKE 2	57	7	29		EMPTY	CONNECTED WITH BONANZA I?	PHOTO	USGS,M230-7904&5,1:40000,B&W
BONANZA LAKE 2	57	7	29		EMPTY		PHOTO	USGS,M230-7847&8,1:40000,B&W
BONANZA LAKE 2	66	7	20	07/20/66	EMPTY	H2O DRAIN POINT	PHOTO	AEROMAP ROLL#66-16,FL/FR(9-3)
BONANZA LAKE 2	70	8	26	08/26/70	EMPTY	FORMING, POST RELEASE	PHOTO	AEROMAP ROLL#70-23APT FL/FR(3-10)
BONANZA LAKE 2	72	7	21	07/21/72	EMPTY	DRAINED	PHOTO	NASA/JCS,M#209,FL#19-218,COLOR
BONANZA LAKE 2	74	8			EMPTY		SLIDE	VC #825-27
BONANZA LAKE 2	74	9	1	09/01/74	EMPTY	NO H2O OBSERVED	PHOTO	USGS, 74V3-110, B&W, OBLIQUE
BONANZA LAKE 2	76	6	11	06/11/76	FORMING?	RECEIVES H2O, CHANNEL DRAIN HOLE	PHOTO	AERMAP FL#76-7(2-2&3-3)

KENNICOTT BASIN OUTBURST LAKES: ALL DATA

BONANZA LAKE 2	78	8	0		EMPTY		PHOTO	NASA,ENLARGEMENT,FL105#7525,1:32500,B&W
BONANZA LAKE 2	78	8	25		EMPTY		PHOTO	NASA,ENLARGEMENT,FL105B#7087,1;19000,CIR
BONANZA LAKE 2	85	9	12	09/12/85	EMPTY		PHOTO	MCCARTHY RD, AKDOT #14-9, 1:12000, CIR
BONANZA LAKE 2	86	6	29		FILLING	SMALL LAKE WATER LEVEL 1930'	PHOTO	NPS,R#5&6(193-195),1;16000,CIR
BONANZA LAKE 2	86	9	6		EMPTY		PHOTO	NPS-12WRST3-42-56&7,1:12000,CIR
BONANZA LAKE 2	88	6	28		FILLING	WATER LEVEL 1920'	PHOTO	NPS,R#1-88(1215&6),1:500',B&W
BONANZA LAKE 2	89	8	10		EMPTY		MAP	NPS KENNECOTT CLAIMS,1:2400, 10'C
BONANZA LAKE 2	89	8	10		EMPTY		PHOTO	NPS,BOANAZA PK#1&2,1:40000,COLOR
BONANZA LAKE 2	90	8	22		EMPTY		PHOTO	NPS,R1-90(#7858-60,73-76),1:48000,COLOR
BONANZA LAKE 2	92	7	0		EMPTY		SLIDE	ROSENKRANS
BONANZA LAKE 2	92	7	2		EMPTY		SLIDE	ROSENKRANS
BONANZA LAKE 2	93	7	15		EMPTY		SLIDES (2)	ROSENKRANS
BONANZA LAKE 2	94	3	31		EMPTY	NO ICE	OBSERVATION	ROSENKRANS, OVERFLIGHT
BONANZA LAKE 2	94	5	13	05/13/94	EMPTY		PHOTO	FLIGHT NOTES , ROSENKRANS
BONANZA LAKE 2	94	5	20	05/20/94	DRAINING	STAGE DECREASING @10:00-12:00	NOTES	OBSERVATION, M. MCDONALD
BONANZA LAKE 2	94	5	21	05/21/94	DRAINING	STAGE DECREASING @19:00	NOTES	OBSERVATION, M. MCDONALD
BONANZA LAKE 2	94	5	24	05/24/94	DRAINING	STAGE DECREASING @18:30	NOTES	OBSERVATION, M. MCDONALD
BONANZA LAKE 2	94	5	25	05/25/94	STATIC	STAGE UNCHANGED @17:00	NOTES	OBSERVATION, M. MCDONALD
BONANZA LAKE 2	94	5	26	05/26/94	DRAINING	STAGE DROPPING	NOTES	OBSERVATION, M. MCDONALD
BONANZA LAKE 2	94	5	28	05/28/94	DRAINING	STAGE DROPPING	NOTES	OBSERVATION, M. MCDONALD
BONANZA LAKE 2	94	5	30	05/30/94	EMPTY	OBSERVED 6/1	NOTES	OBSERVATION, M. MCDONALD
BONANZA LAKE 2	94	6	4	06/04/94	EMPTY	DRAINING CREEK	PHOTO	OBSERVATION - ROSENKRANS
BONANZA LAKE 2	94	7	15	07/15/94	EMPTY	NO ACTIVITY WHILE ERIE IS DRAINING	PHOTO	OBSERVATION, ROSENKRANS
BONANZA LAKE 2	95	4	3		EMPTY		OBSERVATION	AERIAL OBSERVATION, ROSENKRANS
BONANZA LAKE ?	22				ACTIVE	TUNNEL DRIVEN, CONNECT LAKES TO DRAIN	BATEMAN	GSA BULL V33,P535
DONOHO CRK LAKE	48	6	16	06/16/48	FILLING	VERY FULL (?)	PHOTO	TRIMET#300RT-72PL-C-8M164-72RS-16JUNE48-ACR
DONOHO CRK LAKE	57	7	29		EMPTY	SMALL, POSSIBLE ICE IN BOTTOM?	PHOTO	USGS,M230-784&9,1:40000,B&W
DONOHO CRK LAKE	64	8	24		EMPTY	APPEARS EMPTY	PHOTO	POST-K642-77,B&W, OBLIQUE
DONOHO CRK LAKE	69	8	27	08/27/69	EMPTY?	NO H2O OBSERVED	PHOTO	USGS, 69LI-252, B&W, OBLIQUE
DONOHO CRK LAKE	70	8	26	08/26/70	EMPTY	1970 STAGE LINE VISIBLE	PHOTO	AEROMAP ROLL#70-23APT FL/FR(4-14&16)
DONOHO CRK LAKE	72	7	21	07/21/72	EMPTY	DRAINED	PHOTO	NASA/JCS,M#209,FL#19-217&218,COLOR
DONOHO CRK LAKE	74	9	1	09/01/74	FILLING	LATEST DATE KNOWN WITH H20	PHOTO	USGS, 74V3-113 B&W VERTICAL
DONOHO CRK LAKE	75	10	9	10/09/75	EMPTY		PHOTO	USGS 75MS #170 OBLIQUE
DONOHO CRK LAKE	76	6	11	06/11/76	FILLING	RECEIVING H2O	PHOTO	AERMAP FL#76-7(2-4)
DONOHO CRK LAKE	78	8	0		EMPTY		PHOTO	NASA,FL105#7526,1;60000,B&W
DONOHO CRK LAKE	78	8	25		EMPTY		PHOTO	NASA,ENLARGEMENT,FL105B#7087,1:19000,CIR
DONOHO CRK LAKE	86	9	6		EMPTY?	SHADOW, NO STEREO	PHOTO	NPS-12WRST-3-43-39,1:12000,CIR
DONOHO CRK LAKE	89	8	10		EMPTY		PHOTO	NPS,BONANZA PK#1&2,1:40000,COLOR
DONOHO CRK LAKE	90	8	22	08/22/90	EMPTY		PHOTO	NPS,R#1-90, COLOR, FRAME #7873
DONOHO CRK LAKE	94	1	2		EMPTY		SLIDES (2)	ROSENKRANS
DONOHO CRK LAKE	94	3	31		LOW STAGE	ICE COVERED	OBSERVATION	DSR, OVERFLIGHT
DONOHO CRK LAKE	94	5	13	05/13/94	FILLING	HIGH STAGE, MUDDY WATER	PHOTO	FLIGHT NOTES , ROSENKRANS
DONOHO CRK LAKE	94	5	23	05/23/94	FILLING	08:30, FILLING, 50% FULL	REPORT	ELCONIN, AERIAL OBSERVATION
DONOHO CRK LAKE	94	5	26	05/26/94	EMPTY	12:00 HAD EMPTIED, NOW REFILLING	REPORT	ELCONIN, AERIAL OBSERVATION
DONOHO CRK LAKE	94	6	5	06/05/94	FILLING	UNFROZEN, HIGH STAGE, ACTIVE CREEK	PHOTO	OBSERVATION, ROSENKRANS
DONOHO CRK LAKE	94	6	7	06/07/94	FILLING	09:45 REFILLING SINCE 5/26 ALMOST FULL	REPORT	ELCONIN, AERIAL OBSERVATION
DONOHO CRK LAKE	94	6	9	06/09/94	EMPTY	08:45,STRANDLINE BELOW 1ST STRANLINE	REPORT	ELCONIN, AERIAL OBSERVATION
DONOHO CRK LAKE	94	6	12	06/12/94	EMPTY	09:00, NO CHANGE	REPORT	ELCONIN, AERIAL OBSERVATION
DONOHO CRK LAKE	94	6	16	06/16/94	FILLING	09:00, SMALL POND	REPORT	ELCONIN, AERIAL OBSERVATION
DONOHO CRK LAKE	94	6	18	06/18/94	DRAINING	11:00, SMALL POND REMAINS?	REPORT	ELCONIN, AERIAL OBSERVATION
DONOHO CRK LAKE	94	6	28	06/28/94	EMPTY	AERIAL OBSERVATION, NO H20	SLIDE	D. ROSENKRANS
DONOHO CRK LAKE	94	7	15	07/15/94	EMPTY	NO ACTIVITY WHILE ERIE IS DRAINING	PHOTO	OBSERVATION, ROSENKRANS

