Introduction

In the early evening of Saturday, July 31, 1976, a large stationary thunderstorm released as much as 7.5 inches of rainfall in about an hour (about 12 inches in a few hours) in the middle reaches of the Big Thompson River Basin and to a lesser extent in parts of the Cache la Poudre River Basin (U.S. Geological Survey, 1979). In steep mountain terrain with thin or no soil, this large amount of rainfall in such a short period of time produced a flash flood that caught residents and tourists by surprise. The sudden flood that churned down the narrow Big Thompson Canyon scoured the river channel that night, causing over $35 million in damages (1977 dollars) to 418 homes and businesses, many mobile homes, 438 automobiles, numerous bridges, paved and unpaved roads, power and telephone lines, and many other structures. The tragedy claimed the lives of 144 people, including two law enforcement officers trying to evacuate people in danger, and there were 250 reported injuries (U.S. Geological Survey, 1979). Scores of other people narrowly escaped with their lives. More than 800 people were evacuated by helicopter the following morning.

July 2006 revisits the 30th anniversary of the Big Thompson flood—one of the most deadly flash floods in Colorado’s recorded history (Jarrett and Vandas, 2006). Many residents and visitors who were present in the Big Thompson Canyon on July 31, 1976, recall the flood with vivid memories. This fact sheet presents a summary of the hydrologic conditions of the 1976 flood, describes some of the advances in U.S. Geological Survey (USGS) flood science as a consequence of this disaster, and provides a reminder that extreme floods like the 1976 Big Thompson flood have occurred in other locations in Colorado in the past and will occur again. The USGS conducts research and operates a Nationwide streamgage network to help understand and predict the magnitude and likelihood of large streamflow events such as the Big Thompson flood.

The Flood

A complex system of thunderstorms produced intense rainfall from about 6 to 7 pm (MDT) on July 31, 1976, in the Front Range foothills of Colorado’s Big Thompson River (fig. 1) and Cache la Poudre River Basins in Larimer County. This Saturday night marked the eve of Colorado’s 100th anniversary of Statehood, and at the height of the tourist season an estimated 3,500 people were enjoying the cool beauty and recreation of the mountain canyons, unaware of the unusual and unique atmospheric conditions that were occurring.

The topography of the affected area is characterized by narrow canyons bordered by steep, rocky, mountain slopes (fig. 1). On July 31, 1976, a moist air mass began pushing westward from the Great Plains on the east side of the Rockies. During the afternoon, the moist air rose up the mountain slopes and the unstable air began to build into thunderstorms; a schematic illustration showing the cause of the storm and flood is provided in figure 2. Large thunderstorms formed along the Front Range and began to dump heavy rain on the region about 6:30 p.m. This event turned deadly when high-altitude westerly winds, which are usually strong enough to push thunderstorms eastward and out of the area, were unusually weak. The thunderstorms stalled for more than 3 hours over the Big Thompson Canyon, and built into a gigantic thunderstorm system. The thunderstorms produced as much as 12–14 inches of...
Big Thompson River at mouth of Canyon, near Drake (North Fork Big Thompson River at Drake (Big Thompson River tributary below Loveland Heights none 1.4 -- -- -- 8,700 -- --)

35,000 cubic feet per second

flood—about 50 miles northwest of Denver—were similar to those of other flash floods, especially a flood in the South Dakota Black Hills on June 9, 1972, which killed 238 people.

The total rainfall from this event is nearly equivalent to a year's average annual precipitation in this area. To place this in perspective, the 1976 floods produced 12 inches of rain. In the Rocky Mountains in July, one inch of rain often falls in 75 minutes. Thus, to produce 12 inches of rain in 75 minutes, one must have a rainfall rate of 80 inches per hour. This rate of rainfall is beyond the capacity of any rainfall gauge, and the intensity of rainfall was almost certainly greater than this.

What did the Big Thompson flood and USGS flood science teach us about flash floods?

Hardly any of the rain soaked into the steep-sided canyon, thus the river rose quickly over its banks.

A flood produced by as much rain as occurred during the 1976 flood over in and downstream from the storm's rainfall center. The peak discharge estimated at the streamflow-gaging station located on the Big Thompson River at the mouth of the canyon near Drake was 31,200 ft³/s. The debris-choked floodwater wrapped around a large boulder in the North Fork Big Thompson River near Drake. This photograph was taken from the hillside looking downstream at Drake. River flow is from bottom right to top center.

Many Colorado communities, particularly in the western Denver-Boulder-Fort Collins area, burned wildland fire areas, which if unburned would not produce substantial flooding during intense rainstorms.

People underestimate the power of swift-flowing water. It is also easy to misjudge the depth of water on roads. Swift-moving water with a depth of only 1–2 feet is dangerous to walk through and can push or float automobiles into the river channel and to near certain destruction in deeper water.

Comparison of 1976 peak discharges with other peak discharges for selected current (2006) USGS streamflow-gaging stations and miscellaneous measurement sites in the flood area are shown in table 1 and are labeled on this figure. Modified from U.S. Geological Survey (1979).

flood, and in some areas this was the largest flood since the retreat of the glaciers about 10,000 years ago.

