MANITOU SPRINGS FLOOD HAZARD MITIGATION PLAN

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with

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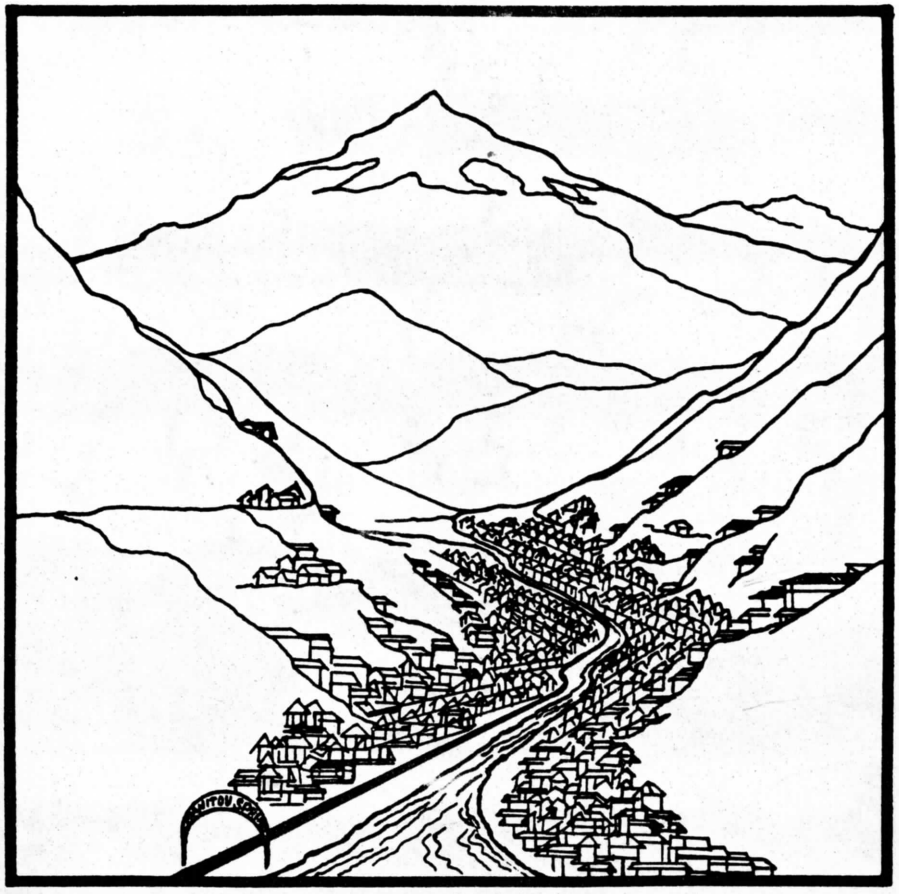

Summer 1985

Center for Community Development & Design

University of Colorado
Colorado Springs

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PREFACE

This research effort represents a dramatic and promising direction in floodplain management in the United States. In recent years flood losses have continued to rise despite massive funding for flood control. Federal policy has recognized this expensive discrepancy, and legislation aimed at long-term flood hazard reduction has been passed by Congress. The key change revolves around the term "mitigation". According to the Federal Emergency Management Agency, approximately 20,000 communities in the United States face flood hazards. While hundreds of these communities have developed flood hazard management plans, Manitou Springs is one of few communities which now has post-flood contingency planning possibilities to consider prior to a devastating flood.

This report makes three distinct contributions. First, it assists the community of Manitou Springs, Colorado by suggesting flood hazard mitigation strategies based on the experience of communities elsewhere in the United States. It provides an in-depth description of the city's flood history and local economic base and develops a detailed scenario of present vulnerability to the flood threat. An extensive literature review reveals how other communities with similar conditions have successfully reduced flood loss potential through warning systems, land acquisition schemes, structural flood control measures, and increased public awareness. Three characteristics which distinguish Manitou Springs from other communities are a heavy reliance on tourism as an economic base, a lack of buildable lots which are not in the floodplain or on steep hillsides, and a large percentage of historic buildings. Also, topography makes some structural projects difficult or impossible.

Second, this report provides guidelines for post-flood contingency planning for Manitou Springs, prior to a flood occurrence. Consequently, when there is a flood, local officials will have a lead on wise recovery and reconstruction planning which will reduce future potential losses.

Finally, this report suggests a methodology for post-flood planning in anticipation of floods. Research shows that post-disaster decisions must be made quickly. In addition, current legislation stipulates that disaster aid is contingent on adequate mitigation planning for reducing the threat from future events. Therefore, if local planners have a vision for community improvement, there is greater likelihood of reducing vulnerability to subsequent floods. We anticipate this methodology has applicability in other communities as well.

The strategy presented takes the local political, economic and physical realities into account, acknowledging factors which restrict such adjustments as changing the floodplain into a greenbelt or channelizing a stream. It also recognizes the opportunity a flood disaster presents for long term hazard reduction. In effect, this pre-flood/post-flood planning and implementation of steps to mitigate the hazard assures that Manitou Springs will be much less vulnerable in terms of lives lost and property damaged from a second flood.

PROJECT GOALS

A. To minimize loss of life in the event of a flash flood.

B. To minimize damage to existing development.

C. To minimize damage to FUTURE development.

D. To minimize damage to public facilities and structures and to historic buildings.

E. To minimize the public expenses for local emergency recovery and reconstruction operations.

In order to facilitate the attainment of the above mentioned goals, the following, more specific, goals must also be attained:

F. Develop and implement a specific hazard mitigation plan for Manitou Springs:

1. Organize a committee to oversee implementation and to work with technical advisors.

2. Assess the vulnerability of Manitou Springs to the flood hazard -- make a thorough survey of all structures, bridges and open spaces.

3. Select a range of mitigation strategies which have applicability to Manitou Springs; develop pre-flood AND post-flood mitigation strategies before a flood occurs.

4. Implement the pre-flood mitigation strategies as soon as possible.

5. Implement the post-flood mitigation strategies upon occurrence of flash flooding.

6. Monitor, upgrade, and streamline the mitigation plan on an ongoing basis to insure that Goals A, B, C, D, and E will always be attained.

EXECUTIVE SUMMARY

The Manitou Springs Flood Hazard Mitigation Project was funded by the Federal Emergency Management Agency. This summary provides background on the project, discusses four of the most interesting issues raised during the course of the project, presents the report recommendations, and, perhaps most importantly, sets the stage for implementation of the recommendations in Manitou Springs.

Manitou Springs is located at the base of Pikes Peak, immediately west of Colorado Springs. The year-round population is approximately 4500 people. During the summer thousands of tourists come and stay in Manitou Springs to enjoy its amenities and proximity to Pikes Peak and other attractions of the Rocky Mountain region.

Land use in Manitou Springs is constrained by the geography. The town is located along the channels of Fountain, Ruxton, Waldo, Beckers Lane, Williams, and Sutherland Creeks. Much of the remainder of the town sits on steep slopes above the floodplain. There is very little land available for development that does not face one of these hazards. Consequently, downtown Manitou Springs is built along the creeks and the floodplain is nearly fully developed. Shops, hotels, homes, and restaurants sit astride or are built partially in the floodway.

The community has had limited experience with flooding in recent memory although serious floods have occurred in the past 75 years. Manitou Springs has a floodplain ordinance and is a member of the regular phase of the National Flood Insurance program but only 32 policies are maintained.

A large portion of Manitou Springs is recognized as a national historic district. There are 850 buildings located in the main historic district and, over 150 of these are in the floodplain.

This research effort represents a joint process developed between the Federal Emergency Management Agency, Manitou Springs local government, the Colorado Division of Disaster Emergency Services, the Center for Community Development and Design, and the Department of Geography and Environmental Studies research team. Manitou Springs officials recognize the need to effectively enforce floodplain regulations and develop a plan to reduce flood hazard vulnerability. State and federal agencies are and have been aware of the constraints facing Manitou Springs including topography, low level of public awareness, economic dependence on tourism, historic nature of the town, and the need for economic development.

A proposal was prepared in late 1984. The Federal Emergency Management Agency funded the effort based on three particular goals:

1) to develop contingency planning for Manitou Springs which can be implemented now, before a flood;
2) to establish guidelines for Manitou Springs to have on hand for planning following a flood to insure that future damage potential is reduced; and,
3) to design a methodology for possible application elsewhere in the United States for pre and pre/post flood hazard mitigation.

The Federal Emergency Management Agency and Manitou Springs are aware that a new emphasis on flood hazard mitigation and preparedness planning saves lives and reduces propoerty losses. Manitou Springs recognized the value of being prepared for a flash flood but did not have the resources to design and implement a plan. In early 1985, the University of Colorado Springs Department of Geography and Environmental Studies and the Center for Community Development and Design put together a research team, a technical advisory committee, and a community group aimed at reaching these goals.

Basically, the methodology consisted of bringing the most effective and innovative plans from around the United States to the attention of Manitou Springs. These flood hazard mitigation strategies and funding prospects for each option were reviewed and recommendations for adoption and implementation in Manitou Springs were studied. In light of the fact that public awareness is essential to the implementation process, a slide/tape presentation of the likely effects of a 100 year flash flood in Manitou Springs was prepared for ongoing public education.

Four key issues which emerged are conflicts between historic preservation and wise floodplain management; reliance on tourism and the large number of visitors during flash flood season; interaction among the various actors involved in wise flood hazard mitigation including local residents, local commercial interests, the state officials and federal agencies and, the essential role of public awareness. Each of these is discussed individually below.

Historic Preservation

Federal and State historic preservation policy limits the type and extent of changes that can be made to historic structures and their sites without endangering their status on historic registries. Flood damage can endanger this status. However, taking steps to reduce an historic structure's vulnerability to flood damages can also endanger its status, e.g., relocation to a flood-free site, structural flood-proofing, installation of flood barriers, etc. Close coordination is needed between historic registry staff and local officials in reducing the flood loss susceptibility of historic structures.

Tourism

Manitou Springs depends on tourism for its economic base. One concern consistently raised by community members was the fear that preparedness planning might discourage tourism. Our findings indicate this fear is unfounded. As an example, Estes Park suffered the equivalent of a 500 year flood in 1982 due to a dam break. Within a week the town's tourism exceeded preflood levels. In fact, Estes Park is the only Colorado community in 1982 to post an increase in tourist dollars during that summer month. A well-prepared community is more attractive than one that is ill-prepared.

Multi-agency Task Force

We worked with a dedicated team of individuals who devoted many hours responding to our questions and providing valuable technical advice in all phases of the project. This integrated mission of flood hazard mitigation will carry on beyond the completion of this particular research effort. The fact that Manitou Springs is closely linked with various agencies involved in flood hazard mitigation in the region, state and nation should improve chances for obtaining funds to speed implementation of the recommendations.

Public Awareness

A scenario with an accompanying slide/tape presentation has been developed in two parts: with present level of preparedness and with a better prepared response and warning capability. Remarkable reductions in loss of life and property damage are found in the second scenario. Clearly, the public awareness message is that awareness saves lives. No funding is required to have a much better prepared community. Residents, business owners, motel owners, and tourists can be informed of the potential benefits of being aware and can be knowledgeable of appropriate actions in the event of a flash flood or flash flood warning.

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A. Situation

Manitou Springs is located in El Paso County at the foot of the Front Range of the Rocky Mountains in east-central Colorado. The city is immediately west of Colorado Springs and has a population of 4,475 (U.S. Department of Commerce, 1980 Census). Situated along Fountain Creek at an altitude of 6,606 feet, the city is at the mouth of Ute Pass and the base of Pikes Peak.

Manitou Springs is renowned for its many mineral springs located throughout the city and for other attractions such as the Garden of Gods, Cave of the Winds, Pikes Peak Cog Railroad, Cliff Dwellings and the Manitou Incline.

B. History

The history of the Manitou Springs area surrounds its 26 springs and reflects the tourism-oriented economy which is evident there today. The Indians were first to discover the natural springs of Manitou Springs, and the valley was considered sacred territory by many tribes. In the 1830's, pioneers began to recognize the natural beauty of the area as they arrived seeking the professed healing powers of the waters. In 1847, Lt. George Ruxton established permanent camps at the mouth of Ute Pass. In the 1860's, gold was discovered in South Park, just over the pass. An influx of people to the area resulted from this discovery (Phelps, 1985). The town was surveyed and laid out in 1871 as the first tourist resort in Colorado (U.S. Army Corps of Engineers, 1974). It was seen as a retreat by both tourists and settlers, promoted by the famous medicinal mineral waters. On July 8, 1876, Manitou was incorporated. A building boom in the 1890's was responsible for most of the buildings which front the main street, Manitou Avenue (Phelps, 1985). The backs of of these buildings face Fountain Creek where their walls form the creek's southern channel. Even into the 1950's, Manitou Springs was one of the two major tourist destinations in Colorado (Stumpp, 1985). Today, visitors to the area are attracted by its historic nature and small-town atmosphere.

Figure 1. Briarhurst Inn constructed in 1874 by Dr. William Bell is located between El Paso Boulevard and Fountain Creek.

C. Environment

1. Climatology

Manitou Springs is located in the east-central portion of the state of Colorado at the foot of the Rocky Mountain Front Range. The upper Fountain Creek watershed lies in portions of two Colorado counties, El Paso and Teller.

The climatology of the region surrounding Manitou Springs is derived from recorded data at Colorado Springs and Lake Moraine. Additional data has been obtained from stations with limited recording periods located at Pikes Peak, Ruxton Park, Woodland Park and Manitou Springs.

Precipitation in the region is approximately 17 to 20 inches per year. The average annual snowfall is 78 inches per year with the heaviest snows occurring in March and possible trace accumulations falling as late as June.

Thunderstorms occur in the region approximately 50 days a year. They are generally accompanied by heavy showers, severe gusty winds, and occasional hail. Precipitation during the period from April to October may make up from 75 to 80 percent of the annual precipitation total. June tends to be dryer than the other warm season months. Rains during April and May are frequently of several days duration with a relatively low hourly rate (McAnelly, 1974). July and August are characterized by heavy afternoon

thunderstorms which, due to the intense localized rain, lead to high runoff rates and localized flooding. The large triangular area between Castle Rock, Colorado Springs and the forks of the Bijou Creek south of Byers, has a history of repeated cloudbursts unequaled along the Front Range. The localization of cloudbursts in this area is influenced by the orographic effects of the Palmer Divide. Precipitation from these storms has reached levels greater than that produced by tropical cyclones (Hansen, 1973).

The probable maximum precipitation for the Manitou Springs area is delineated in Table 1. Figure 2 maps data on probable maximum precipitation for the Pikes Peak Region. Rainstorms of 35 or even 17 inches are rare; however, they have occurred. There have been several storms in the Pikes Peak region that have led to extensive flooding (see Table 2). Storms between the continental divide and the plains are caused by one of the following situations: cold front, tropical cyclone, complex convective storm, or simple convective storm. Figure 3 shows the maximum recorded precipitation for El Paso and surrounding counties. Note that Manitou Springs has received seven inches in one storm. Other storms in the region have dropped as much as 24 inches in a single storm, as recorded in Elbert County.

TABLE 1

PROBABLE MAXIMUM PRECIPITATION FOR 10 SQUARE MILES

Area	6 hours	24 hours	72 hours
Manitou Springs	24-26 inches	32-34 inches	38-40 inches
Teller/El Paso	18-20	26-27	28-30

Additional climatology data may be found in Appendix A of this report.

