FLOOD CONTROL PROBLEMS IN THE SOUTH PLATTE RIVER BASIN, COLORADO

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Introduction. The flood problems confronting the people of Colorado, in many respects, are no different than those in other rapidly growing areas in the United States. Irrigation practices, a demand for water that is greater than the dependable supply, and the effect of the mountains on storm rainfall have created, however, unusual aspects to the problems of flood control.

Description of Area. The South Platte River Basin encompasses most of Northeastern Colorado. (See Plate 1). The western boundary is the Continental Divide, the southern and eastern boundaries are the Arkansas and Republican River drainages, respectively, and the Northern boundary follows the South Platte-North Platte River divide. The South Platte River heads in Central Colorado in South Park, a mountain valley of about 10,000 feet elevation surrounded by peaks extending up to 14,000 feet, and flows easterly to leave the mountains 18 miles southwest of Denver, Colorado. The river then flows northward nearly parallel to the foot hills to Greeley, Colorado, thence northeasterly to leave the State at its northeast corner. The left bank tributaries upstream from Greeley head in the high mountains, and are fed by snow melt and springs. The tributaries below Greeley and the right bank tributaries outside the mountains originate in the semi-arid plains areas and are mostly intermittant streams.

The Rocky Mountains are the major source of the water supply for irrigation, industrial and domestic uses in the South Platte Basin. The prevailing west winds during the winter months deposit precipitation in the form of snow on the mountain slopes when it accumulates until the spring melt. The moist air masses from the Gulf of Mexico frequently are forced up the mountain slopes causing heavy precipitation. Not to be ignored in planning flood control projects in the Basin are the rare intense storms which have been caused by unstable air masses being persistently forced up slope along the mountains in the summer season. Failure to recognize and consider the flood potential of the region in project planning may result in serious loss of life at some future date, on the other hand, providing capacities in projects to control the full flood potential often makes the project economically unjustified. A few of the major storms which have occurred in the South Platte Basin are described in the following paragraphs.

Storms and Floods. There have occurred in the South Platte River Basin, a few major flood producing storms which must be considered in planning flood control works for urban areas. The first storm for which there is much information occurred on May 29th-June 2nd, 1894, along the Front Range from Idaho Springs to the Wyoming State Line. The maximum recorded 24-hour rainfall was 5.80 inches and maximum 96-hour rainfall was 8.54 inches at Ward Center (elevation 9,230 ft.), west and north of Boulder, Colorado. This storm produced a disasterous flood at Boulder, Colorado, and flooding on the South Platte River throughout. The estimated peak discharges on the South Platte River at Denver and Fort Morgan, as a result of this storm, were 14,000 and 31,000 c.f.s. respectively, and 12,000 c.f.s. on Boulder Creek at Boulder.

Damaging floods occurred in both the South Platte River and Arkansas River Basins as a result of a storm during the period June 3-5, 1921 over eastern Colorado. The synoptic situation which produced this storm is typical of most of the flood producing storms in this region. An anticyclone of continental polar air moved into north-central United States, extending to Texas, and effectively blocked the northerly movement of maritime tropical air south of Colorado. Strong easterly winds developed over eastern Colorado and the polar air imported by these winds blocked the northerly displacement of tropical air. The tropical air was lifted over the polar air, and carried up the eastern face of the Front Range, to cause very intense rains. The storm centered in the foot hills of the Arkansas River valley about 75 miles south of Denver where 11.1 inches of rainfall occurred in 6 hours. From three to four inches of rainfall was observed over the foot hills in the South Platte River Basin. The maximum 6-hour rainfall was 4.3 inches at Longmont, Colorado. One of the worst snow storms of record had occurred in the mountains in April, and much of this snow still remained in the high mountains at the time of the June storm. Floods occurred on the South Platte River from the storm runoff combined with snowmelt runoff. The peak discharges on the South Platte River at Denver, Kersey, Balzac and Julesburg were 8,700, 31,000, 31,200 and 30,800 c.f.s. respectively.