River depths went from a few feet to nearly 20 feet, and peak discharges occurred in less than an hour along many reaches. The 1976 flood was the largest recorded flood from a summer thunderstorm rainfall event in the Rocky Mountains. The flood was considered as two parts: one part was the flood on July 1, 1976, and the second part of the flood on July 23–25, 1976. A total of 15 people died in the flood; four died on July 1, 1976, and 11 died on July 23–25, 1976. The flood occurred on July 1, 1976, when the Big Thompson River at the gaging station near Drake reached 8,700 cfs, which is the second highest recorded discharge in the history of the stream. The flood was caused by a combination of the sudden rise in river depths, the extremely high flow rates, and the large contributing drainage areas.

Many Colorado communities, particularly in the eastern escarpments of the Front Range, are located 6,000 to 9,000 feet altitude or lower. Stream-gaging stations and selected miscellaneous measurement sites in the flood area are shown in table 1 and are labeled on this figure. Modified from U.S. Geological Survey (1979).

The storm was limited to a narrow band 5–10 miles wide extending from just southeast of Estes Park (fig. 3) and was headed northeast along Highway 34. The North Fork Big Thompson River, which is an arm of about 7,000 feet, has a peak discharge of 5,500 ft³/s from the 1982 Lawn Lake dam failure. The rainfall on July 1, 1976, was not sufficient to produce such a flood. The rainfall along the band was averaged over the mapped area and not over the entire North Fork Big Thompson River basin.

1 The debris-choked floodwater wrapped around a large boulder in the North Fork Big Thompson River near Drake... This boulder is located near the mouth of the canyon near Drake. The debris-choked floodwater wrapped around a large boulder in the North Fork Big Thompson River near Drake. This photograph was taken from the hillside looking downstream at Drake. River flow is from bottom right to top center.

1, 1976. Highest rainfall amounts occurred near 5,000 feet altitude. River gaging stations and selected miscellaneous measurement sites in the flood area are shown in table 1 and are labeled on this figure. Modified from U.S. Geological Survey (1979).

Figure 3. Aerial photograph showing damage and debris from the Big Thompson flood. (a) 06736000 85.1 1947-76 1965 1,290 8,710 05-30-1995 572, (b) 06738000 305 (150) 1887-76 1919 8,000 31,200 04-30-1980 6,150, (c) 06739000 475 (230) 1902-76 1956 7,650 27,800 04-08-1948 5,340, (d) 06734000 521 (400) 1906-76 1968 1,100 5,430 05-01-1965 1,410, (e) 06737000 693 (460) 1924-76 1949 7,850 28,800 04-04-1936 4,670, (f) 06735000 603 (360) 1930-76 1957 6,168 22,300 06-30-1936 7,500, (g) 06731000 375 (230) 1916-76 1928 1,370 6,100 04-01-1918 2,350, (h) 06733000 203 (150) 1894-76 1907 750 2,500 03-10-1913 870.

1 The Big Thompson flood was a product of a summer thunderstorm rainfall event, which produced several feet of rain in 75 minutes. This flood occurred on July 1, 1976, and was the second largest recorded flood to occur in the Rocky Mountains. This flood caused $25.5 million in damage.

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The Big Thompson flood caused geologists to look at the stratigraphy of sediment deposits in the canyon, and from them to try to interpret the occurrence and frequency of paleofloods, particularly in ungaged basins, and to use such information to better understand rare floods such as the Big Thompson flood. This work helped foster and improve the methods of the emerging science of paleoflood hydrology to improve the understanding of flood frequency and flood-hazard mitigation (Jarrett and Costa, 1988).

Colorado Flood History

Flash flooding is just one of three main types of floods in Colorado (Jarrett and Costa, 1988; Collins and others, 1991). Another type is snowmelt flooding, which predominantly occurs in May and June of each year but usually does not produce substantial flooding. A hazard of such flooding is the possibility of being swept away in cold, fast moving water. The third type is long-duration low-intensity rainfall associated with frontal activity. Such rainfall occurs over large areas and can produce widespread flooding in Colorado, particularly in large drainage basins (Collins and others, 1991).

Although rainstorms and flash floods the magnitude of the Big Thompson flood are infrequent in any one location, they are common from May to October in much of Colorado. Other notable catastrophic flash floods in Colorado occurred in July 1896 and September 1938 in the Bear Creek Basin (foothills west of Denver), October 1911 in the San Juan River Basin, June 1921 in the Arkansas River Basin, May 1935 in the Republican and South Platte River Basins, June 1965 in the South Platte and Arkansas River Basins, and July 1997 in Fort Collins (Collins and others, 1991; http://ccc.atmos.colostate.edu/~odie/rain.html). Many smaller thunderstorms produce locally hazardous flash-flood conditions each summer. It has been estimated that each year, on average, Colorado experiences at least one-hundred-fifty 100-year or larger rainstorms, many of which are very localized (N.J. Doesken, Colorado Climate Center, written communication, 2006). Flooding is particularly common in urbanized areas (even in areas with little topography) where impervious areas can produce hazardous flash flooding as suddenly as the 1976 Big Thompson flood, but with as little as a few inches of rain in an hour. Over 100 dam-failure floods have occurred in Colorado, such as the 1982 Lawn Lake Dam failure (Jarrett and Costa, 1986). Extremely hazardous flash floods can also occur in recently burned wildland fire areas, which if unburned would not produce substantial flooding during intense rainstorms.
Flash floods can develop with almost no warning. Therefore, it is important to know what to do before and during flash floods.