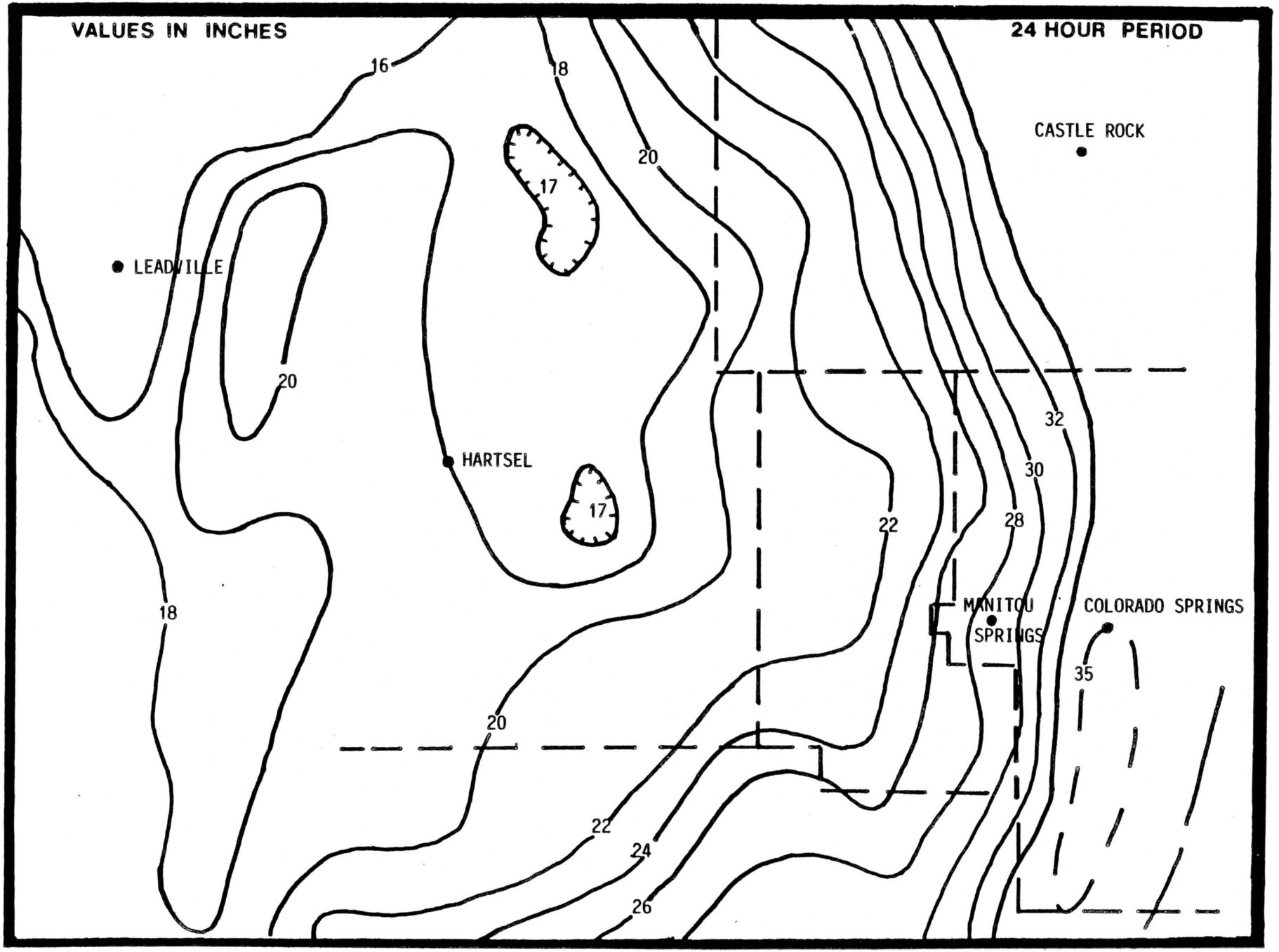

VALUES IN INCHES
24 HOUR PERIOD
16
18
20
17
CASTLE ROCK
LEADVILLE
20
HARTSEL
17
32
30
22
28
18
MANITOU SPRINGS
COLORADO SPRINGS
35
20
22
24
26

Figure 3. **MAXIMUM RECORDED PRECIPITATION**

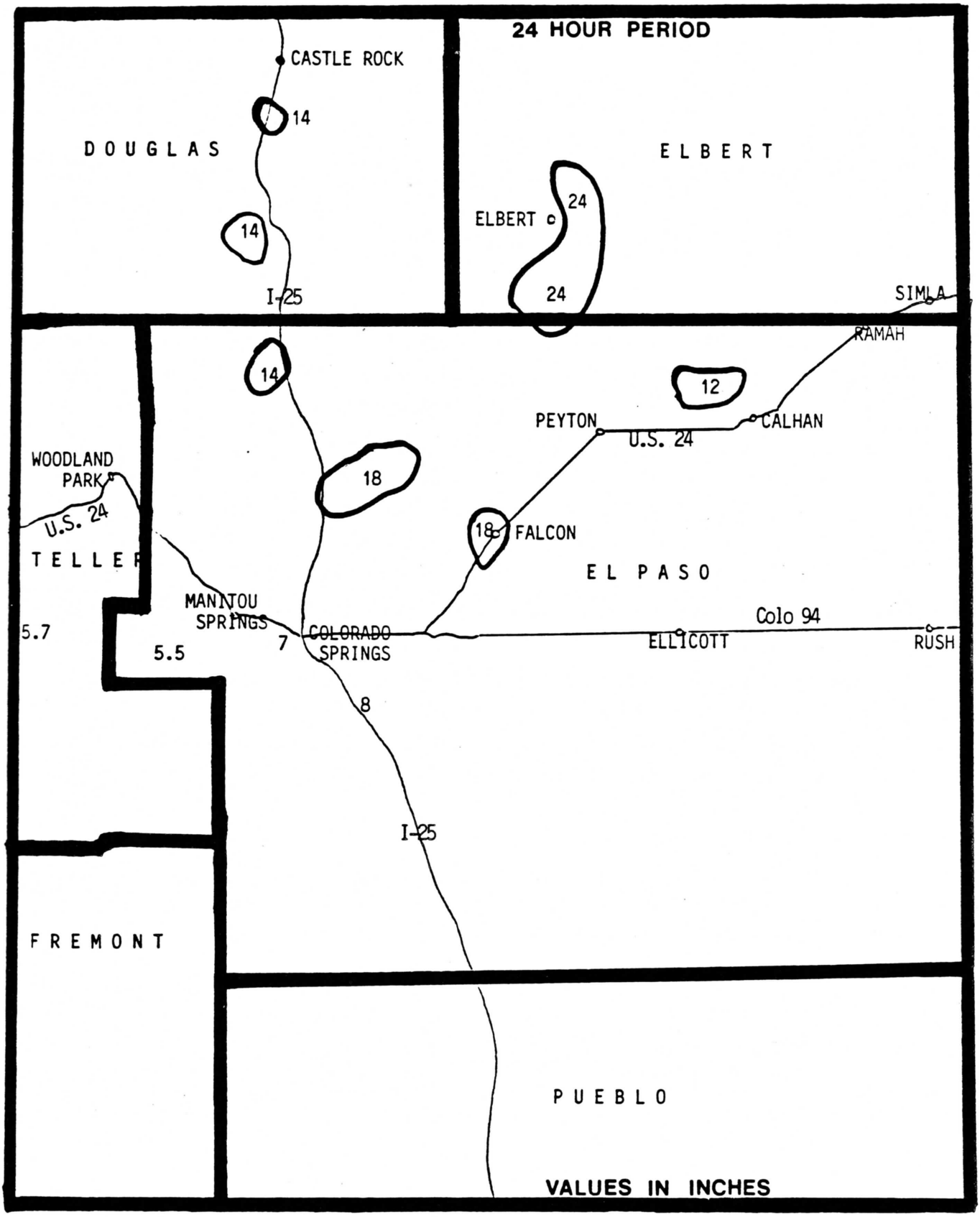


TABLE 2

STORM EVENTS FOR THE PIKES PEAK REGION

AREA	DATE	TYPE STORM	RAINFALL
Penrose	June 2-6, 1921	Complex convective (orographic)	12" in 18 hours
Cheesman	July 19-24, 1929	Complex convective (orographic)	
Kassler	Sept. 9-11, 1933	Complex convective (least orographic)	
Monument/ Cherry Creeks	May 30-31, 1935	Complex convective (least orographic)	26" in 24 hours
Leadville	July 27, 1937	Simple convective (orographic)	
Plum Creek	June 13-20, 1965	Complex convective (least orographic)	18" in 24 hours

Source: U.S. Department of Commerce, NOAA Hydrometeorological Study No.55: 1984b.

Penrose Storm - This was a very extensive storm system occurring in parts of 5 states over 114 hours. It was caused by warm, moist air from the Gulf of Mexico being pushed into the area by low pressure systems over New Mexico. Penrose was the largest center with 12 inches of rain falling in 18 hours (87 percent fell in 6 hours). This rainfall, combined with other centers along the Front Range and Arkansas River basin, led to extremely high flood levels from Pueblo, Colorado downstream into Kansas. Manitou Springs had a smaller storm center which dropped 4 to 5 inches of rain south and west of the city over the Ruxton Creek drainage area.

Monument/Cherry Creek - Warm, moist air form the Gulf of Mexico was pushed into the area by low pressure over northern New Mexico while a strong high pressure system was centered over the northern U.S. The 26 inches in 24 hours which fell near Elbert, Colorado is the highest rainfall amount recorded in the state. The resulting flood along Monument Creek and Fountain Creek caused heavy damage to Colorado Springs and El Paso County.

Plum Creek - Warm, unstable, moist air moved into the area from the Gulf of Mexico and heavy rains fell over a relatively long period. The most intense storms hit on June 16 and 17 with 18 inches falling over the upper Jimmy Camp Creek basin near Falcon. This led to the highest flood flow to drainage area ratio ever recorded in Colorado. Six inches fell west and southwest of Manitou Springs, but no flooding occurred.

Manitou Springs and the upper Fountain Creek watershed occupy the zone subject to orographic type storms of the same type as the Penrose, Monument/Cherry Creek and Plum Creek storms.

2. Hydrology

Fountain Creek rises in the Rampart Range near Woodland Park approximately seven miles northwest of Pikes Peak, draining the northeast slope of the mountain (see Figure 4). Flowing southeasterly through Ute Pass it drains an area of 71 square miles above Manitou Springs and is characterized by steep slopes, rugged terrain, and forest. As Fountain Creek passes through Manitou Springs, the floodplain is heavily developed in many places with city parks occupying the remainder of the space. Other drainages impacting on Manitou Springs before they enter Fountain Creek are Ruxton Creek, Williams Canon, Sutherland Creek and Beckers Lane Tributary.

Ruxton Creek has a drainage area of 17.6 square miles above its confluence with Fountain Creek and drains the eastern face of Pikes Peak. The basin above Manitou Springs is characterized by steep slopes, rugged terrain and forest, while within the city, the floodplain is heavily developed along and even over the channel.

Williams Canon has a drainage area of 2.68 square miles and drains the area north of U.S. Highway 24 near the Cave of the Winds. The basin above U.S. Highway 24 is a steep-walled canyon, while below the channel flows through residential neighborhoods. The channel is contained in a concrete culvert for its last 1100 feet along Canon Avenue before entering Fountain Creek.

Sutherland Creek has a drainage area of 5.37 square miles and drains the area south of the city. The upper basin is forested while the lower basin consists of moderately developed residential neighborhoods.

Beckers Lane Tributary has a drainage area of .88 square miles and drains the area near Beckers Lane along the northeast side of the city. The area consists of moderately developed residential neighborhoods and campgrounds.

A description of the drainage areas for Fountain Creek above Manitou Springs is contained in Table 3. Additional hydrologic data may be found in Appendix A of this report.

Figure 4. **DRAINAGE BASIN**

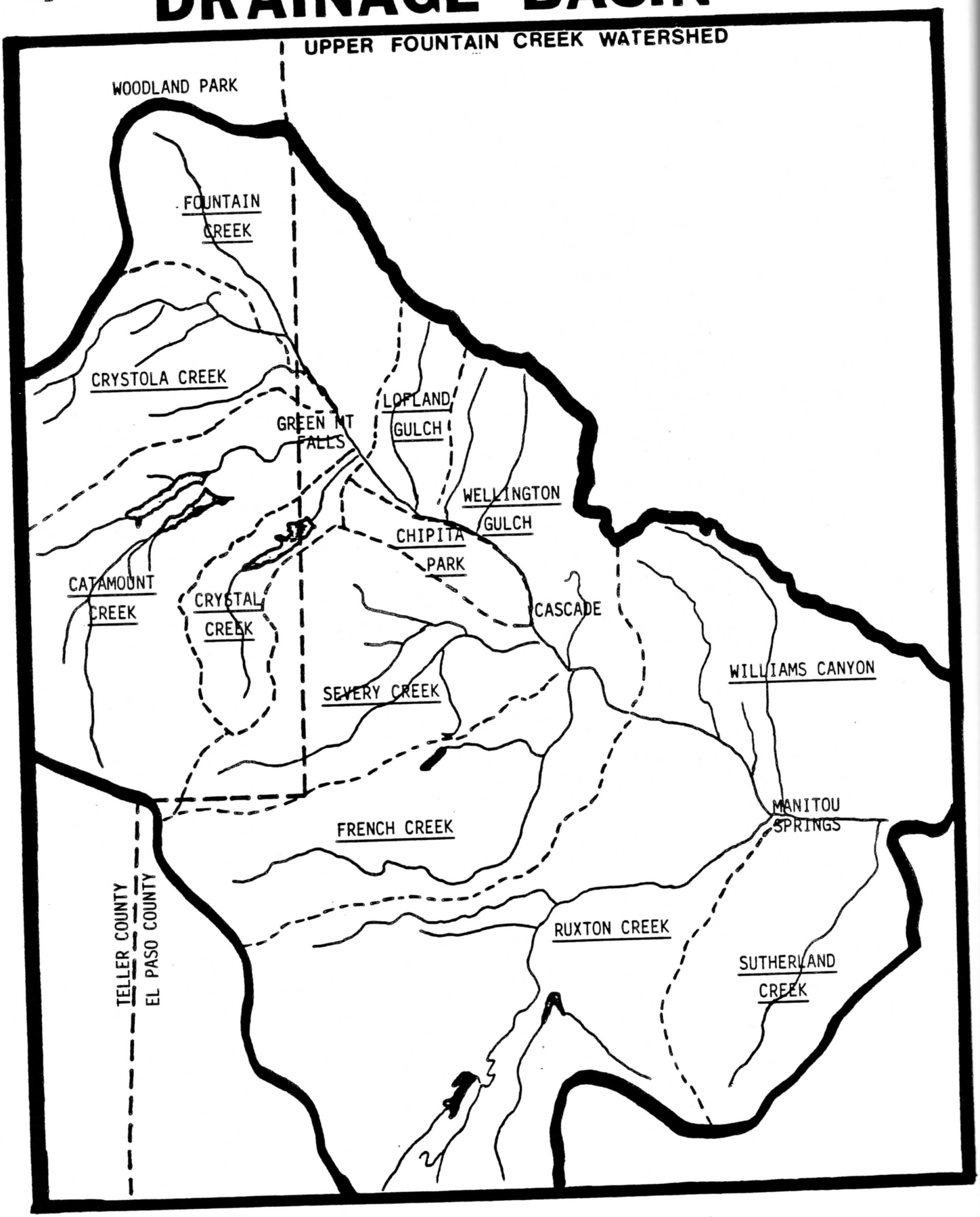


TABLE 3

DRAINAGE AREAS IN FOUNTAIN CREEK WATERSHED ABOVE MANITOU SPRINGS

Location	Drainage Area (sq. mi)
Crystola	13.7
Green Mountain Falls	19.0
Chipita Park	40.6
Cascade	55.4
Above Ruxton Creek	70.5
Below Mouth of Ruxton Creek	89
Below Mouth of Williams Canon	91
Below Mouth of Sutherland Creek	98
Below Mouth of Black Canyon	101

Source: U.S. Corps of Engineers: Floodplain Information, Fountain Creek: 1974.

3. Economy

Throughout its history, the economy of Manitou Springs has been based almost exclusively on tourism. Manitou Springs' dependence on a summer tourist economy relates to the issue of floodplain management in three important ways.