KENNICOTT BASIN OUTBURST LAKES: ALL DATA

DONOHO CRK LAKE	94	7	26	07/26/94	EMPTY	19:30, 16 OBSERVATIONS SINCE 6/27	REPORT	ELCONIN, AERIAL OBSERVATION
DONOHO CRK LAKE	94	7	29	07/29/94	OUTBURST	OUTBURST EVENT 10:43AM, STAGE DOWN 5'?	PHOTO	AERIAL OBSERVATION, ROSENKRANS
DONOHO CRK LAKE	94	7	30	07/30/94	EMPTY	9:18AM AERIAL OBSERVATION	PHOTO	ROSENKRANS
DONOHO CRK LAKE	94	8	2	08/02/94	EMPTY	09:00, NEW STRANDLINE	REPORT	ELCONIN, AERIAL OBSERVATION
DONOHO CRK LAKE	94	8	24		EMPTY	RECEIVING H20	OBSERVATION	AERIAL OBSERVATION, ROSENKRANS
DONOHO CRK LAKE	94	10	13	10/13/94	EMPTY	12:30, 6 OBSERVATIONS SINCE 8/2	REPORT	ELCONIN, AERIAL OBSERVATION
DONOHO CRK LAKE	95	4	3		EMPTY	RECEIVING WATER	PHOTO	ROSENKRANS, AERIAL OBSERVATION
DONOHO CRK LAKE	95	6	6		DRAINING	WASH LINE VISIBLE, 5:00PM (-15FT)	AERIAL OBS	NOTES AND PHOTO DSR
DONOHO CRK LAKE	95	6	7		EMPTY	VERY LOW OR EMPTY	M.MCCARTHY	AERIAL OBSERVATION, VER COMM
DONOHO CRK LAKE	95	6	8		EMPTY	AERIAL OBS. 9:00AM	KELLY BAY	VERBAL COMM.
DONOHO CRK LAKE	95	6	15		FILLING	AERIAL OBSERVATION	KELLY BAY	VERBAL COMM.
DONOHO CRK LAKE	95	6	16		EMPTY	AERIAL OBSERVATION	KELLLY BAY	VERBAL COMM.
DONOHO CRK LAKE	95	7	3		EMPTY	AERIAL OBSERVATION	OBSERVATION	OVERFLIGHT, NOTES, ROSENKRANS
DONOHO CRK LAKE	95	7	22		FILLING	STAGE INCREASING, 14:30	OBSERVATION	VERBAL COMM, LACHAPELLE
DONOHO CRK LAKE	95	7	23		DRAINING	STAGE DROPPING (-15FT)	PHOTO	OBSERVATION AND PHOTO, ROSENKRANS
DONOHO CRK LAKE	95	7	23		FILLING	ICE FRACTURES NOTED, 9:00AM	PHOTO	AERIAL OBSERVATION & PHOTO, ROSENKRANS
DONOHO CRK LAKE	95	7	24		EMPTY	DRAINED 10:00	OBSERVATION	OBSERVATION, ROSENKRANS
DONOHO CRK LAKE	95	8	27		EMPTY	RECEIVING H20	OBSERVATION	AERIAL OBSERVATION, NOTES, ROSENKRANS
DONOHO CRK LAKE	95	9	10		FILLING	DRAINED APPROX. THIS DATE	KELLY BAY	AERIAL OBSERVATION
DONOHO CRK LAKE	95	9	25		EMPTY	SEPT. WASHLINE VISIBLE	OBSERVATION	AERIAL OBSERVATION, ROSENKRANS
ERIE LAKE	48	6	16	06/16/48	FILLING	BELOW PEAK STAGE	PHOTO	TRIMET#243RT-72PL-C-8M164-72RS-16JUNE48-ACR
ERIE LAKE	57	7	29		EMPTY	NARROW AND DEEP,COUPLE BERGS	PHOTO	USGS,#M230-9002&3,1:40000,B&W
ERIE LAKE	57	7	29		FILLING	V SMALL POND,FEW BERGS AT 1/3 LEVEL	PHOTO	USGS,M230-7849&50,1:40000,B&W
ERIE LAKE	70	8	26	08/26/70	FILLING	1970 STRANLINE VISIBLE,SMALL POND,BERGS	PHOTO	AEROMAP ROLL#70-23APT FL/FR(5-13)
ERIE LAKE	70	8	26	08/26/70	FILLING	1970 STRANLINE VISIBLE,SMALL POND,BERGS	PHOTO	AEROMAP ROLL#70-23APT FL/FR(5-13)
ERIE LAKE	72	7	21	07/21/72	FILLING	NEAR PEAK STAGE,NO BERGS	PHOTO	NASA/JCS,M#209,FL#19-217,COLOR
ERIE LAKE	76	6	11	06/11/76	FILLING	RECEIVING H2O	PHOTO	AERMAP FL#76-7(2-8)
ERIE LAKE	78	8	0		EMPTY	BERGS	PHOTO	NASA,FL105#7526,1:60000,B&W
ERIE LAKE	78	8	28		EMPTY		PHOTO	NASA,#FL104B-7959&60,1:60000,CIR
ERIE LAKE	80	7	22		FILLING	OBSERVED FROM DONOHO PEAK	PHOTO	N. SIMMERMAN SLIDE DATED 7/22/80
ERIE LAKE	80	7	24		EMPTY	LAKE EMPTY	PHOTO	N. SIMMERMAN SLIDE DATED 7/24/80
ERIE LAKE	82	8	1	08/01/82	OUTBURST?	HIGH DISCHARGE, PRE HIDDEN CRK LK EVENT?	NOTES	HECHT, PER. COMM. (DSR INTERPRETATION)
ERIE LAKE	86	6	29		FILLING	WATER LEVEL ABOVE LAT MORAINE KNOTCH	PHOTO	NPS,R#5&6(185&186),1;16000,CIR
ERIE LAKE	86	9	6		EMPTY	ICEBERG LEVEL HIGH	PHOTO	NPS-12WRST-3-41-72&3,1:12000,CIR
ERIE LAKE	86	9	6		EMPTY	DRAIN HOLE,ICEBERG LEVEL HIGH, TERRACES	PHOTO	NPS,12WRST-3-42-46&47,1:12000,CIR
ERIE LAKE	88	7	17	07/17/88	OUTBURST	STARTED NIGHT OF 7/17	NOTES	B. HECHT, PER COMM.
ERIE LAKE	89	8	10		EMPTY	BERGS BEYOND LATERAL MORAINE	PHOTO	NPS,BONANZA PK#2&3,1:40000,COLOR
ERIE LAKE	90	8	22		EMPTY	BERGS OUTSIDE L MORAINE FEWER THAN 8/89	PHOTO	NPS,R1-90(7857,62&3,9)1:48000,COLOR
ERIE LAKE	93	6	24		FILLING	BREACHES LATERAL MORAINE	SLIDE	ROSENKRANS
ERIE LAKE	93	7	8		LEAKING	NEED TO CONFIRM DATA LEAKING/EMPTY	LACHAPELLE	PER COM. SITE VISIT
ERIE LAKE	93	7	10		DRAINING	DRAINED IN 24 HR PERIOD, APPRX. DATE	TRACY ????	PER.COMM. AT THE SITE DURING RELEASE
ERIE LAKE	93	7	13		OUTBURST	STAGE LEVEL AT TRAM DOCUMENTED	PHOTO	ROSENKRANS,DSR#3-93 GROUND IMAGE
ERIE LAKE	93	7	13		OUTBURST	INCREASE IN STAGE AT TRAM 7/13/&7/14	STAGE GAGE	USGS KENNICOTT RIVER STAGE RECORD
ERIE LAKE	94	3	31		EMPTY	NO ICE, ONLY BERGS	OBSERVATION	ROSENKRANS OVERFLIGHT
ERIE LAKE	94	5	13	05/13/94	EMPTY	SNOW, NO MELT?, V.LOW STAGE?	OBSERVATION	FLIGHT NOTES AND PHOTO
ERIE LAKE	94	5	23	05/23/94	EMPTY	FILLING	REPORT	ELCONIN AERIAL OBSERVATION, 08:30
ERIE LAKE	94	6	5	06/05/94	FILLING	UNFROZEN, BELOW 1993 STAGE, ACTIVE CREEK	PHOTO	OBSERVATION, ROSENKRANS
ERIE LAKE	94	6	18	06/19/94	FILLING	FILLING SINCE 5/23, 10 OBSERVATIONS, 50% FULL	REPORT	ELCONIN AERIAL OBSERVATION, 11:00
ERIE LAKE	94	6	28	06/28/94	FILLING	>50% FULL	PHOTO	AERIAL OBSERVATION,ROSENKRANS
ERIE LAKE	94	7	12	07/12/94	FILLING	FILLING SINCE 5/23, 22 OBSERVATIONS	REPORT	ELCONIN AERIAL OBSERVATION, 07:45
ERIE LAKE	94	7	14	07/14/94	DRAINING	FULL, STARTING TO DRAIN, STAGE DOWN 1M	REPORT	ELCONIN AERIAL OBSERVATION, 19:15
ERIE LAKE	94	7	14	07/14/94	DRAINING	1ST REPORTED DECREASE IN STAGAE, PM	NOTES	OBSERVATION, ELCONIN