**BEFORE a flash flood:**
- Identify safe areas in your home or wherever you are located; bring outdoor possessions indoors or secure them if time permits.
- Have a portable 3-day emergency supply kit (such as food, water, medical supplies, clothing, rain gear, portable radio, flashlights, blankets).
- Monitor local radio, television, and National Weather Service (NWS) weather radio for potential adverse weather conditions.
- Be familiar with the NWS’s three types of flash flood watches, warnings, and advisories for specific areas: Flash Flood Watch (heavy rains are occurring or expected to occur that could produce flash flooding), Flash Flood Warning (flash flooding is occurring or imminent), and Small Stream and Urban Flood Advisory (minor flooding is occurring or expected that could produce flash flooding).
- Be aware of nature’s environmental warning signs (such as dark clouds, heavy rain, wind, and sounds—trees breaking and loud roars).

**DURING flash-flood conditions:**
- Stay away from streambeds and other low areas.
- Climb to higher ground and a safer location.
- Don’t walk or drive in flooded areas; avoid downed power lines, gas leaks, wild animals, and snakes in and near flooded areas.
- Notify local authorities of flash flooding, if you can safely do so.

**Advances in Flood Protection and Warning**

In the 30 years since the Big Thompson flood, there have been important advances in streamflow monitoring and flood warning. The National Weather Service’s (NWS) NEXRAD radar allows real-time monitoring of precipitation in most places in the United States (http://www.roc.noaa.gov). The USGS operates 270 real-time streamflow-gaging stations on Colorado streams and rivers (http://co.water.usgs.gov), and the Colorado Department of Water Resources also operates more than 300 real-time gages (http://water.state.co.us) that are monitored by the USGS, the NWS, and emergency managers. When substantial flooding occurs, the USGS mobilizes personnel to collect streamflow data in affected areas. Streamflow data improve flood forecasting and provide data for flood-frequency analysis for floodplain management, design of structures located in floodplains, and related water studies. Currently (2006), there are nine real-time streamflow-gaging stations in the upper Big Thompson River Basin operated by the USGS and Colorado Department of Water Resources.

As a result of the June 1965 South Platte River flood that severely affected the Denver area, the Urban Drainage and Flood Control District (UDFCD) was established for the purpose of assisting local governments in the Denver metropolitan area with multi-jurisdictional drainage and flood-control problems. The District covers an area of 1,608 square miles that includes about 1,600 miles of major drainageways and serves a population of approximately 2.3 million people. Soon after the 1976 Big Thompson flood, the District set up an early flood detection and local flood warning program. Currently (2006), UDFCD operates an automated flood detection network comprised of 175 ALERT gaging stations (including 152 rain, 87 stream stage, 18 weather). Other large cities such as Fort Collins and Colorado Springs have similar flood warning and floodplain management programs. However, most Colorado streams are ungaged with their flood potential being monitored by the NWS using rainfall-runoff models and flash flood guidance (http://www.noaa.gov).
Today, flood specialists and emergency responders recognize that awareness of flooding is a combination of weather preparedness and personal responsibility. Before flooding occurs, residents or visitors need to know if buildings are in flood-prone areas, the dangers along stream channels, and if roads may become impassible. In addition, during floods, law-enforcement officials might not be able to drive through flooded areas to provide warnings that people may expect. Flood warnings, such as NWS watches and warnings, UDFCD’s ALERT data, and Colorado Department of Water Resources and USGS real-time rainfall and streamflow data, may not be available particularly in remote mountainous areas. Communications may be disrupted during extreme weather events such as floods, tornadoes, and hailstorms.

Nature often provides early warning signs of impending hazardous flooding. Knowledge and observation of developing thunderstorms (fig. 9) can provide important early warning in areas subject to lightning, hail, tornadoes, and flood-producing rains. In some cases, such as during the July 1976 flood in the Big Thompson Canyon downstream from Drake near the canyon mouth, there is little or no rainfall that might alert people that floodwaters are advancing. Once a flood (meteorologic or dam failure) or debris flow begins, many eyewitnesses often mention hearing rumbling sounds (described as trees breaking, jet airplanes, locomotives, and other loud roars) moving closer to their location. A combination of personal responsibility, planning and awareness, National Weather Service and other local flood agency programs and resources, and personal observations of developing weather conditions are vital to prepare people to help protect themselves when hazardous flooding is imminent.

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References