First, the flood hazard and tourism both peak at the same time of year. "Flash floods are most likely to occur in the late afternoon or early evening from late spring to early fall; at those times more tourists and visitors are in the floodplain" (Downing, 1977a). Provisions must be made in contingency plans which allow for this increase in population.

Second, although residents may be aware of the flood threat, it should be assumed that visitors to the area are unaware of the potential hazard.

And, third, when a flood does occur, the overall economy of the city will be affected. Manitou's almost exclusive reliance on the tourist trade suggests that the large scale disruption resulting from a major flood would be especially evident, as "dependence on one major source of revenue leaves the town vulnerable to fluctuations in the industry" (Community Renewal Associates, 1977). The very attractions that lead tourists to Manitou Springs are predominantly in the most hazardous floodplain areas.

4. Development Pattern

Fountain Creek and its tributaries have been extensively developed along the floodplain with residential, commercial and industrial buildings built next to, and in many cases, over the channel. This is especially true in the main business district of Manitou Springs where many businesses are established along or over Fountain Creek. It is also apparent along Ruxton Creek where residential and commercial buildings are built along or over the narrow channel. The flow from Williams Canon has been channelized to flow in a culvert along Canon Avenue with residential buildings occupying the floodplain. The culvert is designed to only carry minimal flow so the channelization is ineffective. The municipal building and fire station are situated along Fountain Creek with building supports extending into the creek. Figure 5 illustrates the 500-year floodplain inundation zone. It is similar to the 100 year floodplain. For more detailed boundaries refer to the Federal Emergency Management Agency Flood Insurance Rate Map enclosed in a packet at the back of the report.

One of the major problems in passing floodflows is the presence of natural and man-made obstructions within the floodways. These obstructions lead to the formation of dams which, in turn, cause higher backwater depths, increased overbank flooding, and, when they fail, surges in floodflows and increased debris battering.

Natural obstructions to floodflow within the Manitou Springs area occur when trees, brush and other vegetation clog the channel. Although there have been efforts in previous years to clear the channels within Manitou Springs, they are currently extensively vegetated.

There are a variety of obstructions built within the Manitou Springs area with stone arch bridges, utility pipelines, wooden footbridges and even buildings spanning the creek channels in numerous locations. Much of this material, especially the small wooden foot bridges, can be expected to be washed away to form debris dams farther downstream. Other restrictions to floodflows are the many building foundations and supports which extend into and over the channel.

D. Flood Experience

The history of floods in the Manitou Springs area is primarily based on accounts published in newspaper articles, local histories, and the memories of long-term residents (see Table 4). Although there have been many gaging stations in operation along the smaller tributaries of Fountain Creek, only one station has a substantial period of record for Fountain Creek itself. This station, located just east of the Manitou Springs city limits, has been operating since April, 1958 and measures the flow from a drainage area of 102 square miles. Many flood hazard studies have examined aspects of Manitou Springs' vulnerability. These are listed in Table 5.

TABLE 4

HISTORIC FLOODS AT MANITOU SPRINGS

DATE	CHANNEL
July 1, 1882	Williams Canon, Fountain Creek
May 31, 1894	Fountain Creek, Ruxton Creek, Willams Canon
August 5, 1902	Fountain Creek
June 5, 1921	Ruxton Creek, Fountain Creek
September 9, 1940	Fountain Creek
May 10, 1947	Williams Canon, Fountain Creek
August 4, 1964	Fountain Creek

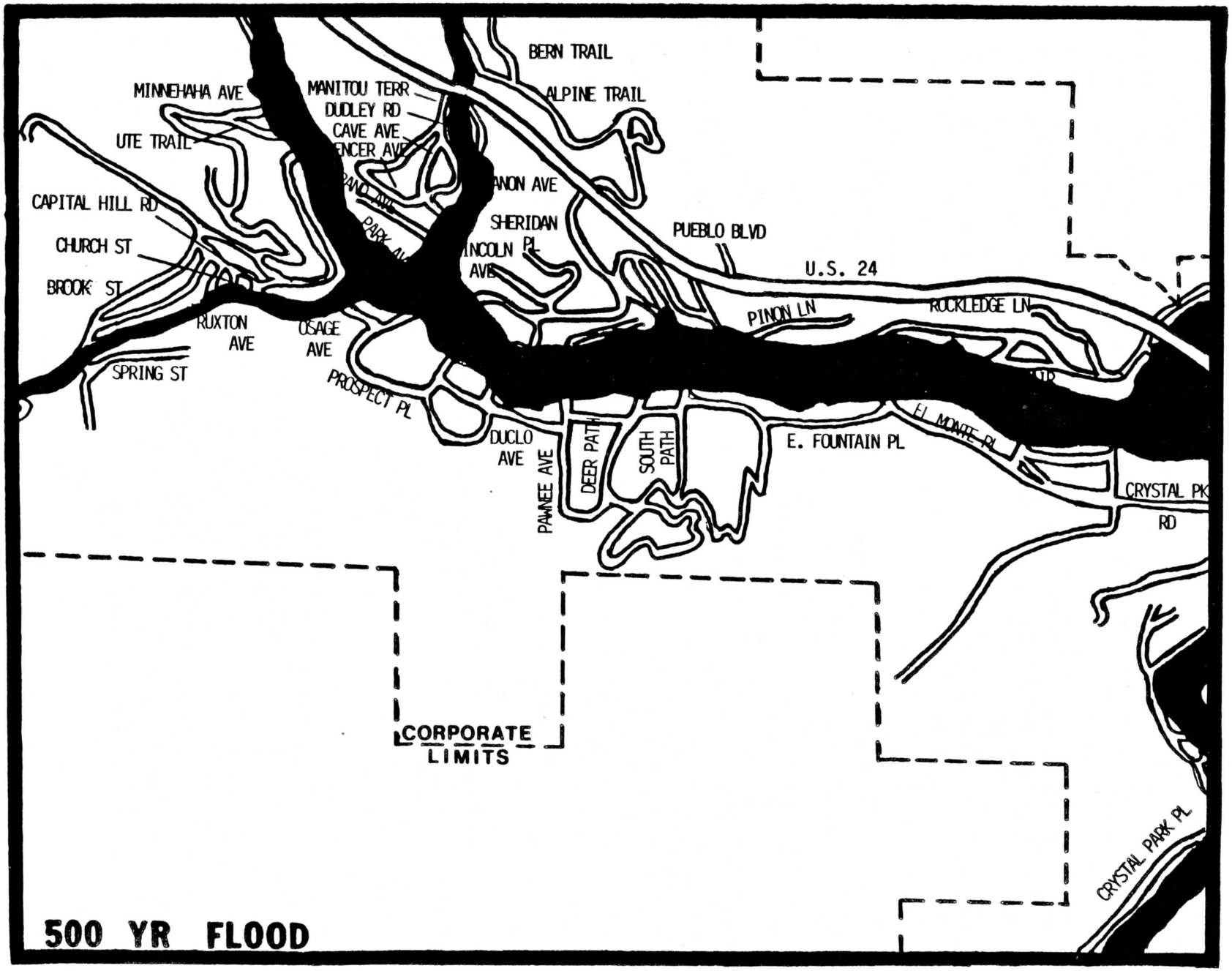


Figure 5. **FLOOD INUNDATION ZONE**

TABLE 5

FLOOD HAZARD STUDIES FOR THE MANITOU SPRINGS AREA

Date	Agent	Remarks
1968	U.S. Army Corps of Engineers	Investigated the possiblity of placing a dam west of Manitou Springs - determined to be not feasible.
1974	U.S. Army Corps of Engineers	Mapped flooded areas and provided information on hazards.
1975	Leigh Whitehead and Associates	Analysis of Sutherland Creek and Crystal Hills
1975	U.S. Department of Housing and Urban Development	Flood Hazard Boundary Map for Manitou Springs
1975	U.S. Department of Housing and Urban Development	Flood Hazard Boundary Map for Green Mountain Falls.
1976	U.S. Army Corps of Engineers	Investigated hydrology for flood insurance study.
1977	U.S. Department of Housing and Urban Development	Flood Hazard Boundary Map for El Paso County, Unincorporated Areas.
1977	U.S. Department of Housing and Urban Development	Flood Hazard Boundary Map for Teller County.
1978	Nelson, Haley, Patterson and Quirk	Comprehensive drainage plan for the Pikes Peak region.
1980	U.S. Soil Conservation Service	Soil Survey for El Paso County analyzes runoff characteristics for Manitou Springs area.
1981	Gilbert, Meyer and Sams	Master Drainage Plan for Manitou Springs
1983a	Federal Emergency Management Agency	Flood Insurance Study, City of Manitou Springs.
1984a	Federal Emergency Management Agency	Flood Insurance Study, City of Colorado Springs.
1984b	Federal Emergency Management Agency	Flood Insurance Study, El Paso County Unincorporated Areas.
1985	U.S. Army Corps of Engineers	Reconnaissance Study Final Report; analysis of structural alternatives; recommends study of warning system.

Newspaper accounts of Manitou Springs flood events provide valuable information on flooding effects, but specific information on intensity, duration, and magnitude of storms and resulting floods is largely lacking. Following are several articles describing effects of various floods at the time of their occurrence.

Flood of July 1, 1882

This flood was caused by heavy rainfall from afternoon thunderstorms that were centered over the Williams Canon drainage basin. A particularly intense cell unleashed a cloudburst around 4:30 P.M., which directed a wall of water down the narrow canyon through Manitou Springs and into Fountain Creek.

The Manitou Springs Item of July 8, 1882 described the event as follows: "Various hotels are the heaviest losers...Manitou Bath House flooded with 2 feet or more of water and it is thought that the heavy sediment on the floor is the reason the building did not float away...road to the Cave of the Winds completely washed away...railroad tracks and bridges washed away...hail as large as hen eggs seen in town with much larger seen up the canon...The city council doubtless will take action looking to the construction of the proper water courses through the town. These should be lined with masonry and always kept open."

The Colorado Springs Weekly Gazette of July 8, 1882 contained the following description: "...so far as could be learned the life of but one person had been sacrificed...two boys had gone up Williams Canon and were caught by the storm...the surviving boy said that he and his brother had gone but a short distance when they heard a terrible roaring behind them and saw a wall of water rushing down upon them...they clambered up the side of the canyon seeking refuge on the top of the old lime kiln, which is about 20 feet high, when a monstrous wave struck the kiln taking the younger boy with it...proprietor of the Ruxton Livery Stable, a short distance up Ruxton Creek saw the waterspout as it broke up Williams Canon and a few seconds afterward heard distinctly the roaring of the water as it made its way through the near (Ruxton) canyon and broke through the back door of his barn, taking with it horses and wagons...Hail, which accompanied the storm crashed through windows and threatened death to anyone who ventured outside. In some parts of town hailstones as large as oranges fell and one measured 11 inches in circumference. In places these hailstones lay in banks several feet in depth."

If the eyewitness reports contained in the newspaper accounts are accurate, the 20 foot wall of water would equal the expected 500 year flood (Federal Emergency Management Agency, 1983).

Flood of May 31, 1894

The flood of May 31, 1894 was caused by heavy general rains occurring over much of the Front Range. This is also the date on which heavy rainfall in the Ward, Colorado area led to flooding along Boulder Creek. The Rocky Mountain News of June 1, 1894 described the situation in the following manner: "Rain has been falling steadily all day making a continuous fall of 50 hours, an unheard of thing for Manitou. Ruxton Creek is still a raging

torrent and the Fountain has been tearing away stone walls and foundations and bridges. Canon Avenue, the road leading to Williams Canon is a mountain torrent down which hundreds of tons of rock have been washed."

The Colorado Springs Weekly Gazette of June 1, 1894 states that "Lake Moraine rose 6 feet in 24 hours...Midland Railroad blocked by slides in Ute Pass...water overflowed Fountain Creek and flooded Colorado City (present day west Colorado Springs)...Ruxton Creek higher than ever before...Williams Canon flooded...City Council employed 15 men to watch the creek and give people warning if necessary...Rainfall of 2 inches or more in previous days in upper Fountain Creek had prepared the soil for rapid runoff."

Flood of August 5, 1902

This flood was caused by a localized heavy thunderstorm in the vicinity of Woodland Park that dropped large amounts of rain on the upper Fountain Creek basin above Manitou Springs.

The Colorado Springs Daily Gazette of August 6, 1902 contains the following description: "...cloudburst did more damage to Manitou and the pass than has been done before by a single storm...No wagon bridges are left in Ute Pass below Cascade with the carriage road being washed out completely...Soda Springs Park is a mass of wreckage, consisting of household goods, timbers, tree trunks, and railroad ties 20-30 feet high...100 light dwellings have been moved from their former foundations...Midland Railroad is totally out of business in Ute Pass being washed out for dozens of roads in many places and the wreckage of the line being scattered along the banks of the creek for 20 miles below the scene of the cloudburst...Warning had been received through Western Union that Green Mountain Falls had been visited by a cloudburst at 2 P.M....Men on horseback went up the pass to give warning...At 3 P.M. a wall of water 15 feet high came down the creek."

The Colorado Springs Weekly Gazette of August 8, 1902 stated that "a wall of water 20 feet high chased a horseback rider down Ute Pass to Manitou . . .Summer cottages, tents, bridges, outhouses, cattle and horses strewn along Fountain Creek ... All county roads west of Manitou Springs impassable ... Bridge at Soda Springs carried away bodily...2 cottages at 364 Manitou Avenue carried 50 feet from their former locations."

The report of a wall of water 15 feet high crashing into Manitou would approximate the 100 year flood for Fountain Creek, as specified by the Federal Emergency Management Agency (1983a).

Flood of June 5, 1921

This flood was part of the large system that dropped extremely heavy amounts of rainfall along parts of the Front Range and along the Arkansas River valley. The rain fell mainly over the Ruxton Creek drainage basin and occurred the day after heavy showers dropped over 12 inches of rain at Penrose, Colorado. With the Manitou Springs flood occurring the day after the devastating Pueblo flood in which more than a hundred lives were lost, newspaper coverage of the Manitou Springs event was somewhat limited.

The Colorado Springs Evening Telegraph of June 6, 1921 describes how the Manitou and Pikes Peak Trolley line was destroyed along with parts of Ruxton Avenue in many places "...lower part of Ruxton Avenue was turned into a raging river doing much damage to homes and businesses...structures along Ruxton and Fountain Creeks had their foundations undermined and tumbled into the waters...Williams flowed all night and debris blocked culverts and flooded streets...Downtown Manitou threatened until temporary dam was constructed which diverted water from Williams Canon to enter Fountain Creek farther down the creek...Fountain Creek swelled out of its banks along Manitou Avenue."

The El Paso County Democrat of June 10, 1921 described how many structures were completely destroyed and the Mayor called for volunteers to watch the creek during the night.

Flood of September 9, 1940

This flood was the result of a heavy localized thunderstorm that occurred over the southern part of Manitou Springs with the heaviest damage taking place in the Plainview section. The cloudburst struck about 2 p.m. and lasted for only about an hour.

The Colorado Springs Daily Gazette of September 10, 1940 described how Pawnee Avenue was the hardest hit with the street containing the flow of water up to 3 feet in depth "...debris left behind reached the floorboards of cars...runoff from Pawnee and El Paso poured through Manitou Avenue just east of the business section...2.2 inches fell in 45 minutes; reported by Plainview resident and 1.98 inches fell during the afternoon; as reported from Ruxton Park."

Flood of May 10, 1947

This flood was caused by a heavy thunderstorm which was centered over the Williams and Waldo Canons north and west of Manitou Springs. Thundershowers were occurring throughout the Manitou Springs' area during the afternoon when extremely heavy downpours struck around 6 p.m. Table 6 summarizes the flood damages which received extensive newspaper coverage.