KENNICOTT BASIN OUTBURST LAKES: ALL DATA

ERIE LAKE	94	7	15	07/15/94	DRAINING	STAGE 10'? BELOW PEAK, 12:00 NOON	PHOTO	AERIAL OBSERVATION, ROSENKRANS
ERIE LAKE	94	7	15	07/15/94	DRAINING	FULL, STAGE DOWN 2M, DRAINING @ N. END	REPORT	ELCONIN,AERIAL OBSERVATION & PHOTO,19:15
ERIE LAKE	94	7	16	07/16/94	DRAINING	10'/PER HR,ONSITE,100'? BELOW PEAK STAGE	NOTES	OBSERVATION, ROSENKRANS, 13:50
ERIE LAKE	94	7	16	07/16/94	DRAINING	50% FULL,STAGE DOWN 20M	REPORT	ELCONIN AERIAL OBSERVATION, 09:15
ERIE LAKE	94	7	17	07/17/94	EMPTY	09:30	REPORT	ELCONIN, AERIAL OBSERVATION
ERIE LAKE	94	7	21	07/21/94	EMPTY	09:00	REPORT	ELCONIN AERIAL OBSERVATION,
ERIE LAKE	94	7	24	07/24/94	FILLING	09:00, VERY LOW STAGE	REPORT	ELCONIN AERIAL OBSERVATION
ERIE LAKE	94	7	26	07/26/94	FILLING	19:30 VERY LOW STAGE	REPORT	ELCONIN AERIAL OBSERVATION
ERIE LAKE	94	7	29	07/29/94	LEAKING	S.POND, 10:46, RECENT STAGE DROP -3M?	PHOTO	AERIAL OBSERVATION, ROSENKRANS
ERIE LAKE	94	7	29	07/29/94	LEAKING	S.POND, 17:30, STAGE DOWN -5M	PHOTO	AERIAL OBSERVATION, LACHAPELLE
ERIE LAKE	94	8	2	08/02/94	EMPTY	19:30	REPORT	ELCONIN AERIAL OBSERVATION
ERIE LAKE	94	8	19	08/19/94	EMPTY	08:45	REPORT	ELCONIN AERIAL OBSERVATION
ERIE LAKE	94	10	13	10/13/94	FILLING	12:30,V.LOW STAGE,FROZEN, DOWN FROM 9/2	REPORT	ELCONIN, AERIAL OBSERVATION
ERIE LAKE	95	4	3		EMPTY	RECEIVING WATER	PHOTO	ROSENKRANS, AERIAL OBSERVATION
ERIE LAKE	95	6	30		FILLING	AERIAL OBSERVATION	KELLY BAY	VERBAL COMM
ERIE LAKE	95	7	3		FILLING	50% FULL	OBSERVATION	NOTES, ROSENKRANS
ERIE LAKE	95	7	8		FILLING	NO SIGN OF RELEASE	PHOTO	ROSENKRANS, AERIAL OBSERVATION & NOTES
ERIE LAKE	95	7	23		FILLING	NO EVIDENCE OF DECREASED STAGE 9:00AM	PHOTO	AERIAL OBSERVATION, NOTES, ROSENKRANS
ERIE LAKE	95	7	23		FILLING	15:00 NO WASHLINE OBSERVED	PHOTO	ROSENKRANS, OBSERVATION
ERIE LAKE	95	8	2		DRAINING	STAGE DROPPING	OBSERVATION	KELLY BAY OVERFLIGHT, PER. COMM
ERIE LAKE	95	8	27		EMPTY	RECEIVING H20	OBSERVATION	ROSENKRANS, NOTES
ERIE LAKE	95	9	25		FILLING	1/3 FULL	NOTES	ROSENKRANS, OBSERVATION
FIREWEED LK/HOLE	48	6	16	06/16/48	EMPTY	FLUVIAL DEPOSITS (?) POSSIBLY ACTIVE PRE 1948	PHOTO	TRIMET#301RT-72PL-C-8M164-72RS-16JUNE48-ACR
FIREWEED LK/HOLE	57	7	29		EMPTY	WATER ENTERING,EXITING KNOTCH HOLE	PHOTO	USGS,M230-7847&8,1:40000,B7W
FIREWEED LK/HOLE	64	8	24		EMPTY	WATER FLOWING INTO KNOTCH AREA	PHOTO	POST,K642-77,B&W,OBLIQUE
FIREWEED LK/HOLE	70	8	26	08/26/70	EMPTY	H2O FLOWS IN, NO LAKE	PHOTO	AEROMAP ROLL#70-23APT FL/FR(3-11)
FIREWEED LK/HOLE	72	7	21	07/21/72	EMPTY	CREEK FLOWS IN	PHOTO	NASA/JCS,M#209,FL#24-78,COLOR
FIREWEED LK/HOLE	78	8	0		EMPTY	CREEK DRAINS INTO KNOTCH HOLE	PHOTO	NASA,ENLARGEMENT,FL105#7525,1:32500,B&W
FIREWEED LK/HOLE	78	8	25		FILLING	HIGHER LEVEL THAN IN SUBSEQUENT YEARS	PHOTO	NASA,FL105B#7089,1:60000,CIR
FIREWEED LK/HOLE	90	8	22		EMPTY	CREEK DRAINS INTO HOLE AT KNOTCH	PHOTO	NPS,R1-90(#7857-58,83-86),1:48000,COLOR
FIREWEED LK/HOLE	94	3	31		EMPTY	STREAM FLOWS IN, DRAINS, NO BLOCKAGE?	OBSERVATION	ROSENKRANS, OVERFLIGHT
FIREWEED LK/HOLE	94	5	13	05/13/94	EMPTY	WATER FLOWS THROUGH AND OUT KNOTCH	OBSERVATION	FLIGHT NOTES AND PHOTO, ROSENKRANS
GATES LAKES	48	6	16	06/16/48	FILLING	TWO LAKES OBSERVED	PHOTO	TRIMET#241RT-72PL-C-8M164-72RS-16JUNE48-ACR
GATES LAKES	57	7	29		FILLING	3 LAKES AT 50% LEVEL?	PHOTO	USGS,M230-7850-2,1:40000,B&W
GATES LAKES	57	7	29		FILLING	50% FULL?, 3 BODIES OF WATER	PHOTO	USGS,M230-7811-13,1:40000,B&W
GATES LAKES	70	8	26	08/26/70	FILLING	TWO SMALL PONDS	PHOTO	AEROMAP,ROLL#70-23APT,FL/FR(5-16&17)
GATES LAKES	72	7	21	07/21/72	FILLING	2 PONDS CONNECTED, V. FULL	PHOTO	NASA/JCS,M#209,FL#19-215,(#24-81)COLOR
GATES LAKES	75	8	6	08/06/75	FILLING		PHOTO	USGS 75M4 #112 OBLIQUE
GATES LAKES	78	8	0		EMPTY?		PHOTO	NASA,ENLARGEMENT,FL105#7525,1:32500,B&W
GATES LAKES	78	8	28		EMPTY		PHOTO	NASA,#FL104B-7958&9,1:60000,CIR
GATES LAKES	89	8	22		FILLING	SMALL PONDS,25% FULL/LEVEL?	PHOTO	NPS,R1-90(#7896-72),1:48000,COLOR
GATES LAKES	90	8	17		FILLING	TWO LKS WITH WATER, DATE???	SLIDES (2)	PRELLER/MAYO FLIGHT
GATES LAKES	94	3	31		EMPTY	NO ICE	OBSERVATION	ROSENKRANS, OVERFLIGHT
GATES LAKES	94	5	13	05/13/94	FILLING	V.LOW STAGE IN ONE LAKE	OBSERVATION	FLIGHT NOTES AND PHOTO, ROSENKRANS
GATES LAKES	94	6	9	06/09/94	FILLING	08:45, 50% FULL	REPORT	ELCONIN, AERIAL OBSERVATION
GATES LAKES	94	7	4	07/04/94	FILLING	08:30, UNCHANGED SINCE 6/9, 50% FULL	REPORT	ELCONIN, AERIAL OBSERVATION
GATES LAKES	94	7	8	07/08/94	STAGE -1M	09:30, SMALL DROP IN STAGE @ BOTH LAKES	REPORT	ELCONIN, AERIAL OBSERVATION
GATES LAKES	94	7	24	07/24/94	STAGE -1M	09:00, UNCHANGED SINCE 7/8	REPORT	ELCONIN, AERIAL OBSERVATION
GATES LAKES	94	7	27	07/27/94	STAGE -2M	07:30, SMALL DROP IN STAGE	REPORT	ELCONIN, AERIAL OBSERVATION
GATES LAKES	94	8	19	08/19/94	STAGE -2M	08:45, UNCHANGED SINCE 7/27	REPORT	ELCONIN, AERIAL OBSERVATION
GATES LAKES	94	10	13	10/13/94	EMPTY	12:30, N.LK DOWN, S.LK EMPTY	REPORT	ELCONIN, AERIAL OBSERVATION
GATES LAKES	95	4	3		EMPTY		PHOTO	DSR AERIAL OBSERVATION