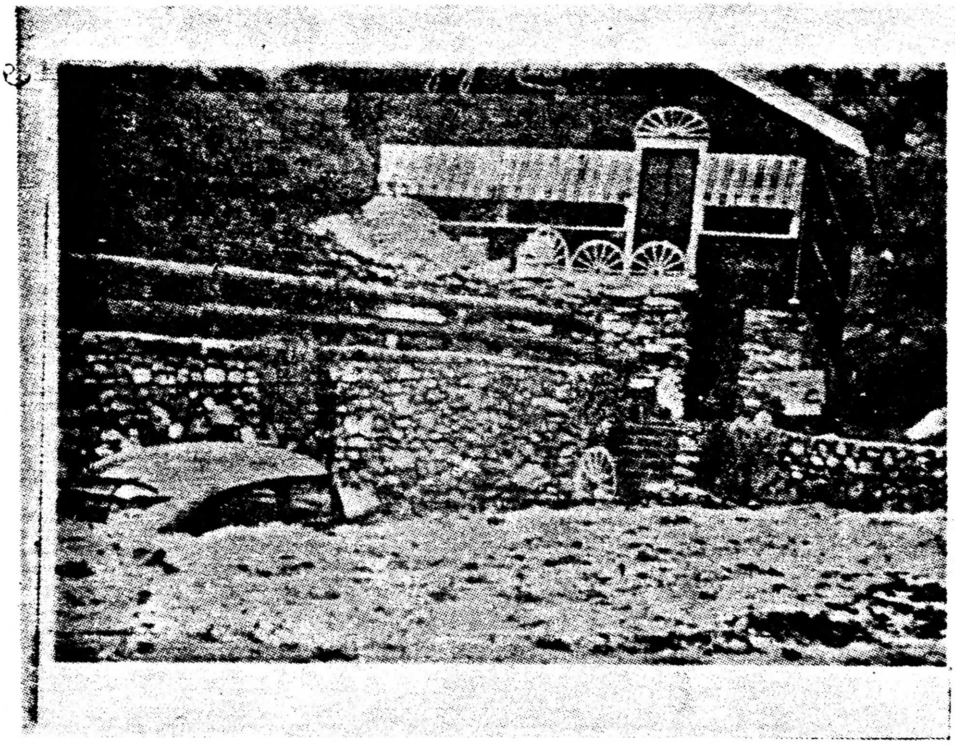


Figure 6. Debris deposits left along Canon Avenue in the aftermath of the torrent of water exiting Williams Canon.

TABLE 6

FLOOD DAMAGES WITH EXTENSIVE NEWSPAPER COVERAGE- MANITOU SPRINGS

Flood	Damages	Source
July 1882	"difficult to estimate, but it is more than our readers have any idea..."	Colorado Springs Weekly Gazette, July 8, 1882
May 1894	"in the thousands"	Colorado Springs Weekly Gazette June 1, 1894
August 1902	"probably as high as $25,000" Midland Railroad damages put at $12,000	El Paso County Democrat August 9, 1902
June 1921	$100,000 municipal and private property damages; $100,000 in damages to Pikes Peak Cog R.R.	Colorado Springs Evening Telegraph June 6, 1921
May 1947	$100,000 for streets, bridges and roads; $50,000 Red Cross Aid; $1,000 damages to Manitou Electric Company	Colorado Springs Gazette-Telegraph May 12, 1947

The Colorado Springs Gazette-Telegraph of May 11, 1947 describes the flood as follows: "Water from Waldo Canon cut U.S. Highway 24 when the culvert could not carry the flood flow and overtopped the road...a wave of water descended from Ute Pass carrying away a number of small wooden bridges...water overflowed Fountain Creek and was flowing curb high along Manitou Avenue...cottage camps on low ground along Fountain Creek in east Manitou Springs and west Colorado Springs were flooded...the small bridges washed out in Manitou Springs were carried downstream where they piled up before a bridge forming a dam...the dam of bridges broke away sending the debris downstream to the next obstruction...bridges on 21st and 30th Streets washed out and the 8th Street Bridge in a precarious condition...many motorists evacuated...gas mains broke...water and electrical services interrupted."

The Colorado Springs Free Press of May 12, 1947 stated that "Mayfair Bridge was destroyed...Cottonwood Camp and Greenwich Village Court as well as other campgrounds bordering the stream received damage to grounds and surroundings...One person drowned when she stepped into an uncovered manhole along Canon Avenue near the Cliff House and was carried away...the amount of water flowing down the street made it impossible to see where the water pressure had lifted the cover off...Flow from Williams Canon continued to flow down Canon Avenue until late on May 11."

Flood of August 4, 1964

This flood was caused by a localized thunderstorm which was centered over the downtown Manitou Springs area. The storm started about 3 P.M. and lasted about 3 hours.

The Colorado Springs Gazette-Telegraph described how shops in the Arcade and downtown Manitou Springs were flooded...Iron Springs Chateau flooded as water rushed down Ruxton Creek.

The Colorado Springs Free Press reported that "tourists and children that had taken shelter in the Arcade from heavy rain and hail were forced to stand on the platform along the outside of the structure as gutters overflowed sending water inside...the bar at the Cliff House has from 3 to 4 feet of water...car seen floating down Canon Avenue...Campers at Pikes Peak Trailer Court were taken by surprise and had to swim for their lives."

The flow rate measured at the gaging station east of Manitou Springs indicated that this flood was approximately an 8 year flood as outlined in the Flood Insurance Study (Federal Emergency Management Agency, 1983a).

Figure 7. Flood elevations along Fountain Creek adjacent to Lover's Lane Bridge.

Figure 8. Flood elevations along Ruxton Creek just below the Iron Springs Chateau.

II. MANITOU SPRINGS - CURRENT STATUS

A. The Flash Flood Threat

Land use in Manitou Springs is constrained by geography. The town is located along the channels of Fountain, Ruxton, Waldo, Beckers Lane, Williams, and Sutherland Creeks. Much of the remainder of the town is located on steep slopes above the floodplain. There is very little land available for development that does not face flood or slope stability hazards. Consequently, downtown Manitou Springs is built along the creeks, and the floodplain is nearly fully developed. Shops, hotels, homes, and restaurants sit astride or are built partially in the floodway.

B. Floodplain Management

In August 1983, the City of Manitou Springs adopted a floodplain management ordinance, number 0184, in compliance with National Flood Insurance Program regulations. This ordinance establishes a two-district (flood-way and flood fringe) approach. New construction and substantial improvements to existing structures are severely restricted in the floodway but may be allowed in the flood fringe, provided the construction takes place so as to limit damages from the base flood. (A copy of the ordinance is attached as Appendix E.)

1. National Flood Insurance Program

Manitou Springs entered the emergency phase of the National Flood Insurance Program in 1975. The Federal Emergency Management Agency released its report entitled Flood Insurance Study: Manitou Springs in 1983 and Manitou Springs entered the regular phase of the program in 1984. As of May, 1985, there are 32 flood insurance policies in force in Manitou Springs.

2. Warning System

The current flash flood warning system along Fountain Creek was installed in April 1975. The equipment from the National Weather Service is located at Cascade, Colorado and consists of a stream level monitoring device, transmission equipment and receiving devices located within the Manitou Springs Police Department. An alarm is sounded in the station whenever the level of the stream rises above a designated height. It is estimated that 15 minutes of warning time would be provided before the high level of water reached Manitou Springs.

The National Oceanic and Atmospheric Administration of the U.S. Department of Commerce keeps a round-the-clock surveillance on the nation's rivers and issues warnings when there is a threat of flooding. The National Weather Service Forecast Centers provide flood forecasts for the major river systems and flash flood guidance for the smaller streams and headwater regions. Flash flood watches are issued by these Centers and flash flood warnings are issued by National Weather Service Offices that have local and county warning responsibility.

Upon issuance of flash flood watches and warnings, the director of the El Paso County office of Disaster Emergency Services can direct designated individuals to take up positions along Fountain Creek and use staff gages to measure stream levels. The positions for the staff gages are along Ruxton Creek and Fountain Creek within the immediate Manitou Springs area (see Table 7 and Figure 9).

TABLE 7

STREAM GAGING STATIONS IN THE MANITOU SPRINGS AREA

Stream Site	Altitude	Drainage Area	Period of Record	Maximum Discharge
N. Cascade Creek at Cascade	8400 ft	4.28 sq mi	1949-1972	11.5 cfs
S. Cascade Creek at Cascade	8400	3.41	1935-1950	28.2
French Creek near Cascade	7320	9.93	1950-1973	50.5
Ruxton Creek near Halfway	9250	3.96	1949-1972	5.97
Lion Creek near Halfway	9250	2.00	1908-1950	11.6
Sheep Creek near Halfway	9100	.73	1908-1950	12.8
S. Ruxton Creek near Halfway	9390	3.95	1907-1930	
Sutherland Creek at Manitou Springs	6620	4.40	1919-1930	11.5
Fountain Creek near Colorado Springs	6110	102	1958-1985	2630

Source: U.S. Geological Survey, Water Resource Records: 1955, 1964, 1969, 1971-1984.

Figure 9. **CURRENT WARNING SYSTEM**

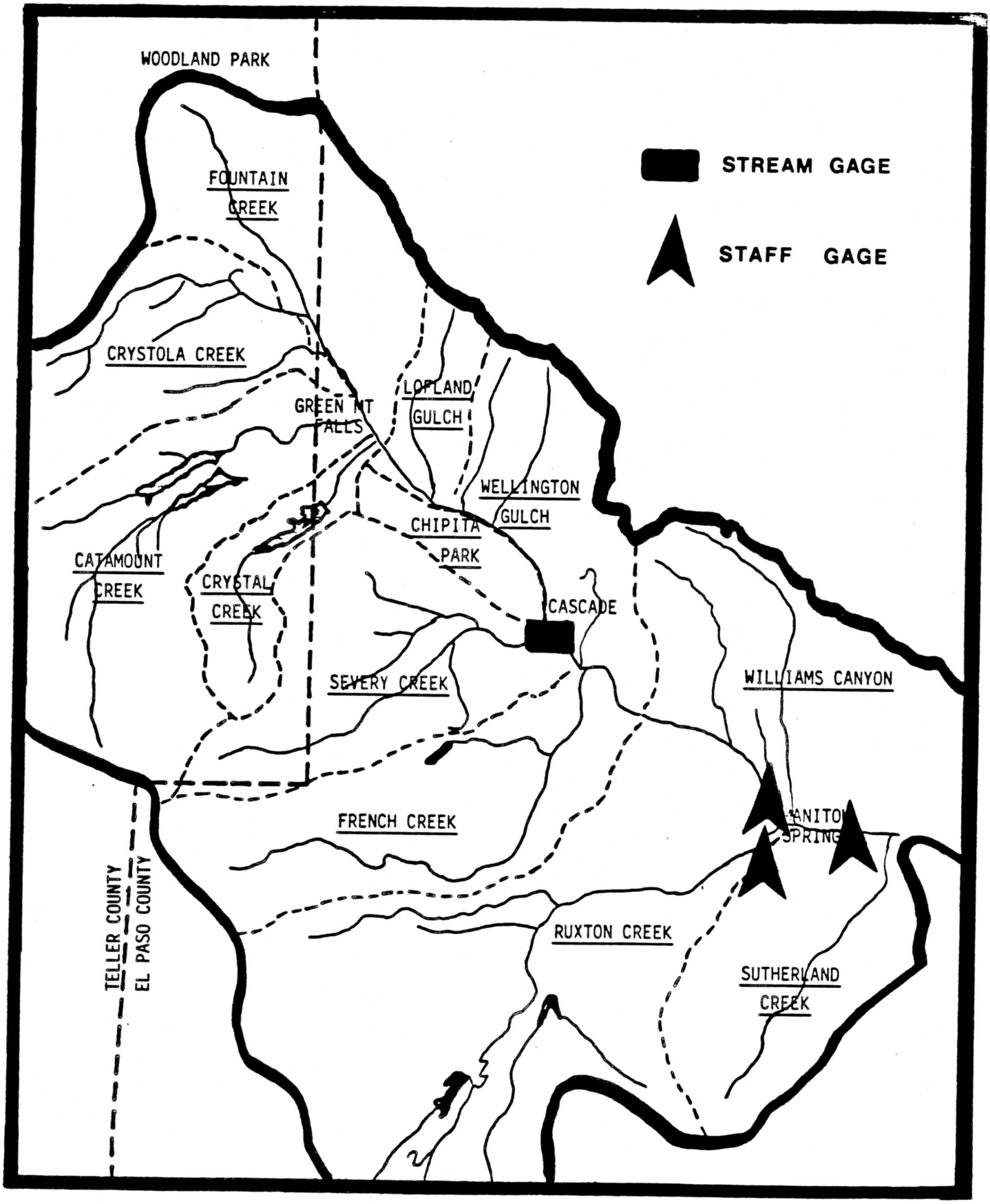


TABLE 8

HIGH HAZARD DAMS ABOVE MANITOU SPRINGS

Dam	State of Repair	Flow At Manitou Springs	Type of Dam	Travel Time To Manitou Springs
North Catamount	Excellent	76460 cfs	Earthfill	34 minutes
South Catamount	Excellent	34000	Earthfill w/steel facing	42
Crystal Creek	Good	17000	Earthfill w/steel facing	44
Big Tooth*	Poor	8920	Earthfill	22
Lake Moraine*	Good	6240	Earth and Rockfill	33
Manitou	Good	10270	Earthfill	30

* Currently undergoing repair with reservoir drained

Source: Colorado State Engineer Dam Inspection Reports: 1983.

The high hazard dams located above Manitou Springs (Table 8) are the responsibility of the owners. Colorado Springs owns five of the dams above Manitou Springs and Manitou Springs owns one. Caretakers trained by the State Engineer's office watch for unusual erosion or seepage problems that could indicate weakening of the dam's structure. The reservoirs serve as water storage for the cities of Colorado Springs and Manitou Springs and normally are filled to capacity by the end of the summer. Effects of flooding can be offset only if the reservoirs are large enough to contain the runoff. The caretakers follow an established set of procedures based on conditions listed below:

Condition A - Severe upstream flooding results from an isolated thunderstorm, rain or snow. One or more of the dams in the drainage below will be threatened by the flood.

1. Make immediate inspection and establish communications.
2. Notify appropriate personnel (water systems operations).
3. Open gated spillways and outlet pipes.
4. Move in and use equipment to lower reservoir level or raise damcrest if required.
5 Maintain on site observation and communication until danger passes or situation becomes Condition C or D.

Condition B - Dam is partially or totally failing when condition is discovered; failure of dam cannot be prevented. (Overtopping, sudden increase in seepage, serious earthquake damage, large downstream slope slides, serious piping).

1. Make immediate inspection and establish communication.
2. Notify authorities: Disaster Emergency Services
   El Paso County Sheriff
   Colorado State Highway Patrol
   Green Mountain Police Department
   Manitou Springs Police Department
   Colorado Springs Police Department
3. Advise radio, television and press media.
4. Warn downstream residents.
5. Evacuate and rescue.
6. Take action on upstream and downstream dams and control structures.
7. Advise regional office (Colorado State Engineer-Denver, Colorado Water Division Engineer-Pueblo).

Condition C - Dam shows signs of rapidly developing failure such as piping, seepage with turbidity, very much reduced freeboard, serious erosion downstream, and slope slides. Time may be available for action to save the dam, such as reducing the reservoir level by opening outlets and gated spillways, lowering spillway crest, using pumps or siphons, sandbagging crest, and blanketing seepage areas.

1. Make immediate inspection and establish communications.
2. Notify authorities: Disaster Emergency Services
   El Paso County Sheriff
   Colorado State Highway Patrol
   Green Mountain Police Department
   Manitou Springs Police Department
   Colorado Springs Police Department
3. Advise radio, television and press media.
4. Warn downstream residents.
5. Evacuate and rescue.
6. Take action on upstream and downstream dams and control structures.
7. Advise regional office. (Colorado State Engineer-Denver, Colorado Water Division Engineer-Pueblo)

Condition D - Dam shows evidence of a slowly developing failure (slow increase in volume of seepage and turbidity, appearance of sand boils, slope cracking, transverse cracks in embankment crest). Time should be available to lower reservoir level and get equipment to site for further action.

1. Make immediate inspection and establish communications.
2. Advise regional office. (Colorado State Engineer-Denver, Colorado Water Division Engineer-Pueblo)
3. Take action on dam and upstream and downstream control structures.
4. Advise authorities, media and others as situation warrants.

3. Floodproofing

Currently, the most effective type of floodproofing evident in Manitou Springs is that of elevation out of the floodplain. The elevation and setback measures were incorporated into the design of historic structures

due to their popularity around the turn of the century, when most of the structures were built. Also, these structures are on hillslopes and retaining walls are required to stabilize the slope and provide a level area on which to build. Many more recent developments have adopted these measures in order to blend favorably with existing architectural styles. Most of these buildings are residential, although several motels and businesses have been constructed in the same manner.

Additionally, there are efforts to floodproof buildings which currently exist in the floodplain. Two particular examples are mentioned here. Renovation and remodeling efforts were completed in April, 1985 at the Promenade, a shopping mall located at 735 Manitou Avenue. The front 25% of the mall is located in the floodfringe, with a 100 year flood level of three feet. Aluminum flood shields are stored on the property to be positioned over doors and tempered glass display windows in the event of a flash flood warning. Also, an effort was made to seal the existing stucco walls as well as the space between the walls and sidewalk (Garrison, 1985).

Restoration is underway at the Loop, an historic building at the intersection of Manitou Avenue and Ruxton Avenue. The 100 year flood level at this location is eight feet. In keeping with the building's original character, stucco bulkheads with concrete footings that have been wrapped in plastic below ground level have been installed where patio doors formerly existed. These new bulkheads were engineered to withstand the force of eight feet of water. Doors and windows in the northwest wall of the structure have been sealed, and construction of a new wall in the interior of the building to supplement that which currently exists is in progress. The city of Manitou Springs has additionally required flood shields for windows and doors in conjunction with new, solidly built door jams and bar latches. As of early May, 1985, $20,000 of the rehabilitation costs were attributed to floodproofing measures (Garrison, 1985).

4. Public Education

At the present time there are no special public education or community awareness programs being offered in Manitou. The local newspaper runs occasional articles on the flood hazards facing the city. In 1985 a series reporting on this Flood Hazard Contingency Planning project received a good deal of positive attention and the prospects for implementation are promising. A chronology of the project and local newspaper articles pertaining to the effort can be found as Appendix H of this report.

5. Structural Control

The following structural control measures were presented by the U.S. Army Corps of Engineers as possible flood hazard adjustments for the Manitou Springs area, but are not cost effective.

a. Diversion Tunnel. A concrete-lined tunnel to divert flows from the Fountain Creek watershed above Manitou Springs around the community and discharge them back into Fountain Creek near Black Canyon has been proposed. This diversion tunnel would be fifteen feet in diameter and have a length of approximately 8700 feet. It would tunnel through the mountain sides just north of the community. A small embankment would divert all

flows exceeding the 1300 cfs capacity of the Fountain Creek channel into the diversion tunnel. This water would then be released into a stilling basin in order to dissipate energy before reentering the Fountain Creek channel. Capacity of the diversion tunnel would be 7800 cfs, which is equivalent to a fifty year flow. Total costs for this solution are estimated at over $17,000,000. A larger diversion tunnel capable of carrying a higher frequency flood would naturally have a higher cost associated with it. Any further consideration of this alternative would require a detailed floodplain analysis to determine the impact of this solution on residents along Black Canyon.

b. Large Detention Structure. The valley through which Fountain Creek flows just above Manitou Springs is very steep and narrow, making it difficult to obtain much storage for any possible detention structure. Any structure over 30 to 40 feet high would require the relocation of U.S. Highway 24. This would also be difficult due to the narrow valley and the large road cuts that would be necessary. For this reason, possible locations of detention structures were investigated farther upstream. One possible site is about one mile upstream of the community of Crystola. Contributing drainage area above this location is 4.2 square miles. The maximum possible height of any structure without affecting U.S. Highway 24 at this location is approximately forty feet. This would result in a storage capacity of 250 acre-feet, less than a ten year volume. There is also a second possible site about 3,000 feet below Crystola with a contributing drainage area of 5.2 square miles. This location would allow a maximum height of 80 feet before affecting U.S. Highway 24. Capacity would be 500 acre-feet which is about the 25 year volume. Even if both detention dams could be built, they would not provide adequate protection for Manitou Springs. No other adequate sites were found for a large detention structure which did not require major relocations.

A Corps of Engineers report entitled "Arkansas River Above John Martin Dam Survey Report" written in 1968 had previously examined the feasibility of constructing a dam on Fountain Creek two miles west of Manitou Springs. This report also found that the costs associated with relocating U.S. Highway 24 made such a project too costly.

c. Channelization Project. Channelizing Fountain Creek through Manitou Springs was considered. Construction costs would be high because a concrete-lined, high velocity channel would be required to handle the design flow of 40,000 cfs (SPF). Channel projects allowing for protection from the 56 year flow (10,000 cfs) and the 17 year flow (5000 cfs) were also studied. Problems with these alternatives are mainly associated with obtaining rights-of-way through the heavily developed downtown area of Manitou Springs. Alterations to buildings and relocating bridges were other areas of concern. The estimated cost of the SPF project was $32,000,000 (1967 cost) while the 56 year and 17 year projects have an estimated cost of $10,500,000 and $9,000,000 (October 1984 cost), respectively.

d. Small Dams. Small dams were examined as possible methods of controlling the flood flows from Ruxton and Sutherland Creeks as well as Williams and Waldo Canons. The investigation showed that because of the steep slopes of the terrain the number of dams needed would be extremely high in order to store the necessary volume of water (100 year flow). This would cause the construction costs to be high as well.

Investigations into utilizing a multi-dam approach showed that it would take more than 115 small dams (20 feet high) with an estimated cost of $50,000 each to protect Manitou Springs from the total amount of 100 year rainfall. This alternative would not protect Manitou Springs from the flow from the upper Fountain Creek Watershed.

Information on structural alternatives investigated by the Corps of Engineers is from the Status Report on the Upper Fountain Creek Watershed Reconaissance Study and excerpts from the unpublished final report on the Reconaissance Study.

C. Historic Preservation and the Floodplain

The historic nature of Manitou Springs contributes a great deal to the unique character of the area. The historic district, which encompasses approximately three-fourths of the city, attracts tourists interested in tradition and history and exhibits characteristics which generate Manitou Springs' charming character and perpetuates a spirit of community.

Manitou Springs' multiple resource district is composed of three areas: Crystal Valley Cemetery, the Keithley log cabin district, and the main district. The main district is composed of 1,001 buildings, 85% of which contribute to its historic nature (Miller, 1985). Of these approximately 850 contributing buildings, over 150 are located in the floodplain. (A map of the Manitou Springs multiple resource area is available at the city planning office in City Hall for public inspection.)

Generally, there are three pre-flood options for dealing with structures which currently exist in the floodplain. The first of these, relocation, is not recommended when dealing with historic buildings. U.S. Department of the Interior's Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings states, "Removing or relocating historic buildings or landscape features, thus destroying the historic relationship between buildings, landscape features, and open space" is not recommended. Additionally, the "relationship between historic building(s) and landscape features -- or the building site -- helps to define the historic character and should be considered an integral part of overall planning and rehabilitation work" (U.S. Department of the Interior, 1983).

The second option is to leave the building alone, relying on such non-structural measures as flood insurance. However, this is only a short term solution since flooding will occur sometime in the future, and its occurrence can result in damages that can jeopardize an historic property's designation. If the damage is significant enough, the property can lose its designation as an historic structure. Therefore, it may be preferable to choose the third option.

The third option is structural floodproofing. Here again, an historic structure's designation may be jeopardized if visible changes made to resist flooding are too significant. Therefore, any proposed floodproofing design needs to be coordinated with representatives of the national and state historic registries to protect the property's historic designation.

Provisions have been made in the National Flood Insurance Program which recognize the historic character of an area and allow for variances to be issued by a community for the "reconstruction, rehabilitation or restoration of structures listed on the National Register of Historic Places or a State Inventory of Historic Places, without regard to the procedures set forth..." (Federal Emergency Management Agency, 1984b). This provides that a building listed on the National Register or State Inventory which is damaged in a flood may be rebuilt in the same location regardless of the degree of damage and whether or not the property is located in either the floodway or floodfringe. Whether listed individually or as contributing to an historic district, buildings on the National Register of Historic Places have the same status (Abele, 1985) and would all be subject to the variance discussed above. However, if a structure receives damage to an extent greater than 50% and is consequently rebuilt, its historic character may be questioned. The Advisory Council on Historic Preservation would then have to determine on an individual basis whether the property and structure should be retained on the National Register.

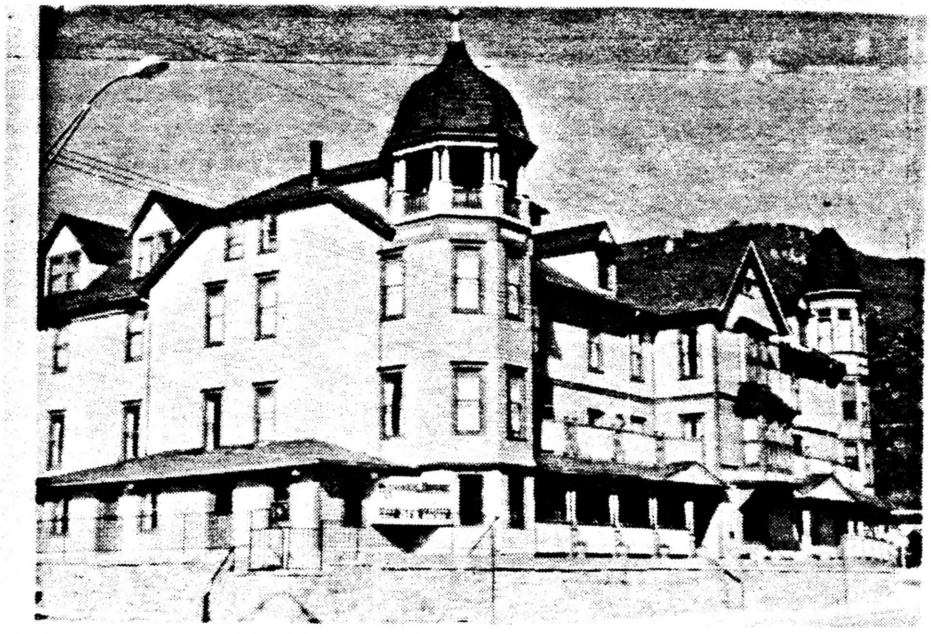


Figure 10. Barker House (formerly the Navajo Hotel) along Manitou Avenue showing the Elevated Entries and Protective Floodwall.

D. Damage Estimates

Determining damages for a given magnitude of flooding involves examining damages from historic floods, use of depth-damage curves, inventories of capital investment, and property value appraisals. The U.S. Army Corps of Engineers conducted field surveys during October, 1983, as part of its Reconaissance Study for the Upper Fountain Creek Watershed north of Pueblo. Information from this survey is contained in Tables 9, 10, and 11. Total annual average damages for the Manitou Springs area are currently estimated at $1,615,700.

TABLE 9

NUMBER OF DAMAGEABLE BUILDINGS

	500 year	100 year	50 year	25 year
Right Bank				
Residential	8	8	8	6
Commercial	78	71	47	44
Public	7	7	5	5
TOTAL	93	85	60	55
Left Bank				
Residential	42	36	22	10
Commercial	43	41	40	33
Public	2	2	2	2
TOTAL	87	79	64	45
Both Banks				
Residential	50	44	30	16
Commercial	121	112	87	77
Public	9	9	7	7
	180	164	124	100

Source: Unpublished Preliminary Report on Fountain Creek Watershed North of Pueblo, Colorado, Reconaissance Study by U.S. Army Corps of Engineers, Albuquerque District, April, 1985.

TABLE 10

VALUE OF DAMAGEABLE PROPERTY IN THE 500 YEAR FLOODPLAIN
(Figures in Thousands of Dollars)

	Right Bank	Left Bank	Both Banks
Residential	$ 690	$ 5,707	$ 6,397
Commercial	24,910	30,980	55,890
Public	3,400	2,850	6,250
Streets and Utilities	4,320	2,580	6,900
TOTAL	$ 33,320	$ 42,117	$ 75,437

Source: U.S. Army Corps of Engineers: Reconaissance Study Preliminary Report: 1985. Uses October 1984 prices at 8 and 3/8% interest.

TABLE 11

SINGLE OCCURRENCE DAMAGES
(Figures in Thousands of Dollars)

	500 year	100 year	50 year	25 year
Residential	$ 4,465	$ 3,323	$ 697	$ 339
Commercial	39,670	25,596	17,781	9,292
Public	4,817	3,591	2,918	2,069
Streets and Utilities	2,760	2,070	1,380	1,035
TOTAL	$ 51,712	$ 34,580	$ 22,776	$ 12,735

Source: U.S. Army Corps of Engineers: Reconaissance Study Preliminary Report, April, 1985.

TABLE 12

AVERAGE ANNUAL DAMAGES
(Figures in Thousands of Dollars)

	Right Bank	Left Bank	Both Banks
Residential	$ 18.3	$ 66.8	$ 85.1
Commercial	625.0	629.8	1254.8
Public	126.3	108.5	234.8
Streets and Utilities	25.7	15.3	41.0
TOTAL	$ 795.3	$ 820.4	$ 1615.7

Source: U.S. Army Corps of Engineers: Reconnaissance Study Preliminary Report, April, 1985.

The population-at-risk is broken down into resident, visitor and worker categories in Table 13. Note the fluctuation in number of people during the course of the day.

TABLE 13

RESIDENT, VISITOR AND WORKER ESTIMATES

Location	Visitors			Workers		
	2:00 PM	5:00 PM	11:00 PM	2:00 PM	5:00 PM	11:00 PM
Motels	120	240	420	30	20	10
Campgrounds	360	600	1200	15	15	10
Retail	500	200	0	200	200	0
Services	50	30	0	75	75	0
Parks	50	35	10	4	4	0
Driving Through	200	150	50	2	1	1
Municipal Bldg	10	5	0	20	8	4
Restaurants	200	400	100	50	75	25
Residents	80	350	400	0	0	0
TOTAL	1570	1970	2280	396	391	50

Source: 1980 census figures, visual surveys and estimated vacancy totals.

E. SCENARIO - THE ONE HUNDRED YEAR FLOOD

Scenarios are effective devices for increasing awareness and educating decision-makers of the possible consequences of a disaster. They should not be viewed as forecasts of the future. This scenario will assist decision-makers in developing a flood mitigation plan for Manitou Springs.

Public awareness and public education are needed in order for the residents of Manitou Springs to have a realistic perception of the hazards which face them. Local authorities should implement a modest education program concerning the flash flood potential.

The scenario has three interrelated objectives: first, to simulate the magnitude, characteristics, and distribution of human casualties, structural damage, and disruption of social systems likely to occur in Manitou Springs during a 100-year flash flood at its current level of preparedness; second, to show the capacity of existing emergency procedures for reducing the flood's impact; and third, to give examples of possible flood mitigation techniques that would heighten awareness, reduce stress, and reduce damage potential (Erickson: 1975, p.75).

The loss of life and property from floods has become the number one natural hazard nationwide in recent years. In Colorado alone 275 communities are subject to flooding. This represents approximately 150,000 people now living in Colorado's floodplains.

It has been nearly twenty years since a devastating flood has been witnessed in the Pikes Peak Region. We can not predict whether the next flash flood will strike today, this year, or years from now - we only know that it will, in fact, occur.

The day of the scenario is typical for the Colorado Front Range. The weather forecast calls for a chance of afternoon thunderstorms. An accumulation of thunderheads over Manitou Springs and the entire Pikes Peak Region is not sufficient cause for alarm to the residents and tourists of Manitou Springs on this warm, summer afternoon.