KENNICOTT BASIN OUTBURST LAKES: ALL DATA

GATES LAKES	95	7	21		FILLING	TWO MUDDY LAKES	OBSERVATION	AERIAL OBSERVATION, ROSENKRANS
GATES LAKES	95	7	23		FILLING	NO SIGN OF DRAINAGE, 9:00AM	PHOTO	AERIAL OBSERVATION, NOTES AND PHOTO
GATES LAKES	95	8	27		EMPTY	DRAINED	OBSERVATION	AERIAL OBSERVATION, ROSENKRANS
HIDDEN CRK LAKE	0				UNKNOWN	MAPPING ERROR, LAKE DEPICITED AS GLACIER	USGS B#374	MAP PREPARED BY SCHRADER 1900&1907
HIDDEN CRK LAKE	7				ACTIVE	LAKE 0.5X1.5 MILES, FOOT TRAIL N. SIDE	USGS B#374	ICY LAKE DESCRIBED
HIDDEN CRK LAKE	9				ACTIVE ?	POTHOLE RELEASED EARLY IN 1909	USGS B#448	REFERENCED PAGE 14
HIDDEN CRK LAKE	11	9	15		OUTBURST	ICY LK BROKE,BRIDGE DAMAGE,POTHOLE ACTIVE	PUBLISHED	COPPER SPIKE, PAGE 128
HIDDEN CRK LAKE	16		.		ACTIVE	FLOOD EVENT DESTROYED RR BRIDGE	USGS B#662	REFERENCED PAGE 163
HIDDEN CRK LAKE	16	9	12	09/12/16	POST/OUTB	STRANDED BERGS, STRANDLINE VISIBLE	USGS B#894	MOFFIT, PLATE #5A
HIDDEN CRK LAKE	19	6	25	EST	FILLING	YEAR/DATE?,STAGE>94,DATE EST @ L.JUNE	PHOTO	PRE-1938 PHOTO,E.HOLLARD-KENNECOTT,KID
HIDDEN CRK LAKE	19	7	20	EST	FILLING	YEAR/DATE?,STAGE>94,DATE EST @M/L.JULY	PHOTO	PRE-1938 PHOTO,C.HODGES-KENNECOTT,KID
HIDDEN CRK LAKE	21	9	16	09/16/21	OUTBURST	POTHOLE GEYSER ACTIVE , 40' HIGH	PUBLISHED	MCCARTHY WEEKLY NEWS, SEP16, 1921
HIDDEN CRK LAKE	22				ACTIVE	0.5X1.5 MILES, DRAINS AUTUMN & SPRING	PUBLISHED	GSA BULL V33,P536, BATEMAN
HIDDEN CRK LAKE	22	9	2	09/02/21	OUTBURST	POTHOLE BROKE 2 WEEK EARLY	PUBLISHED	MCCARTHY WEEKLY NEWS, SEP. 9, 1922
HIDDEN CRK LAKE	23	8	20	08/20/23	OUTBURST	NEW POTHOLE THROUGH MORAINE (8/16-8/23)	PUBLISHED	MCCARTHY WEEKLY NEWS, AUG. 23 1923
HIDDEN CRK LAKE	25	9	7	09/07/25	OUTBURST	FLOOD DESTROYED BRIDGE, NUMEROUS SOURCE	PUBLISHED	MCCARTHY WEEKLY NEWS, SEP.12, 1925
HIDDEN CRK LAKE	26	8	29	08/29/26	OUTBURST	POTHOLE NOT AS SPECTACULAR AS USUAL	PUBLISHED	MCCARTHY WEEKLY NEWS, SEP. 4, 1926
HIDDEN CRK LAKE	27				ACTIVE	USUALLY RELEASED IN AUGUST PRIOR TO 1928	USGS	BULL #984. MOFFIT COMMENT PLATE 5A,1938
HIDDEN CRK LAKE	28	6	16	06/16/28	FILLING	SKETCH FIELD NOTES, WATER LEVEL DEPICTED	NOTES	MOFFIT FIELD NOTES, USGS, BK#639 P105
HIDDEN CRK LAKE	33	8	28	08/28/33	OUTBURST?	"POTHOLE BROKE, FOOT KENNICOTT GL."	DATABANK	USWB CLIMATE DATA, YEHLE
HIDDEN CRK LAKE	37	8	14		POST/OUTB?	ICE DAM FRACTURES & POTHOLES DRAINED ?	PHOTO	WASHBURN, #570
HIDDEN CRK LAKE	45	7	31	07/31/45	ACTIVE	NO RR BRIDGE, DESTROYED BETWEEN 1938 &1945	PHOTO	BI-57 WRST COLLECTION,PHOTOGRAPHER UNKN
HIDDEN CRK LAKE	48	6	16	06/16/48	FILLING	PRERELEASE, A LOT OF SLUSH IN LAKE AT DAM	PHOTO	TRIMET#241RT-72PL-C-8M164-72RS-16JUNE48-ACR
HIDDEN CRK LAKE	51	7	10	07/10/51	FILLING	PARTLY FULL, 1950 STRANDED BERGS & CREVASS	PHOTO	ALASKA ICE DAMMED LAKES(STONE,1963) FIG#5
HIDDEN CRK LAKE	57	7	29		FILLING	UPPER END OF LAKE VISIBLE	PHOTO	USGS,M231-8444&5,1:40000,B&W