At 3:30 p.m., the sky has blackened and rain is beginning to fall in the mountains.

By 4:30 p.m., the storm has unleashed its full fury over the Fountain and Ruxton Creek drainage basins. The heavy rain causes many picnickers and campers in higher elevations to seek shelter or head for home.

Only light rain is falling in the lower elevations causing little concern.

By 4:45 p.m., the National Weather Service issues a general flash flood watch for El Paso County. The watch is transmitted by local radio and television stations about fifteen minutes later:

"The National Weather Service has issued a flash flood watch for valleys and low-lying areas of El Paso County until 7:00 pm."

Motorists travelling on Ute Pass are having difficulty keeping control of their vehicles during the steady downpour. One car is washed off the highway.

By 5:00 pm, the thunderstorm has intensified and shows no sign of moving out of the area. The town of Cascade reports three inches of rain in the last half-hour. Flooding is beginning to occur on the east side of Manitou Springs.

At 5:25 p.m., the National Weather Service sends out a flash flood warning:

> "The National Weather Service has issued a flash flood warning effective until 10:00 p.m. for persons in Teller, El Paso, and Freemont Counties in Colorado. Heavy rain was indicated by radar to be moving into these counties at 5:10 p.m. Woodland Park in Teller County reported two inches in thirty minutes."

The police department sends two patrol cars out to warn people to the south of Fountain Creek of the threatening flood. No officers are sent to the opposite side of the creek because of the life threatening situation that prevails (H. Greenman, 1985).

The sky over Manitou Springs has become incredibly black, interrupted only by sudden flashes of lightening. The intense rainfall is causing numerous rock and mud slides along the canyon walls and highway, trapping those people trying to escape by car. Flooding has already cut off the upper junction of Highway 24 and Manitou Avenue. Several cars are floating along the roads in low-lying areas.

Many residents and business owners, however, discount the warning, feeling secure within their own walls, and instill this false sense of security to their guests and customers.

One resident of the Fountain Creek Adult Apartments--which borders the north bank of Fountain Creek--seems unconcerned:

> "I've lived in this apartment for four years and have never seen that water rise more than two feet. It's (the creek) not a threat to my property."

By 5:45 p.m., all residents of the Fountain Creek Apartments must be evacuated to the Manitou Springs High School.

The first crashing wave of flood water hit Manitou Springs at the upper reach of Ruxton Creek. Because the channel is lined with concrete in its upper stretch, its flow is restricted and its velocity is increased.

The portion of the channel that flows beneath the Iron Springs Chateau Melodrama is unable to retain the flow, sending a six foot surge of water through the main dining room.

> "We could hear the rushing water but were advised to not drive out. All of a sudden the wall gave way and the river went right through the dining room; people and tables were thrown into a heap on the other side; There was nothing we could do to help them."

Seventeen lives are lost.

Power shortages become numerous as lines are torn down.

Numerous bridges cause damming with sudden surges of water as they eventually give way. Cars, animals and other debris fill the advancing waters.

A crashing wall of water hits the western reach of Fountain Creek just upstream from town. Three motels are inundated as Fountain Creek rushes beneath and through their structures. Some tenants escape by climbing the hill behind the motels. Nineteen others are swept to their deaths.

By 6:00 p.m., an official evacuation program has begun. Because the city has no pre-planned routes to safety the project is chaotic and inefficient. Colorado Springs' officials are having difficulty entering Manitou Springs due to the severe flooding. Flood water in the overbanks is exceeding ten feet in depth and flow velocities are now exceeding fifteen feet per second.

Confusion over warnings and evacuation procedures are overloading the few telephone lines not down. Some people are still unaware of the flood's speed and strength, spending a fatal length of time collecting valuables and pets.

> "I was taking pictues for the local paper when I noticed a woman with one arm wrapped around a post and the other around her dog. She was lucky she was so near the bank or I could never have pulled her out. The strength of the stream was overwhelming."

A mother and her three children try to escape from their drifting car when a giant wave sweeps the car and the three children away. All three children are killed. (Gazette Telegraph, 7/25/65).

In most areas the creek is cresting at least nine feet above the stream bank (U.S. Army Corps of Engineers, 1984a). Side canyons and tributaries are flooding--the powerful water is destroying cars, bridges, homes and any other obstacle that gets in its path.

Older structures located along and over Fountain Creek suffer the most damage as the flood reaches its peak. The numerous businesses and tourist shops that lie parallel to the creek and to Manitou Avenue are demolished as the creek roars past engulfing them. Video and pinball machines from Arcade Amusements are left in a chaotic mass of debris, leaving the proposed Manitou Mall area devastated.

The historic Episcopal church is inundated and all its contents virtually destroyed beyond repair.

The Manitou Springs fire and police departments face further difficulties as a crushing force of water knocks down the support beams for City Hall, causing the back half of the building to collapse into Fountain Creek. Luckily, the building had been evacuated because of its location on the creek.

Another victim is claimed on Ruxton Avenue as he and his sister try to escape their home.

> "We heard the water and eventually rocks and boulders hitting the side of the house. We saw that the creek and road were now one huge river and tried to get out and climb the bluff behind us. My brother was trapped between the outside wall and a giant wave of water...and then . . . I couldn't even see him anymore" (Gazettte Telegraph, 6/20/65).

Gas and electric lines are destroyed causing power outages and small explosions. Sanitary sewage lines fill with pressure, blowing manhole covers and spewing raw sewage into the floodwaters. The hazard of disease now adds its threat to the city.

Cottages and motels once found along the lowland floodplain are washed out, many dislocated.

The next few days are spent recovering bodies and providing shelter and food to the homeless. Victims are difficult to identify as their bodies were badly mutilated by the river and identification and clothing were stripped off by the powerful flow. Cars were destroyed and washed miles downstream. Mud and debris fill the entire Manitou Springs area.

Ninety-seven people were known to die in Manitou Springs and many others are still missing. Few are injured; there are only survivors or non-survivors. No one drowns in such a disaster but, rather, is killed by the powerful blows of water and debris. Structural damages within the city are in the multi-millions and clean-up costs will further escalate the total (U.S. Army Corps of Engineers, 1985).

IV. RECOMMENDATIONS FOR MANITOU SPRINGS

The recommendations have been divided into six phases. They are listed below. Elaboration on each phase follows the list.

A. Overview

PHASE I: Establish a Steering Committee for Long-Term Implementation of the Plan

Schedule: Initiate Immediately
Duration: Ongoing

A. Coordinate with adjacent communities

B. Investigate funding sources

C. Form an area-wide flood control district

D. Develop a public education program

E. Coordinate with historic registry staff

F. Encourage purchase of flood insurance

G. Oversee regulation of floodplain development (Ordinance 0184)

PHASE II: Survey the Community

Schedule: Month Two
Duration: 30 Days

PHASE III: Identify Mitigation Strategies

Schedule: Month Three
Duration: 30 Days

A. Prepare a warning and evacuation plan

B. Develop a floodproofing program

C. Develop a program for improving passage of flood flows

PHASE IV: Develop Pre-Flood and Post-Flood Mitigation Plans

Schedule: Month Four
Duration: 30 Days

PHASE V: Implement Pre-Flood Mitigation Plan

Schedule: Month Five
Duration: Ongoing

PHASE VI: Implement Post-Flood Mitigation Plan

Schedule: Post-Flood
Duration: Ongoing

The next section describes the recommendations. Addresses and phone numbers of key agencies are provided in the Appendix D.

B. Elaboration of Phases

1. PHASE I: Establish a Long-Term Implementation Committee

Schedule: Immediately
Duration: Ongoing

Manitou Springs should formally establish an intergovernmental, interagency and interdisciplinary committee to assist in the continued development and implementation of its Hazard Mitigation Plan.

A community group and a technical advisory group were established in January, 1985. Community members are listed as Appendix J of this report. These groups are motivated and have already taken initiative aimed at implementing these recommendations. Meetings should be regularly scheduled and guests from the National Flood Insurance Program, the state Historic Registry staff, Urban Drainage and Flood Control District in Denver, and others with relevant expertise should be invited in an advisory capacity.

Recommendation A. Coordinate With Adjacent Communities

The Committee should further pursue the involvement of all communities in the river basin to develop a coordinated plan for mitigating anticipated flash flooding.

The County Civil Defense officer is a logical coordinator of this effort. Mr. McWilliams can provide a forum for discussion. He can invite civil defense officials from Teller County and the neighboring cities to develop a comprehensive response capability and to set the stage for integrated emergency management for floods and possibly other hazards. He can invite the State Department of Emergency Services to conduct drills and exercises to develop a comprehensive approach in the region.

The committee can also request workshops from the Colorado Water Conservation Board, the Federal Emergency Management Agency, and the Pikes Peak Area Council of Governments to foster the regional approach to planning.

Recommendation B. Investigate Funding Sources

The committee should investigate all possible sources for funding the implementation of these recommendations, including Federal and State cost-sharing, joint funding with adjacent communities and other techniques.

TABLE 17

Available Asistance for Program Development

Element	Financial Assistance	Technical Assistance	Useful Information
Problem Analysis	CDBG[4] FEMA COE[2]	ES FEMA NWS1 PHS SCS[1] COE[1] CWCB[1]	ES FEMA[1] NWS1 RC SCS1 COE1 CWCB1 USGS[1]
Warning	CDBG[4] FEMA[3] COE[1]	NWS1 SCS COE1 DODES[1]	NWS1 SCS COE DODES1
Evacuation and Rescue	CDBG[4] FEMA[3]	ES FEMA RC[1] SCS[1] COE[1] DODES	ES FEMA PHS RC1 SCS COE DODES
Damage Reduction	CDBG[4] FEMA[3] SCS[2]	ES PHS SCS COE[1] CWCB[1]	ES RC SCS COE1 CWCB1 USGS
Recovery	CDBG[4] FEMA[3] RC[1] COE[1] SCS[1]	ES FEMA1 PHS RC1 SCS COE[1]	ES FEMA1 PHS RC1 SCS COE
Public	CDBG[4] FEMA[3]	FEMA NWS1 PHS RC SCS COE[1] CWCB DODES	FEMA NWS1 PHS RC SCS COE1 CWCB DODES
Plan Implementation	CDBG[4] FEMA[3]	FEMA1 NWS1 RC SCS COE[1]	FEMA NWS RC SCS COE1
Plan Maintenance	CDBG[4] FEMA[3]	FEMA1 NWS1 SCS	FEMA1 NWS SCS

1 Major Involvement
2 Project Authorization or Congressional Guidance
3 Grants to states
4 Grants

CDBG - Community Development Block Grant Program, HUD
ES - Extension Service, Department of Agriculture
FEMA - Federal Emergency Management Agency
COE - Corps of Engineers
NWS - National Weather Service
PHS - Public Health Service
RC - Red Cross
SCS - Soil Conservation Service
CWCB - Colorado Water Conservation Board
DODES- Division of Disaster Emergency Services

Source: Adopted from the New York State Warning System Study, 1984.

Table 17 shows potential funding sources based upon experiences elsewhere in the United States. The committee can explore each possibility by contacting each agency directly. Manitou Springs will be more effective in the funding quest if the community acts in conjunction with others in the region.

Settle (1985) developed a matrix showing the types of funding sources and programs which are available for emergency management (see Table 18). While not all of the programs shown there may have direct application in Manitou Springs, it is heartening to note the vast array of funding alternatives which have been adopted elsewhere.

TABLE 18

Matrix for Emergency Management Funding

Funding and Financing Alternatives for Local Governments	Mitigation (long-term) Reduce/ Eliminate Disaster	Preparedness (to respond) When Mitigation Cannot Help	Response (to emergency)	Recovery (short- and long-term)
Budget Transfers (temporary loan)	X	X	X	X
Mutual Aid Agreements (state and local)			X	X short-term
Joint Powers Agreements (JPA/JPIA)			X	X
Tax Anticipation Notes (short-term loans)	X	X	X	X
Bonds (municipal, industrial development)	X			X
Insurance Funding and Programs (federal, state, and local)				X
Assessment District	X	X		X
Grant-in-Aid (block and categorical)	X	X		X
Property or Sales Tax Increases	X	X		X
Lease Purchase Agreements	X			X
Tax Increment Financing (redevelopment)	X			X
State or Federal Highway/Gas Tax Funds (depends on state)**	X**	X**		X

(Federal and state disaster aid covered under response and recovery)

Source: Settle, 1985.

Recommendation C. Form a Flood Control District

The committee should encourage adjacent communities to join with Manitou Springs to form an area-wide flood control district. Such a district would promote cost-sharing. Presently, Manitou Springs and neighboring communities are attempting to manage flood problems that have basin-wide origins and impacts needing basin-wide management. A very good example of such a program is the Denver areas' Urban Drainage and Flood Control District (UDFCD) which was created in 1969 by an Act of the Colorado State Legislature. The UDFCD includes all of Denver county and parts of Adams, Arapahoe, Jefferson, Boulder and Douglas Counties, and it acts as a coordinating agency for the collection and dissemination of drainage information, floodplain definition and assistance in qualifying for flood insurance programs.

The District has the power to plan, design, construct, acquire, equip, relocate, maintain and operate drainage facilities and can enact floodplain regulation. It can also make planning and design information available, including maps of the Drainage District that delineate drainage basins and provide physical and hydrological parameters, design rainfall information for runoff analysis, statistical analysis of long-term records and provide other information that becomes available from time to time.

The Colorado Division of Disaster Emergency Services is now coordinating the development of similar drainage and flood control districts on the western slope of Colorado, centered in Grand Junction and in the San Luis Valley. The committee should learn from the experiences elsewhere with successful regional drainage districts.

An Urban Drainage and Flood Control District would also be instrumental in the development of a more sophisticated warning system. The current warning plan for Manitou Springs includes one alarm in place for the Upper Fountain Creek watershed that interfaces with the Manitou Springs Police Department. The City of Colorado Springs is planning to install dam measuring devices that will monitor the condition of the six dams above Manitou Springs and report that information directly to the Water Control Center on Mesa Road. One umbrella organization to receive all data on flood conditions would facilitate more effective decision-making, and an area-wide flood control district would fill this need perfectly. Each community in the District would benefit, and costs could be shared. The development of a formal relationship between Manitou Springs, El Paso County, Teller County, Colorado Springs and the upstream communities of Green Mountain Falls, Chipita Park, Woodland Park and Divide would be extremely beneficial for flood warning, drainage issues and post-flood preparation.

There has been discussion regarding the establishment of a position of floodplain administrator who would oversee construction activities within the floodplain. Such a role would be ideally situated in the proposed district. For further information on the Denver UDFCD contact L. Scott Tucker, Executive Director, or Jack Truby, Colorado Division of Disaster Emergency Services (addresses and phone numbers found in Appendix D).

Recommendation D. Develop a Public Education Program

The committee should work with the local media and public and private groups to heighten awareness of the hazard and actions that can be taken to mitigate its effects.

Community awareness through public education is vital to reduce the flood threat. Public education is a key to saving lives in a flash flood as the short lead time requires quick, positive action. Many tools may be used to increase the level of awareness including the following options: showing the Manitou Springs flash flood scenario (the slide show is available at the public library, the commentary can be found as Appendix I of this report) Signs can be installed identifying the flood threat; evacuation routes can be marked with 100 year flood elevations, and historical high water marks; pamphlets can be prepared and sent to residents and business owners; and, workshops can be held to maintain a high level of preparedness.

Recommendation E. Coordinate with Historic Registry Staff

The committee should contact representatives of both the National and State historic registries in order to identify ways to maintain the historic designations of places within the city while achieving hazard mitigation goals.

Certain questions must be answered before a flood so that post-flood operations run smoothly. These include (1) what types of design alterations are or are not acceptable for protecting buildings and other historic structures from flooding; and, (2) how is the threshold established for determining when damage from fire, flood or other hazard would endanger a structure's historic designation.

The City of Manitou Springs can initiate negotiations with the local business owners, the Colorado Water Conservation Board and the Federal Emergency Management Agency to develop a "Memo of Understanding" which would establish the procedures for reconstruction of historically contributing buildings in the floodway and floodfringe. This document can stipulate post-flood activities for the buildings based on their location and degree of damage and would serve to minimize confusion in the aftermath of a flood and speed the recovery period.

Recommendation F. Encourage Local Property Owners to Purchase Flood Insurance

The Committee should work with the local insurance agents and the Federal Emergency Management Agency staff to encourage the purchase of flood insurance by local property owners.

With Manitou Springs' topography and development pattern, flood damages are inevitable. Flood insurance is one of the most effective means to mitigate these anticipated losses. Yet, only a very small percentage of the city's floodprone properties are currently covered by flood insurance (only 32 policies are in effect as of May, 1985) Flood

insurance under the NFIP is heavily subsidized and therefore available at low rates, e.g., $.50 per $100 of coverage, to a limit of $300,000. Contents coverage is available at $1.00 per $100, to a limit of $200,000. Residential coverage is available at somewhat lower rates and limits.

A flood insurance promotional campaign should be held every Spring with the cooperation of the Federal Emergency Management Agency and local insurance agents. This campaign should be made a part of the city's flash flood education program. The Federal Emergency Management Agency has available brochures, maps and other information that can be used to promote the purchase of flood insurance. In addition, its staff can assist by providing workshops and other presentations to provide insurance agent training and to answer questions on its programs.

Recommendation G. Assist in Regulating Floodplain Development

The Committee should assist the city's floodplain development permit official in the process of implementing Ordinance #0184, Manitou Springs Floodplain Ordinance. A copy of the Ordinance is attached as Appendix E of this report.

The city planning department, economic development group, and city council should take the lead. These groups should take full advantage of the technical assistance available from the Colorado Water Conservation Board and Federal Emergency Management staff. The distinctions between the floodplain and the floodway as specified in the ordinance should be understood and be reflected in policy and permit procedures.

According to the Federal Emergency Management Agency (1983:p. 17), "The floodway includes the channel of a river and the adjacent floodplain that must be reserved in order to discharge the base flood. The Federal Emergency Management Agency requires the community to designate a part of the floodplain as a 'regulatory floodway' to avoid the possibility of significantly increasing upstream flood elevations. This 'regulatory floodway' cannot cause a cumulative increase in the water surface elevation of the base flood of more than one foot at any point. Some state standards specify smaller allowable increases. Within the designated floodway a community must prohibit development that would cause any additional rise in base flood elevations."

In the same Federal Emergency Management Agency publication (p. 13), the flood insurance rate structure is explained. Since Manitou Springs is a 'regular' member of the National Flood Insurance Program, Flood Insurance Rate Maps are available. This regular status enables Manitou Springs residents to purchase increased amounts of flood insurance while new and substantially improved structures in the floodplain are charged actuarial rates--at much higher cost than the subsidized rates.

Committee members are referred to the 1983 FEMA publication Questions and Answers on the National Flood Insurance Program for more specific information.

2. Phase II: Survey Community

Schedule: Month Two
Duration: 30 Days

The committee, with the assistance of Federal and State technical agencies, should perform a survey of the community to provide information necessary to identify mitigation needs and strategies.

Where to Survey:

--Stream channel--Identify channel maintenance needs, points where widening or the alteration would reduce damages, and points where flow breaks out of the channels. The survey should provide the basis for immediate and long-term channel improvements and maintenance.

--Floodplain (especially the floodway)-- Survey the following items:

(a) buildings, residential, nonresidential, and especially historic;

(b) streets, bridges, culverts, water, sewer and other utility lines and facilities; and,

(c) critical facilities, especially public buildings, water and power plants, emergency and health facilities, hazardous materials sites, and gas stations.

--Floodplain and adjacent areas -- This serves to identify the anticipated path of flood waters. Also the survey helps planners by identifying building types, uses, contents, occupancy patterns, extent of potential flood damages, effects on flood flows, and mitigation opportunities including floodproofing and relocation.

--Entire community-- This can serve as the basis for identifying potential locations for siting or relocating pre-and post-flood development, especially critical facilities and for preparing warning and evacuation plans and procedures. Perhaps most importantly, this survey will identify all undeveloped areas to which proposed development can be directed or to which post-disaster reconstruction can be re-sited. The city should emphasize the placement of critical facilities such as public offices and emergency service facilities to these open areas.

Identify the following items:

(a) vacant lots and other potential development sites. One-half of this survey has been completed. It is attached as Appendix F;

(b) population concentrations at various times of day;

(c) evacuation routes and impediments to rapid egress; and

(d) residences and work places of elderly and handicapped.

In connection with the community survey, Manitou Springs should do the following:

(a) develop site-specific mitigation designs for selected floodplain properties e.g., those with high loss potential or which increase the hazard;

(b) determine the economic feasibility of pre-flood implementation of these designs;

(c) coordinate designs for historic structures with representatives of the national and state historic registries;

(d) implement those designs that are feasible in the pre-flood period; and,

(e) for structures or areas where floodproofing proves economically infeasible or unrealistic, develop a plan to:

1. direct the post-flood reconstruction of destroyed or severely damaged structures to flood-free areas; and

2. design the post-flood reconstruction of remaining structures to protect them from future flooding.

3. PHASE III: Identify Mitigation Strategies

Schedule: Month Three
Duration: 30 Days

Based on the Phase II survey results, and with the assistance of the Federal and State technical agencies, the committee should identify mitigation strategies for the protection of lives and property.

Recommendation A: Prepare a Warning and Evacuation Plan

The committee, with the assistance of Federal and State technical agencies, should prepare a warning and evacuation plan for the city. The following six major issues in warning and evacuation planning should be covered:

(a) operational aspects -- set up an EOC in a safe location, upgrade the existing warning system, and address warning dissemination, evacuation routing and traffic control;

(b) staffing -- identify full-time, part-time and volunteer staff and their responsibilities, and assign back-ups;

(c) maintenance -- procedures to keep the plans, facilities and equipment operating;

(d) funding -- initial and incremental funding, including upgrading on a yearly basis and cost-sharing;

(e) training -- program to train staff, and exercises involving the public; and,

(f) coordination with adjacent communities -- integration of the city's warning and evacuation procedures into those of adjacent communities.

Given the large number of people exposed to the threat of flooding in Manitou Springs (see Table 13) and the limited amount of lead time, it is apparent that a warning system with the capability to evaluate real-time data and rapidly disseminate warning instructions is needed in order to mitigate the impact from a flash flood.

Types of warning systems range greatly, from a very inexpensive cooperative effort of volunteers who watch the weather and height of water in the stream channel to multi-million dollar satellite packages. Recommended for immediate implementation in Manitou Springs are the organization of a network of volunteers in the Ute Pass area to keep statistics on weather patterns and stream flows and a modest upgrading of the existing system of stream gages.

The following discussion of warning systems explains the methodology of how they work, and leads to a better understanding of why these systems can be of great benefit to a community. Elaborate warning systems are recommended as a long term flood hazard mitigation strategy for Manitou Springs as its capability to fund them expands.

Design of an effective flash flood warning system includes the collection of real-time data, evaluation of real-time data and dissemination of the warning.

Collection of Real-Time Data

The design of a collection system for real-time data could include the following:

(a) automatic system of telemetry stream and rain gages;
(b) volunteer weather observers to provide ground truthing;
(c) weather radar; and,
(d) automatic reservoir monitoring devices.

Stream and rain gages - stream gages that transmit stream level changes and tipping rain gages that transmit each tip automatically to the evaluation center are essential for real-time data collection. A location map of proposed stream and rain gaging sites is shown in Figure 13.

Observers - To provide ground confirmation of weather and stream conditions, it is necessary to recruit volunteer observers throughout the drainage area. Stream observers would report flow depths from staff gages placed in various locations and any unusual erosion or debris buildup. Rain observers would be provided with plastic rain gages and would report rainfall data to the evaluation center. Certain individuals could be provided with radio equipment to provide a backup communication link in case of telephone line disruption.

Weather Radar - Information from radar is provided by the National Weather Service operating from Limon, Colorado. This input would be received at the evaluation center where severe thunderstorm activity can be tracked continuously. When it becomes available, the evaluation center could augment its radar interpretation equipment with the Program for Regional Observing and Forecasting Services (PROFS) to insure the most capable method of following storms which may lead to flooding. The city, along with other local government entities, could lobby for locating the new PROFS system in Colorado Springs. See Appendix K for further description of the PROFS program. Current plans are for Denver and Pueblo to receive the system, but not Colorado Springs.

Automatic Reservoir Monitoring Devices - The high hazard dams above Manitou Springs pose a special problem and must be closely monitored to insure safety. The City of Colorado Springs is currently planning on installing automatic reservoir level and flow measuring devices for all city-owned dams. The system will be capable of satellite transmission to the Department of Utilities' Water Division Control Center for real-time data collection. This information could also be directed to the evaluation center when established.

Evaluation of Real-Time Data

The data collected must be analyzed quickly in order for an effective warning to be issued. To accomplish this task a micro-computer coupled with an established decision procedure must be available.

Micro-computer - Provides for the automatic collection, verification, storage and display of all iincoming telemetry data. Accompanying software will allow rainfall data to be interpreted and provide method of forecasting peak flows for the basin.

Decision Procedure - Allows personnel other than qualified hydrologists to be able to interpret real-time data and make necessary decisions. Manuals could relate stream levels or rainfall data to flood forecast and include necessary actions to follow when these conditions are met.

Current analysis of weather radar is provided by the National Weather Service offices in Colorado Springs and Denver. The evaluation center could also include the services of a private meteorologist who could concentrate the analysis of radar information for the impacted area instead of interpreting data for a large area (Front Range to Eastern Plains).

Dissemination of the Warning

The dissemination of flood warnings to the public is the responsibility of local police and disaster emergency services personnel. Warnings and evacuation orders can be disseminated by police and fire vehicles using public address systems, NOAA weather radio, emergency broadcast system and emergency sirens. Upgrading emergency siren capability to include voice transmission would allow for a more effective means of disseminating flood warnings, especially to tourists who would be unfamiliar with safety actions.

The warning system for Fountain Creek could have a capability for automatic sensing of rain and stream information and real-time processing of the data for timely response. The system could include six dam reservoir level and flow monitors, twelve automatic rain reporting devices and eight stream level reporting devices. The dam monitors would utilize satellite transmission while the rain and stream units would transmit by radio. Locations for the monitoring devices are shown in Figure 13. The costs for the warning system components are shown in Table 19.

TABLE 19

COSTS OF RECOMMENDED WARNING SYSTEM

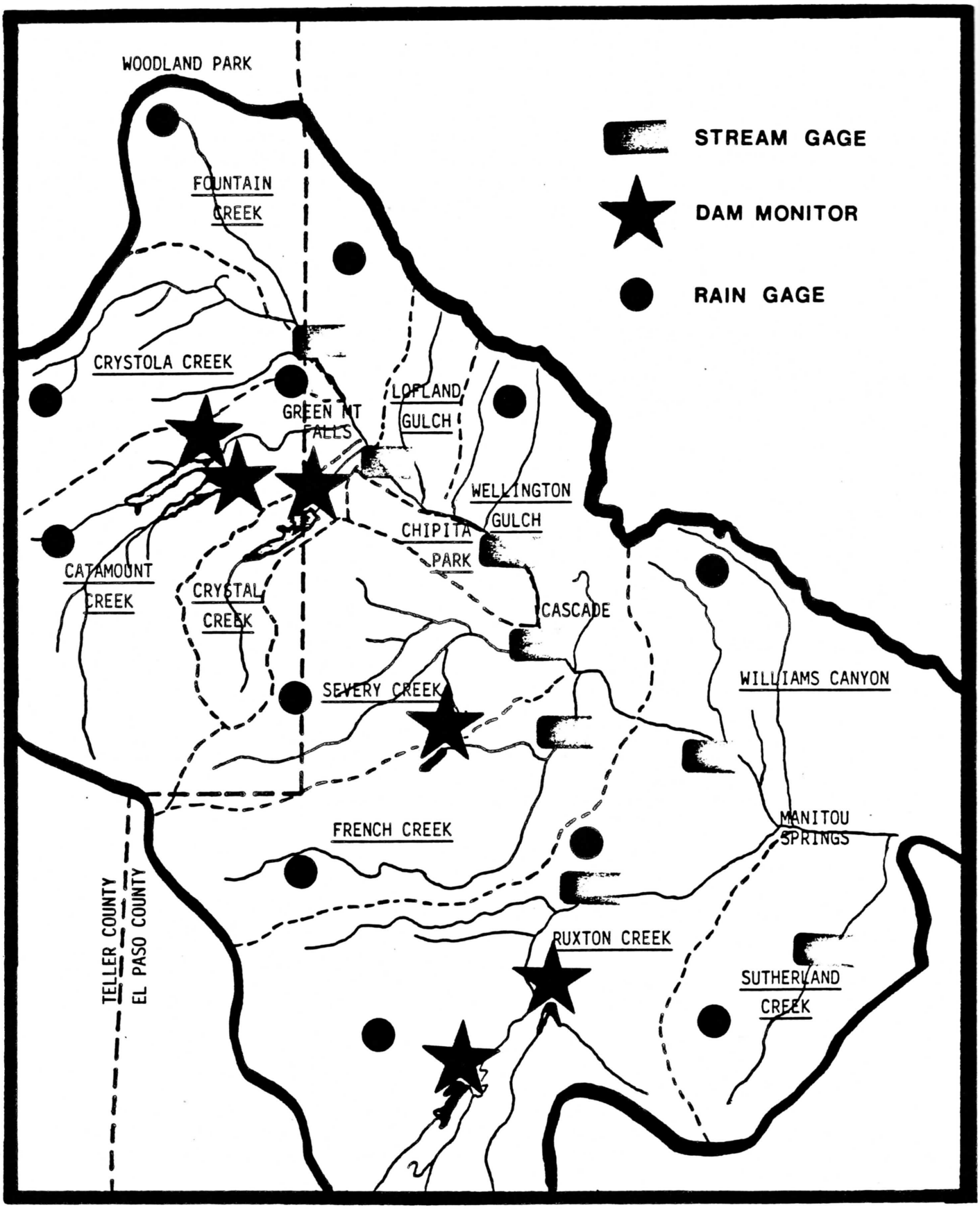
Rain gages	12 @ $ 5,000 ea	$ 60,000
Stream gages	8 @ 2,000 ea	16,000
Dam monitors	6 @ 10,000 ea	60,000
Micro Computer	2 @ 5,000 ea	10,000
Repeator Station	2 @ 3,000 ea	6,000
Electronics		18,000
Transmitters/ Receivers		60,000
Installation		200,000
TOTAL		$537,000

Local Emergency Operations Plan (LEOP)

The City of Manitou Springs could develop a Local Emergency Operations Plan in order to minimize confusion, injury, and loss of life in the event of a disaster. Although it is recommended that the plan be focused to deal specifically with the threat of flash flooding, the procedures which are developed could be followed in any emergency situation.

Although adoption of the plan rests with local decision-makers, it could be drafted and coordinated by an appointed planning committee and presented to the city council for approval. Assistance may be provided by the Colorado Department of Public Safety, Division of Disaster Emergency Services (DODES) and the El Paso County Disaster Emergency Services coordinator, Bob McWilliams, in the form of sample plans, explanation of procedures, and additional direction.

Figure 13. **RECOMMENDED WARNING SYSTEM**



The LEOP should address the general situation in Manitou Springs with respect to the flood threat and contain a list of the departments and organizations that would respond to a flood (e.g. city council, police and fire departments, social services, and public information office) and define their responsibilities. It should include such key elements as warning and communication procedures, evacuation measures, sheltering considerations, coordination and control, public information, damage assessment, and disaster declaration (Glassman, 1985). After a plan is developed, it is critical that it be tested. This process will reveal any deficiencies, which are found even in the best of plans, increase efficiency, and heighten public awareness (Glassman, 1985).

The following ideas are intended to stimulate discussion among the planning committee.