HIDDEN CRK LAKE	57	7	29	07/29/57	FILLING	POST, COMMENT ON PHOTO DESCRIPTION	AGIPRJ4.11	FIELD IGY-RPT,NOTES PHOTO 5X019, 400OEL
HIDDEN CRK LAKE	57	7	29		FILLING	BASE FOR USGS TOPO EL 3028',<40%ICEBERGS	PHOTO	USGS,M230-7813&4,1:40000,B&W
HIDDEN CRK LAKE	57	7	29		FILLING	LAKE LEVEL AT 3028 FOOT ELEVATION	USGS MAP	TOPOGRAPHIC MAP SHOWS LAKE ELEVATION
HIDDEN CRK LAKE	57	8	1		FILLING	APPRX DATE, HIGHEST KNOWN STAGE	PHOTO	A.POST, 4.11 AUG, 1957
HIDDEN CRK LAKE	57	8	4	08/04/57	OUTBURST	STRANDLINE,PARTLY DRAINED?,PERCHED BERGS	PHOTO	FIELD IGY-RPT, VIERECK PHOTO #LV-57-B151
HIDDEN CRK LAKE	57	8	4	08/04/57	OUTBURST	REFERENCED PHOTO, NOT INSPECTED	IGY PRJ4.2	FIELD IGY-RPT, MILLETT PHOTO I-126
HIDDEN CRK LAKE	62	8	13	08/13/62	LEAKING	STARTED DRAINING, EAST SIDE CARRIED H2O	NOTES	YEHLE, USGS PHOTO AND FIELD NOTES
HIDDEN CRK LAKE	62	8	14	08/14/62	OUTBURST	RELEASE STARTED 8/13 FINISHED 8/14	OBSERVATION	YEHLE USGS, NOTES AND PHOTO
HIDDEN CRK LAKE	64	8	24	08/24/64	POST/OUTB	POST RELEASE, STRANDLINE,	PHOTO	USGS,K642-76, OBLIQUE
HIDDEN CRK LAKE	67	9	1	EST	POST/OUTB	STRANDED BERGS, FALL , NO SNOW, EST DATE	SLIDE	G. BURDICK (G.GREENE COLLECTION, NOV-67)
HIDDEN CRK LAKE	68	3			OUTBURST?	FLOOD ON CHITINA R OBSERVED	POST/MAYO	USGS HA-#455, REF. (PER COMM MCKECHINE)
HIDDEN CRK LAKE	69	8	27		POST/OUTB	POST RELEASE, PERCHED BERGS	PHOTO	POST,69R3-201,B&W,DISTANT OBLIQUE
HIDDEN CRK LAKE	70	8	26	08/26/70	POST/OUTB	POST RELEASE, ICEBERG STRANDLINE	PHOTO	AEROMAP ROLL#70-23APT FL/FR(5-17&4-19)
HIDDEN CRK LAKE	72	7	21	07/21/72	FILLING	STAGE REACHES/EXCEEDS WILLOW RM	PHOTO	NASA/JCS,M#209,FL#24-81,COL(#23-81,CIR)
HIDDEN CRK LAKE	73	10	6		POST/OUTB	1973 HIGHWATER MARK EAST CHANNEL	M.MILES	AKDOT DATED PHOTO
HIDDEN CRK LAKE	74	7			FILLING	VERY HIGH STAGE,PRE-RELEASE	G.GREENE	PHOTO NOT DATED PROCESSED OCTOBER 1974
HIDDEN CRK LAKE	74	8	11		FILLING	LAKE LEVEL DEPICTED	SLIDE	G.WINLKER, USGS
HIDDEN CRK LAKE	74	8	16		OUTBURST	PHOTOGRAPH DEPICITING STAGE PRE-RELEASE	AK MAG.	SIMMERMAN PHOTO AND ARTICLE, AUG. 1975
HIDDEN CRK LAKE	74	8	16		OUTBURST	E. CHANNEL BRIDGE DAMAGE	DOCUMENTS	AKDOT, M. MILES
HIDDEN CRK LAKE	74	8	16	08/16/74	OUTBURST	FLOOD EVENT AND LAKE OBSERVED	PHOTO	G. MULL, SLIDES AND OBSERVATIONS COMM.
HIDDEN CRK LAKE	74	9	4		POST/OUTB	POST RELEASE,SMALL LAKE,REFILLING?	PHOTO	USGS,EL-13000',#74V106-110,B&W
HIDDEN CRK LAKE	75	8	6		OUTBURST	LAKE DRAINING,>50%FULL,STRANDED BERGS	PHOTO	USGS,#75M4-1/2,OBLIQUE,1:20179,B&W
HIDDEN CRK LAKE	75	8	6		OUTBURST	BRIDGE DAMAGE	DOCUMENTS	AKDOT, M. MILES
HIDDEN CRK LAKE	75	8	16		POST/OUTB	WASHED OUT KENNICOTT R. BRIDGE APPROACH	M.MILES	AKDOT RECORDS
HIDDEN CRK LAKE	75	10	9	10/09/75	POST/OUTB	POST RELEASE, STRANDLINE, STAGE @ 25%?	PHOTO	UDGS 75MS #170&172 OBLIQUE
HIDDEN CRK LAKE	76	7	22		POST/OUTB	IMM. POST RELEASE, LK MUD MARK, SMALL LK	PHOTO	USGS,#76M1-121,OBLIQUE,1:20179,B&W
HIDDEN CRK LAKE	77	8	6		POST/OUTB	RELEASE PRIOR AUG 5/6, BRIDGE DAMAGE	G. GREENE	VERBAL COMM.