1. Plans should be made for an emergency operations center when City Hall is incapacitated. Any important documentation should be stored outside of the floodplain.

2. Evacuation considerations include the following questions. Who can authorize an evacuation? What modes of evacuation will be used? Who is in control of the evacuation? (Glassman, 1985). Lists should be made and maintained of all elderly and handicapped persons working or residing in the floodplain to expedite evacuation efforts. The plan should also consider tourists who are unfamiliar with the situation and terrain.

3. The LEOP should designate shelters located outside of the floodplain, who can authorize opening the shelters, and who will manage them. (Glassman, 1985).

4. The City of Manitou Springs may wish to consider mutual aid agreements with the City of Colorado Springs and/or El Paso County (Glassman, 1985).

Recommendation B: Develop a Floodproofing Program

The committee, with the assistance of the Federal and State technical agencies, should prepare a floodproofing program for the city.

Where economically feasible, building owners should be encouraged to floodproof their structures in a manner compatible with the building's architecture and historic character. For example, exterior walls could be reinforced with concrete on the inside of the building so as not to alter its outer appearance. Display windows could be protected by various types of flood shields. The Colorado Water Conservation Board's Colorado Flood-Proofing Manual provides specific examples of various types of floodproofing as well as cost/benefit analyses.

Effectiveness depends on matching the particular type of floodproofing with the building design and location and the amount of available warning time. Floodproofing costs fluctuate with such variables as the type of structure, building design, method of floodproofing, location, and material and labor costs. Benefits include saving lives, protection of the building and its contents, and reduced flood insurance premiums.

Recommendation C. Develop a Program for Improving the Passage of Flood Waters

The committee, with the assistance of the Federal and State technical agencies, should develop a program for removing impediments to flow, increasing channel efficiency and maintaining improved conditions over the long-term.

4. PHASE IV: Develop Pre-Flood and Post-Flood Hazard Mitigation Plans

Schedule: Month Four
Duration: 30 Days

The committee, with the assistance of the Federal and State technical agencies, should organize the mitigation strategies identified in Phase III into pre-and post-flood implementation plans.

Certain activities can begin now, prior to a major flood. These include the measures Risted above. Other mitigations measures are likely to be more politically and economically feasible following a major flood. This process can be incorporated into the community's current effort to update its Master Plan. Post-flood planning assures that Manitou Springs will face reduced vulnerability in the long term future. Pre-flood planning for post-flood circumstances is essential. After a flood many crucial decisions must be made quickly. A list of do's and don't for community leaders who are faced with post-disaster recovery based on a major disaster recovery research effort is given below.

1. DON'T wait until restoration is over before examining long-term reconstruction issues.

2. DO immediately consider whether new decision-making mechanisms are needed.

3. DO examine who the local specialists are.

4. DON'T assume the private sector will hold off until public decisions are made.

5. If significant relocation of families and businesses is to occur DO consider the full range of services and consequences.

6. DO recognize that fundamental city change is unlikely.

7. DON'T assume temporary housing will be temporary.

8. DON'T confuse physical recovery with actual city economic recovery.

9. DO use every opportunity to make the city safer, but DON'T try to make the city invulnerable.

10. Perhaps most importantly, when tempted to delay a decision, DON'T. (Haas, et. al., 1977).

If Manitou Springs has a vision of itself for the future, plans can be made now to implement far-reaching goals to improve the long term quality of life. In particular, plans for possible acquisition and relocation of housing, commercial areas, and public facilities can be discussed prior to the major flood. Major community-wide floodproofing projects envisioned now can serve as the basis of the post-flood Manitou Springs. If plans are accessible and well-designed prior to the occurrence of a major flood, community leaders can simply take the report from the shelf and begin implementation. Estes Park community leaders benefited greatly from looking toward the future in a constructive way. After the flood occurred, the community was prepared to execute dramatic changes toward beautifying the town, improving traffic flows, and reducing long term flood vulnerability. Refer to Section III for more details on acquisition, relocation, and pre-flood/post-flood planning in other communities.

5. PHASE V: Implement Pre-Flood Mitigation Plan

Schedule: Month Five
Duration: Ongoing

The Committee should implement the pre-flood mitigation plan immediately upon its completion. Refer to the discussion following the recommendations in Phase III.

6. PHASE VI: Implement Post-Flood Mitigation Plan

Schedule: Post-Flood
Duration: Ongoing

The committee should implement the post-flood mitigation plan immediately following anticipated flash flooding.

The hazard mitigation plan will play the major role in determining the effectiveness and speed of Manitou Springs recovery from a flash flood disaster. As stated above, with the plan already in place, all that the city will have to do is pull the plan off the shelf and begin implementation.

C. Post-Mitigation Scenario

It is a typical summer afternoon on the front range. Manitou Springs is experiencing the characteristic afternoon showers that showed no hint of escalating into a torrential flash flood.

By 4:00 p.m., the recently implemented satellite warning system notifies city officials that a massive thunderhead is nearing Manitou Springs.

At 5:15 p.m., the alarms sound, notifying the residents and tourists of Manitou Springs that a flash flood would, in fact, hit the city in approximately seventeen minutes.

The workshops attended by business owners, city officials, and residents prior to flood season prove beneficial in educating these people to take prompt, positive action to the flood event. Evacuation routes were pre-planned and practiced so few residents hesitate in moving to higher ground.

There is little chaos except for the excitement of the flood itself.

Monthly debris clean-up of the channels cut back on back-water damming, although numerous footbridges still hamper the stream flow. Residents on both sides of Fountain Creek are notified, either by the flood alarms themselves or by radio, to evacuate. Most respond to the reliable warning system--knowing it is only sounded in the event of a severe flash flood. The heightened awareness of the community makes all citizens more confident about their ability to respond to the warning.

Although saving lives is the primary benefit from the flash flood warning system, some property damage is prevented through emergency flood-proofing.

City Hall, the Fire Department, and the Police Department had been relocated out of the floodplain as part of the Manitou Springs Flood Hazard Mitigation Plan. These buildings now serve as the central network for all communication and emergency activities.

Personnel at the utilities and water departments are notified so that power and gas lines can be shut off. They are also informed of possible pressure increases in the sewage lines. Thus, any major damage of utility lines does not cause a threat to the community.

The partial greenbelt running alongside Fountain Creek provides an open area for swelling streams to flow. Although the greenbelt also serves to beautify the Manitou Springs area, its most beneficial purpose is served today.

Signs indicating evacuation routes are located throughout the city, directing people to head for safety by foot rather than car - a far safer alternative.

Prior to the flood season, Manitou Springs Police Department developed a list noting the addresses of all elderly and handicapped persons living in the city so that they can be aided during the evacuation.

Manitou's effective pre-hazard policies for flash flood situations saves this city and its citizens.

APPENDIX A

TABLE A-1
MANITOU SPRINGS POPULATION

1980 - 4475
1979 - 4206
1978 - 4447
1977 - 4225
1976 - 4202
1975 - 4206
1974 - 4290
1973 - 4375
1972 - 4345
1971 - 4315
1970 - 4278
1960 - 3626
1950 - 2580
1940 - 1462
1930 - 1205
1920 - 1129
1910 - 1357
1900 - 1412
1885 - 698
1880 - 500

TABLE A-2
CLIMATOLOGY DATA

	Manitou Springs	Colorado Springs	Lake Moraine	Pikes Peak
January Mean Temp.	26	28.8		20.4
January Mean Low Temp.	12.8	15.6		9.6
Lowest Recorded Temp.	-35	-27		-37
Mean Date Last Spring Frost	May 29	May 7	June 5	June 16
Latest Occurrence Spring Frost	June 16	June 3	June 17	June 22
Mean Date Last Fall Frost	Sept. 23	Oct. 11	Sept. 15	August 11
Earliest Occurrence Fall Frost	Sept. 1	Sept. 11		
July Mean Temp.	65	70.4		53.3
July Mean High	77	84.6		
Highest Recorded Temp.		100		
Humidity-Mean Annual	57	54		
Cloudy Days in %	21	16		24
Clear Days in %	50	54		47
Mean Annual Precip.	17	13.9	24.3	29.3
Maximum Precip. in 24 hrs		7	5.5	5.5
Mean Precip. Apr-Sep	12.9	11.9		18.6
Minimum Annual Precip	9	6.1	15.7	9.28
Mean Annual Snowfall	78	37.8		149.7

Source: Hansen, W., Climatography of the Front Range, Colorado: 1979.

TABLE A-3
FLOOD CHARACTERISTICS OF FOUNTAIN CREEK

Location	Peak Discharge	Height of Rise	Rate of Rise	Duration of Flooding	Channel Velocity
Manitou Springs	500 22070	7.6 ft	2.5 ft/hr	8.3 hrs	18.8 mph
City Limits	100 13000	5.5	4.2	5.2	16.1
Below Confluence	500 23300	15.1	5.0	8.3	12.2
of Ruxton Creek	100 13750	11.6	8.9	5.2	9.8
Below Confluence	500 25570	12.4	4.0	8.3	18.6
of Williams Canon	100 15000	9.1	7.0	5.2	15.9
Below Confluence	500 27750	7.5	2.8	7.0	17.4
of Sutherland	100 16000	5.1	3.9	3.5	14.9
Creek					
Below Confluence	500 29100	9.6	3.0	8.0	15.8
of Black Canyon	100 17100	8.5	6.1	4.5	12.2

Source: U.S. Army of Corps of Engineers: Floodplain Information; 1974

TABLE A-4
COMPARISON OF MAXIMUM FLOW AND DRAINAGE AREA

Maximum Flow (cfs)	Drainage Area (sq miles)	Location
2630	.3	Little Pinto Creek tributary, Newcastle Utah
7210	1.0	Glen Comfort, CO
45000	6.9	Hillsboro, NM
76000	22.9	Eldorado Canyon, NV
31200	150	Big Thompson, CO
50600	91	Rapid City, SD
124000	66	Jimmy Camp Creek, CO

Sources:

Maddox, Robert and Caracena, Fernando. Meteorological Aspects of the Big Thompson Flash Flood of 31 July 1976, NOAA Technical Report ERL 388-APCL 41, 1977.

Livingston, R. and Klein, John, Water Resources of El Paso County, Colorado, Colorado Water Resources Circular No. 32, Colorado Water Conservation Board, 1976.

National Oceanic and Atmospheric Administration; Hydrometeorological, Study No. 55, 1984b.

TABLE A-5
SUMMARY OF DISCHARGES

Location	Drainage Area	Peak Discharge (cfs) 10-Yr Flood	50-Yr Flood	100-Yr Flood	500-Yr Flood
Fountain Creek at Teller County	12 sq mi	2200	5800	7500	14000
Fountain Creek at Manitou Springs upper city limits	71	2800	8200	12300	28500
Fountain Creek below confluence with Williams Canon	91	3200	9300	13750	31500
Fountain Creek upstream of U.S. Highway 24	98	3650	10700	16000	37500
Fountain Creek at Monument Creek	358	9200	28500	42200	98000
Sutherland Creek at Fountain Creek	5.37	2630	4620	5730	10200
Williams Canon at Fountain Creek	2.68	1930	3640	4710	8940
Ruxton Creek at Fountain	17.6	2540	4350	5330	9350

Source: Federal Emergency Management Agency: Flood Insurance Studies for Manitou Springs, Colorado Springs and Unincorporated El Paso County, 1984a, 1983a.

TABLE A-6
MAXIMUM KNOWN FLOOD DISCHARGES FOR STREAMS IN THE PIKES PEAK REGION

Stream	Location in Colorado	Contributing Drainage Area	Date	Amount	Peak Discharge per Sq. Mile
Monument Creek	Colorado Springs	238 sq mi	5/30/35	50000 cfs	210 cfs
Black Squirrel Creek	South of Ellicott	482	6/04/21	56000	116
Jimmy Camp Creek	Fountain	54	6/17/65	124000	2284
Plum Creek	Louviers	302	6/16/65	154000	510
East Plum Creek	North of Castle Rock	108	6/16/65	126000	1167
Cherry Creek	Melvin	336	6/16/65	39900	119
West Bijou Creek	Kiowa	86	6/17/65	67200	784

Source: U.S. Corps of Engineers: Floodplain Information: 1974.

TABLE A-7
FOUNTAIN CREEK FLOW RATES

This data is obtained from the gaging station located one mile downstream from Sutherland Creek. The area of drainage is 102 square miles and the first recording was obtained in April, 1958.

YEAR	DATE	TIME	MAXIMUM FLOW (cfs)
1958	July		752
1959	June 20		584
1960	July 11		89
1961	July 1	2100	456
	July 7	1530	560
	July 8	1600	432
	July 11	1200	955
	August 2	2000	359
	August 11	1600	880
	September 19	1930	334
1962	June 3	1730	259
	June 19	1300	366
1963	August 3	1800	428
	August 6	2330	428
1964	May 29	1330	672
	August 4	1545	2630
	August 7	1415	800
1965	June 17	1700	359
	July 2	1900	310
1966	July 24	1730	295
1967	May 26	1800	544
1968	August 2	1500	301
1969	July 24	1730	295
1970	July 21	0200	616
1971	August 31		96
1972	August 16		223
1974	July 14		500
1975	July 20		492
1976	August 2		408
1977	August 2		560
1978	July 13		416
1979	August 26	1645	416
1980	May 15	2245	338
1981	June 2	2200	650
1982	June 12	1600	305
1983	May 31		286

Source: U.S. Geological Survey, Water Records: 1964, 1969, 1971-1984.

TABLE A-8

FLOW RATES FROM GAGING STATIONS ABOVE MANITOU SPRINGS

Year	North Catamount Flow	North Catamount Date	South Cascade Flow	South Cascade Date	Lion Creek Flow	Lion Creek Date	Sheep Creek Flow	Sheep Creek Date
1921					11.6	June 4	12.8	June 5
1935	15.0	May 25	13.5	May 26	5.28	May 25	2.53	May 31
1936	10.5	August 6	28.2	August 7	7.0	May 11	3.18	Aug 7
1937	3.5	October 1	2.9	June 6	2.38	May 4	1.23	Apr 15
1938	15.2	May 16	8.2	May 17	1.70	May 14	2.43	Sep 3
1939	4.7	May 6	3.8	June 1	3.46	May 23	1.15	Apr 30
1940	3.4	June 2	5.4	May 30	1.57	Sep 10	1.07	Sep 10
1941	23.1	May 15	20.3	May 27	4.12	May 24	3.94	May 25
1942	11.3	May 4	4.4	June 1	10.90	May 13	11.80	May 12
1943	18.3	June 2	16.1	May 1			1.11	Aug 15
1944					3.76	May 14	4.50	May 13
1945	7.5	August 8	10.9	August 12	1.84	Aug 14	1.39	Aug 14
1946	2.5	May 13	7.0	August 23			.84	Aug 23
1947	30.5	May 21	14.1	May 13	5.89	May 11	4.62	May 21
1948	7.8	May 10	8.1	May 24			1.44	May 25
1949	6.5	May 15	7.4	June 8	1.39	May 14	1.23	May 15
1950	3.3	April 22	2.3	Sep 11	.99	July 11	.58	July 11

North Catamount Creek gaging station: located 2 miles west of Green Mountain Falls, 1/4 mile upstream of confluence with S. Catamount Creek. Altitude is 9190 feet and drainage area is 5.8 square miles.

South Catamount Creek gaging station: located 1000 feet upstream from mouth and 3/4 mile west of Cascade. Altitude is 8400 feet and drainage area is 3.41 square miles.

Lion Creek gaging station: located 3 miles west of Manitou Springs, 500 feet upstream from mouth and 1/2 mile southwest of Halfway. Altitude is 9250 feet and drainage area is 2.00 square miles.

Sheep Creek gaging station: located 3 miles west of Manitou Springs, 500 feet upstream from mouth and 1/4 mile west of Halfway. Altitude is 9100 feet and drainage area is .73 square miles.

Source: U.S. Geological Survey Water Records: 1955.