KENNICOTT BASIN OUTBURST LAKES: ALL DATA

HIDDEN CRK LAKE	78	8	10		OUTBURST	LARGE FLOOD	J. MILLER	OBSERVATION, VERBAL COMM.
HIDDEN CRK LAKE	78	8	28		POST/OUTB	ICEBERGS ID STAGE LEVEL RECENT AND OLD	PHOTO	NASA,ENLARGEMENT,FL104#8028,1:32500,B&W
HIDDEN CRK LAKE	78	8	28		POST/OUTB	DRAINAGE HOLE VISIBLE	PHOTO	NASA,#FL104B-7957&8,1;60000,CIR
HIDDEN CRK LAKE	80	8	7		FILLING?	PRE-RELEASE?? FOOT BRIDGE STANDING	OBSERVATION	LACHAPELLE, BRIDGE OBSERVATION, PER COMM
HIDDEN CRK LAKE	81	7	1		FILLING	PRE-RELEASE, FOOT BRIDGE STANDING	OBSERVATION	J. HANNAH, PER. COMM
HIDDEN CRK LAKE	81	7	19		OUTBURST	FLOOD OBSERVED AND BRIDGE COLLAPSED	PHOTO	GREENE,G.PER. COMM AND PHOTO JUL/81
HIDDEN CRK LAKE	81	8	7	08/07/81	OUTBURST?	MAJOR FLOOD EVENT ON KENNICOTT RAIN?	NOTES	HECHT PER COMM.
HIDDEN CRK LAKE	81	8	22	08/22/81	OUTBURST?	SUSPECTED RELEASE DATE, POSSIBLY RAIN ?	NOTES	B. HECHT, PER. COMM.
HIDDEN CRK LAKE	82	7	6		FILLING	APPEARS FULL	PHOTO	OBLIUQE, WASO-MMB 1983 RPT, COLOR
HIDDEN CRK LAKE	82	7	31		POST/OUTB	PEAK STAGE LINE VISIBLE, POST RELEASE	N.OLMSTED	PHOTOS & PER COMM. JULY, DAY UNKNOWN
HIDDEN CRK LAKE	82	8	1	08/01/82	OUTBURST?	SHARP ANNUAL PEAKS OBSERVED ON KENNICOT	NOTES	HECHT, PER. COMM.
HIDDEN CRK LAKE	82	8	13		OUTBURST?	FLOOD EVENT OBSERVED BETWEEN 8/10 & 8/16	OBSERVATION	R. ELLIOT,PER. COMM. (VERBAL)
HIDDEN CRK LAKE	82	8	16	08/16/82	OUTBURST?	SHARP ANNUAL PEAK OBSERVED ON KENNICOTT	NOTES	HECHT, PER. COMM.
HIDDEN CRK LAKE	83				ACTIVE	PEAK STAGE EXCEEDED 1986 LEVEL	D. FRIEND	D. FRIEND, VERBAL COMM.
HIDDEN CRK LAKE	83	8	7		OUTBURST	FLOOD EVENT OBSERVED, EARLY IN MONTH	OBSERVATION	R. ELLIOT,PER. COMM. (VERBAL)
HIDDEN CRK LAKE	84				ACTIVE	PEAK STAGE EXCEEDED 1986 LEVEL	D. FRIEND	D. FRIEND, VERBAL COMM.
HIDDEN CRK LAKE	84	8	1		OUTBURST ?	SIDE CHANNEL FLOODED JULY/AUGUST	OBSERVATION	A. SCHNIDER,PER.COMM (VERBAL)
HIDDEN CRK LAKE	84	8	4	08/04/84	OUTBURST?	LARGE FLOOD EVENT, 1ST WEEK AUGUST	OBSERVATION	G. GREENE, PER COMM. (VERBAL)
HIDDEN CRK LAKE	84	8	26	08/26/84	OUTBURST?	ANNUAL PEAK DISCHARGE RECORDED WMC	OBSERVATION	WMC DATA, HECHT PER. PER. COMM. (DEFINATE)
HIDDEN CRK LAKE	84	8	31	08/31/84	POST/OUTB	POST RELEASE, SOME PERCHED ICEBERGS	PHOTO	USGS,84R3, OBLIQUE
HIDDEN CRK LAKE	85				ACTIVE	PEAK STAGE EXCEEDED 1986 LEVEL	D. FRIEND	D. FRIEND VERBAL COMM.
HIDDEN CRK LAKE	85	7	27	08/27/85	FILLING	LARGE LAKE	TM IMAGE	LANDSAT PATH 65, ROW 7
HIDDEN CRK LAKE	85	8	16	08/16/85	OUTBURST	BIG FLOOD, CLEAR CRK 1M DEEP W/RAINS	NOTES	DAN DOAK, PER COMM (LETTER)
HIDDEN CRK LAKE	86	7	27		FILLING	LAKE LEVEL VISIBLE	PHOTO	ARO-CR HOVIS FIELD SURVEY OF SITE
HIDDEN CRK LAKE	86	8	2		LEAKING	LAKE LEVEL STARTS TO DROP	OBSERVATION	D. FRIEND MS THESIS & CONVERSATION
HIDDEN CRK LAKE	86	8	6		OUTBURST	PEAK STAGE RECORDED ON 1974 AERIAL PHOTO	OBSERVATION	D. FRIEND, MS THESIS & CONVERSATION
HIDDEN CRK LAKE	86	9	6		POST/OUTB	DRAIN HOLES,BEACHED BERGS	PHOTO	NPS,12WRST-3-45-29&30,1:12000,CIR
HIDDEN CRK LAKE	88	7	18	07/18/88	OUTBURST?	WATER LEVEL @ BASE OF EAST CHANNEL TRAM	NOTES	DAN DOAK, PER. COMM LETTER
HIDDEN CRK LAKE	88	7	23	07/23/88	OUTBURST	EVENT OBSERVED IN MCCARTHY	NOTES	B. HECHT, PER COMM. (DEFINATE)
HIDDEN CRK LAKE	88	7	27	07/27/88	OUTBURST	PHOTO OF FLOOD EVENT AT A TRAM	PHOTO	MOSSEN, E&W CHANNELS DATE ???
HIDDEN CRK LAKE	89	7	19	07/19/89	OUTBURST?	RIVER VERY HIGH	NOTES	DAN DOAK, PER COMM. (LETTER)
HIDDEN CRK LAKE	90	7	4		OUTBURST		USGS	DRAFT REPORT,JONES, TABLE #2
HIDDEN CRK LAKE	90	8	13		POST/OUTB	SMALL LAKE, POST RELEASE	SLIDE	PRELLER/MAYO FLIGHT
HIDDEN CRK LAKE	90	8	22		POST/OUTB	NO WATER,HIDDEN CRK FLOWING INTO HOLE	PHOTO	NPS,R1-90(#7872),1:48000,COLOR
HIDDEN CRK LAKE	91	8	3		OUTBURST		USGS	DRAFT REPORT STAN JONES TABLE #2
HIDDEN CRK LAKE	91	8	5		POST/OUTB		USGS	DRAFT REPORT STAN JONES TABLE #2
HIDDEN CRK LAKE	92	7	2		FILLING	WATER LEVEL TO ROCK GL, PLOT H2O LEVEL	SLIDE	ROSENKRANS, DATE WITHIN 1 or 2 days
HIDDEN CRK LAKE	92	7	6		OUTBURST	50% VOLUME,STRANDED BERGS,PEAK 92 STAGE	PHOTO	G. GREEN DATED PHOTO
HIDDEN CRK LAKE	92	7	7		POST/OUTB	PEAK DISCHARGE AT TRAM	STAGE GAGE	USGS KENNICOTT RIVER STAGE RECORD
HIDDEN CRK LAKE	93	4	7		FILLING	LAKE FROZEN	SLIDES (2)	ROSENKRANS
HIDDEN CRK LAKE	93	6	24		FILLING	WATER LEVEL NEAR ROCK GL, PLOT H2O LEVEL	PRINTS (2)	DSR-#3-93
HIDDEN CRK LAKE	93	7	5		OUTBURST	PEAK DISCHARGE AT TRAM 7/6/93	STAGE GAGE	USGS STAGE RECORD AT KENNICOTT TRAM
HIDDEN CRK LAKE	93	7	6		POST/OUTB	VISUAL CONFIRMATION, ALOT OF BERGS	SLIDE	GROUND,OBLIQUE,HUMMEL TRIP
HIDDEN CRK LAKE	93	9	4		DRAINING	FLOOD EVENT AT TRAM, HIDDEN LK OR RAIN?	STAGE GAGE	USGS KENNICOTT RIVER STAGE RECORD
HIDDEN CRK LAKE	93	9	23		POST/OUTB	TWO DRAIN HOLES & CLOSEUP SHOTS	SLIDES (8)	ROSENKRANS & PRINT (DSR-#4-10-93)
HIDDEN CRK LAKE	94	1	2	01/02/94	FILLING	FROZEN LAKE	SLIDES (6)	ROSENKRANS
HIDDEN CRK LAKE	94	3	31	03/31/94	FILLING	ICE/STAGE HIGHER THAN 1/94?	OBSERVATION	ROSENKRANS, OVERFLIGHT
HIDDEN CRK LAKE	94	5	13	05/13/94	FILLING	HIGHER STAGE THAN 3/31?, CRK OPEN,SNOW	PHOTO	FLIGHT NOTES , ROSENKRANS
HIDDEN CRK LAKE	94	6	5	06/05/94	FILLING	FROZEN, BELOW 1993 STAGE, ACTIVE CREEK	PHOTO	OBSERVATION, ROSENKRANS
HIDDEN CRK LAKE	94	6	28	06/28/94	FILLING	UNFROZEN, STAGE MARKED, ACTIVE CREEK	PHOTO	OBSERVATION, ROSENKRANS
HIDDEN CRK LAKE	94	7	15	07/15/94	FILLING	AERIAL INSPECTION	PHOTO	OBSERVATION, ROSENKRANS
HIDDEN CRK LAKE	94	7	16	07/16/94	FILLING	09:15, -2M WASHLINE ON GLACIER	REPORT	ELCONIN, AERIAL OBSERVATION

KENNICOTT BASIN OUTBURST LAKES: ALL DATA

HIDDEN CRK LAKE	94	7	16	07/16/94	FILLING	STAGE MARKED	PHOTO	OBSERVATION, ROSENKRANS
HIDDEN CRK LAKE	94	7	27	07/27/94	LEAKING	STAGE @-1M?, ICE WASHLINE, RATE 1"/DAY?	PHOTO	OBSERVATION, ROSENKRANS
HIDDEN CRK LAKE	94	7	28	07/28/94	LEAKING	PM-LAST LIGHT,S. DROP IN ICE DAM EL. ?	PHOTO	USGS TIME LAPSE CAMERA
HIDDEN CRK LAKE	94	7	28	07/28/94	LEAKING	AM-1ST LIGHT, S.ICE BLOCKS BEACHED	PHOTO	USGS TIME LAPSE CAMERA
HIDDEN CRK LAKE	94	7	29	07/29/94	OUTBURST	OUTBURST EVENT 17:30, STAGE DOWN 70'?	PHOTO	AERIAL OBSERVATION, LACHAPELLE
HIDDEN CRK LAKE	94	7	29	07/29/94	OUTBURST	OUTBURST EVENT 10:00 AM STAGE DOWN 35'?	PHOTO	AERIAL OBSERVATION, DSR
HIDDEN CRK LAKE	94	7	29	07/29/94	OUTBURST	AM-1ST LIGHT, ICE DAM EL DROPPING	PHOTO	USGS TIME LAPSE CAMERA
HIDDEN CRK LAKE	94	7	30	07/30/94	POST/OUTB	RELEASE OVER, PRIOR TO 9:00AM	PHOTO	AERIAL OBSERVATION, DSR
HIDDEN CRK LAKE	94	8	2	08/02/94	REFILLING	S. POND STAGE INCREASING UNTIL 8/5	PHOTO	USGS TIME LAPSE CAMERA
HIDDEN CRK LAKE	94	8	2	08/02/94	REFILLING	SMALL LAKE AT ICE DAM	PHOTO	AERIAL OBSERVATION DSR
HIDDEN CRK LAKE	94	8	5	08/05/94	DRAINING	S. POND STAGE STARTS TO DECREASE	PHOTO	USGS TIME LAPSE CAMERA
HIDDEN CRK LAKE	94	8	6	08/06/94	DRAINING	S. POND STAGE DECREASES BELOW VIEW	PHOTO	USGS TIME LAPSE CAMERA
HIDDEN CRK LAKE	94	8	8	08/08/94	POST/OUTB	09:45	REPORT	ELCONIN, AERIAL OBSERVATION
HIDDEN CRK LAKE	94	8	19	08/19/94	POST/OUTB	08:45, UNCHANGED SINCE 8/8	REPORT	ELCONIN, AERIAL OBSERVATION
HIDDEN CRK LAKE	94	8	31	08/31/94	REFILLING	SMALL LAKE OBSERVED DURING SURVEY	PHOTO	FIELD SURVEY, ROSENKRANS
HIDDEN CRK LAKE	94	9	2	09/02/94	POST/OUTB	LAKE DRAINED SOMETIME SINCE 8/31	PHOTO	AERIAL OBSERVATION, DSR
HIDDEN CRK LAKE	94	10	13	10/13/94	REFILLING	12:30, TWO SMALL PONDS @ GLACIER FACE	REPORT	ELCONIN, AERIAL OBSERVATION
HIDDEN CRK LAKE	95	1	1	01/01/95	FILLING	STAGE BELOW BURIED ICE	PHOTO	ROSENKRANS, AERIAL OBSERVATION
HIDDEN CRK LAKE	95	4	3	03/04/95	FILLING	SAME AS 1/1/95??	PHOTO	ROSENKRANS, AERIAL OBSERVATION
HIDDEN CRK LAKE	95	6	6	06/06/05	FILLING	SNOW MELTED, LOWER THAN 1994	PHOTO	ROSENKRANS, AERIAL OBSERVATION
HIDDEN CRK LAKE	95	7	3	07/03/95	FILLING	WATER LEVEL LOWER THAN 1994	PHOTO	ROSENKRANS- STAGE MARKED
HIDDEN CRK LAKE	95	7	8	07/08/95	FILLING	WATER LEVEL LOWER THAN 1994	PHOTO	ROSENKRANS, NOTES & AERIAL OBSERVATION
HIDDEN CRK LAKE	95	7	20	07/20/95	FILLING	LAKE STAGE INCREASING, TIME LAPSE CAMERA	PHOTO	ROSENKRANS - TIME LAPSE CAMERA
HIDDEN CRK LAKE	95	7	21	07/21/95	LEAKING	LAKE STAGE BEGINS TO DROP (MINOR), MID DAY	PHOTO	ROSENKRANS - TIME LAPSE CAMERA
HIDDEN CRK LAKE	95	7	21	07/21/95	LEAKING	PENDING RELEASE UNDETECTED 14:00, DSR	AERIAL OBS	ROSENKRANS DISTANT OBSERVATION
HIDDEN CRK LAKE	95	7	21	07/21/95	LEAKING	LAKE STAGE STATIONARY IN AM	PHOTO	ROSENKRANS - TIME LAPSE CAMERA
HIDDEN CRK LAKE	95	7	21	07/21/95	LEAKING	PENDING RELEASE UNDETECTED KELLY BAY, 21:0	KELLY BAY	VERBAL COMM. TOURIST FLIGHT
HIDDEN CRK LAKE	95	7	21	07/21/95	OUTBURST	(17:00) CHANGE IN KENNICOTT R. STAGE	HYDROGRAPH	USGS STAGE RECORD, LACHAPELLE INTERPRET
HIDDEN CRK LAKE	95	7	21	07/21/95	OUTBURST	LAKE STAGE DOWN 2-5 FEET (EST.) AT DUSK	PHOTO	ROSENKRANS - TIME LAPSE CAMERA
HIDDEN CRK LAKE	95	7	22	07/22/95	OUTBURST	LAKE STAGE DOWN 5-10 (EST.) FEET DAWN	PHOTO	ROSENKRANS - TIME LAPSE CAMERA
HIDDEN CRK LAKE	95	7	22	07/22/95	OUTBURST	LAKE STAGE DOWN 5-10'@ 14:00 (DOWN 10-30 FE	M.MCCARTHY	AERIAL OBSERVATION, LACHAPELLE CONFIRMS
HIDDEN CRK LAKE	95	7	22	07/22/95	OUTBURST	ICE DAM BEGINS (?) TO DROP	PHOTO	ROSENKRANS - TIME LAPSE CAMERA
HIDDEN CRK LAKE	95	7	23	07/23/95	OUTBURST	WATER @ LEVEL OF TERMINAL MORAINE 9:00	PHOTO	ROSENKRANS AERIAL OBSERVATION & NOTES
HIDDEN CRK LAKE	95	7	23	07/23/95	POST/OUTB	ICE DAM STOP DROPPING, NOON-MID DAY	PHOTO	ROSENKRANS - TIME LAPSE CAMERA
HIDDEN CRK LAKE	95	7	23	07/23/95	POST/OUTB	NO WATER 15:00	PHOTO	OBSERVATION , ROSENKRANS
HIDDEN CRK LAKE	95	7	24	07/24/95	POST/OUTB	NO WATER,ICE CRACKING AND NOISY 10:00	PHOTO	OBSERVATION, ROSENKRANS
HIDDEN CRK LAKE	95	8	27	08/27/95	REFILLING	RECEIVING H20	NOTES	AERIAL OBSERVATION, ROSENKRANS
HIDDEN CRK LAKE	95	9	25	09/25/95	REFILLING	1/3 FULL LEVEL @ BURIED ICE	PHOTO	AERIAL OBSERVATION , ROSENKRANS
JUMBO LAKE	24	5	25	05/25/24	EMPTY	"KENNICOTT LK" BROKE, OVERFLOWED 5/20/24	DATABANK	USWB CLIMATE DATA, YEHLE
JUMBO LAKE	48	6	16	06/16/48	EMPTY	POST RELEASE	PHOTO	TRIMET#298RT-72PL-C-8M164-72RS-16JUNE48-ACR
JUMBO LAKE	57	7	29		EMPTY		PHOTO	USGS,M230-7847-9,1:40000,B&W
JUMBO LAKE	57	7	29		EMPTY	LONG AND NARROW, NO BERGS NOTED	PHOTO	USGS,#M230-7904&5,1:40000,B&W,
JUMBO LAKE	64	8	24	08/24/64	EMPTY		PHOTO	USGS,K642-76A, OBLIQUE
JUMBO LAKE	64	8	24		EMPTY	APPEARS EMPTY	PHOTO	POST,K642-77,B&W,OBLIQUE
JUMBO LAKE	66	7	20	07/20/66	EMPTY	H2O DRAIN POINTS @ JUMBO CRK & ROOT GL	PHOTO	AEROMAP ROLL#66-16,FL/FR(9-5)
JUMBO LAKE	70	8	26	08/26/70	EMPTY	POST RELEASE	PHOTO	AEROMAP ROLL#70-23APT FL/FR(3-10)
JUMBO LAKE	72	7	21	07/21/72	EMPTY	DRAINED	PHOTO	NASA/JCS,M#209,FL#19-218,COLOR
JUMBO LAKE	74	9	1	10/01/74	EMPTY	NO H2O OBSERVED	PHOTO	USGS, 74V3-110, B&W, OBLIQUE
JUMBO LAKE	76	6	11	06/11/76	EMPTY	RECEIVING H2O, CHANNEL DRAIN HOLE	PHOTO	AERMAP FL#76-7(2-4)
JUMBO LAKE	78	8	0		EMPTY		PHOTO	NASA,ENLARGEMENT,FL105#7525,1:32500,B&W
JUMBO LAKE	78	8	25		EMPTY		PHOTO	NASA,ENLARGEMENT,FL105B#7087,1:19000,CIR
JUMBO LAKE	83	8	19	08/19/83	EMPTY	DRAIN HOLE AND CHANNEL, JUMBO CRK ENTERS	PHOTO	83-CO3257,FL#14X,FR,#7

KENNICOTT BASIN OUTBURST LAKES: ALL DATA

JUMBO LAKE	85	9	12	09/12/85	EMPTY		PHOTO	MCCARTHY RD, AKDOT#14-9, 1:12000, CIR
JUMBO LAKE	86	6	29		FILLING	SMALL LAKE BETWEEN JUMBO & AMAZON CRKS	PHOTO	NPS,R#5&6(189-192),1;16000,CIR
JUMBO LAKE	86	9	6		EMPTY	DRAIN HOLES AT AMAZON AND JUMBO CRKS	PHOTO	NPS-12WRST-3-42-54&5,1:12000,CIR
JUMBO LAKE	88	6	28		EMPTY		PHOTO	NPS,R#1-88(1217),1:500',B&W
JUMBO LAKE	89	8	10		EMPTY		MAP	NPS KENNECOTT CLAIMS, 1:2400, 10'C
JUMBO LAKE	89	8	10		EMPTY	NUMEROUS PUSH MORAINES	PHOTO	NPS,BONANZA PK#1&2,1:40000,COLOR
JUMBO LAKE	90	0	0		ACTIVE	FILLED 19 DAYS, FLOODED PARKING LOT	USGS	WRIR#93-4078,JONES,P29, PER.COMM ELCONIN
JUMBO LAKE	90	8	22		EMPTY	DRAIN HOLES AT AMAZON AND JUMBO CREEKS	PHOTO	NPS,R1-90(#7858-60,73-76),1:48000,COLOR
JUMBO LAKE	93	7	15		EMPTY		SLIDE	ROSENKRANS
JUMBO LAKE	94	3	31		EMPTY	NO ICE	OBSERVATION	ROSENKRANS, OVERFLIGHT
JUMBO LAKE	94	5	13	05/13/94	FILLING	MOD. STAGE, MUDDY WATER	PHOTO	FLIGHT NOTES , ROSENKRANS
JUMBO LAKE	94	5	20	05/20/94	DRAINING	STAGE DECREASING @10:00-12:00	NOTES	OBSERVATION, M. MCDONALD
JUMBO LAKE	94	5	21	05/21/94	DRAINING	STAGE DECREASING @19:00	NOTES	OBSERVATION, M. MCDONALD
JUMBO LAKE	94	5	23	05/23/95	DRAINING	08:30, 50% FULL, 2M WASH LINE	REPORT	ELCONIN, AERIAL OBSERVATION
JUMBO LAKE	94	5	24	05/24/94	DRAINING	STAGE DECREASING @18:30	NOTES	OBSERVATION, M. MCDONALD
JUMBO LAKE	94	5	25	05/25/94	DRAINING	S.END DRAINED, N. END DRAINING 17:00	NOTES	OBSERVATION, M. MCDONALD
JUMBO LAKE	94	5	26	05/26/94	DRAINING	S.END DRAINED, N. END PONDED 14:00	NOTES	OBSERVATION, M. MCDONALD
JUMBO LAKE	94	5	26	05/26/94	EMPTY	12:00, PONDED RESIDUAL	REPORT	ELCONIN, AERIAL OBSERVATION
JUMBO LAKE	94	6	4	06/04/94	FILLING	POST RELEASE, STRANDLINE VISIBLE	PHOTO	OBSERVATION, ROSENKRANS
JUMBO LAKE	94	6	26	06/26/94	EMPTY	08:00, PONDED RESIDUAL GONE	REPORT	ELCONIN, AERIAL OBSERVATION
JUMBO LAKE	94	7	26	07/26/94	EMPTY	19:30, CALVING ACTIVITY AT N END OF LAKE	REPORT	ELCONIN, AERIAL OBSERVATION
JUMBO LAKE	94	7	29	07/29/94	FILLING	FILLED BY OUTBURST EVENT 10:57AM	PHOTO	AERIAL OBSERVATION, DSR
JUMBO LAKE	94	7	30	07/30/94	DRAINING	DRAINING, POST RELEASE, STAGE DOWN -7M?	OBSERVATION	ROSENKRANS "NOON?" OBSERVATION,
JUMBO LAKE	94	8	2	08/02/94	EMPTY	09:00, NEW STRANDLINE, WITH ICEBERGS	REPORT	ELCONIN, AERIAL OBSERVATION
JUMBO LAKE	94	10	13	10/13/94	EMPTY	12:30,UNCHANGED SINCE 8/23 (7 OBSERVTNS)	REPORT	ELCONIN, AERIAL OBSERVATION
JUMBO LAKE	95	4	3		EMPTY		PHOTO	AERIAL OBSERVATION
JUMBO LAKE	95	7	23		FILLING	CONTAINS OUTBURST WATER 9:00AM	PHOTO	AERIAL OBSERVATION, NOTES, ROSENKRANS
JUMBO LAKE	95	7	23		FILLING	NO WASH LINE OBSERVED 15:00	NOTES	OBSERVATION, ROSENKRANS
JUMBO LAKE	95	8	27		EMPTY	NO WATER	OBSERVATION	ROSENKRANS
JUMBO LAKE	95	9	25		EMPTY	RECEIVING H20	NOTES	ROSENKRANS OBSERVATION

APPENDIX 5

Combined East and West Fork Kennicott River discharge volume from Hidden Creek Lake outburst floods.

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Combined East and West Fork Kennicott River discharge volume from Hidden Creek Lake outburst floods.

Year	Volume[1] (cubic feet)
1986[2]	2.40×10^9
1994	2.37×10^9
1995	1.52×10^9

[1] Volumes were calculated using flood hydrographs and subtracting out baseflow (Dunne and Leopold, 1978).

[2] From Friend (1988).