The most severe storm of record in this region occurred May 30-31, 1935, along a line from the head waters of Kiowa Creek southeast of Denver to where the Republican River crosses the Colorado-Kansas boundary. The synoptic situation which produced this storm was somewhat similar to that of the June 1921 storm, except the cyclonic system to the southward of Colorado was maritime Pacific air, and maritime tropical air was persistently forced up a trough formed by an occluded front of the continental polar air and maritime Pacific air. It was estimated that 24 inches of rain fell in 24 hours with the major portion in 9 hours in two storm centers, one over Kiowa and Bijou Creek, and the other over the Republican River. Presented in Table 1 below are a few of the estimated peak discharges caused by the runoff from the 1935 storm.

Table No. 1 - Peak Discharge in 1935 Floods

Location	Peak Discharge second feet	Drainage Area affected by storm square miles	Peak Discharge per square miles c.f.s.
South Platte River			
Denver	12,300	-	-
Kersey	13,000	-	-
Ft. Morgan	84,300	-	-
Kiowa Creek			
Near Elbert:			
Sec. 34,T9S., R.64 W.	43,500	60	725
Sec. 21,T6S., R.63 W.	110,000	190	578
West Bijou Creek			
Sec. 13,T,8 S.,R. 62W.	34,250	118	291
Middle Bijou Creek			
Sec. 26,T.7S.,R60 W.	71,270	151	473
Sec. 28,T.4S.,R60 W.	143,640	230	623

It should be noted that if the Kiowa-Bijou storm center had shifted 12 miles to the west, a catastrophic flood would have occurred on Cherry Creek through Denver.

During August 30th, September 4th, 1938, a series of local thunderstorms occurred along the front range due to unstable maritime tropical air being deflected westward under the influence of a cyclonic center to the southward and a quasi-stationary cold front over the Great Plains. On the afternoon of September 2nd, a cloudburst occurred over the front range west of Ft. Collins, and then a second cloudburst occurred during the evening over the same general area. Also during the evening of September 2nd, a cloudburst occurred over Mount Vernon Canyon in Bear Creek watershed west of Denver. It was estimated that 7.9 inches of rain fell in 6 hours in Mount Vernon Canyon which resulted in an unofficial estimated peak discharge of 10,000-11,000 c.f.s. in Mount Vernon Creek (drainage area 10 sq. mi.) at Morrison, Colorado. The flood peaks on Boulder Creek near Eldorado Springs and St. Vrain Creek at its mouth were 7,390 and 11,300 c.f.s., respectively.

Prolonged rains and snow during April 1942 resulted in damaging floods on the South Platte. For practically the full month of April the South Platte maintained flows in excess of 5000 c.f.s. at Denver with a peak discharge of 10,700 c.f.s. Flood damages to bridges, irrigation diversion structures and crops were severe, and were caused primarily by erosion around head walls of structures and destruction of levees by under cutting by the prolonged high water.

Characteristic of the mountainous areas of eastern Colorado are the frequent afternoon showers during the summer months which, much to the dismay of vacationers, have spoiled many an outing. The early morning sun heats the eastern face of the mountains at a faster rate than the plains, thereby causing a flow of air up the mountain slopes. The flow toward the mountains increases as the morning progresses, and thunderheads soon form over the mountains. The resultant storms usually begin about noon and move northeasterly to be dissipated over the plains within 50-75 miles of the foot hills. The intensity of rainfall is a function of the amount of moisture in the air mass over the plains region. Unofficial records of rainfall collected by the Corps of Engineers indicate that six to eight inches falling in four to six hours is not uncommon in this type of storm. The flash floods caused by cloudbursts usually have very high peak discharges in comparison with the flood volume, and normally valley storage reduces the peaks to bankfull stages after the crests have moved downstream a few miles.

<u>Channel Capacities.</u> The unimproved portions of the South Platte River channel have bankfull capacities of between 1500-3000 c.f.s. above Denver, 2000-4000 c.f.s. from Denver to the mouth of the St. Vrain with a gradual transition to 4000-6000 downstream. The improved channel of the South Platte River through Denver accommodated the 10,700 c.f.s. peak flow in the 1942 flood with only minor overflow and damages. The channel was designed to carry about 18,000 c.f.s., however, there are many bridges across the river which restrict the flow and no doubt would become clogged with debris during flows much over 12,000-14,000 c.f.s.

Practically all the left bank tributaries of the South Platte River after leaving the mountains meander through meadow lands in shallow stream channels. A discharge of 2000 c.f.s. will usually cause overbank flow and minor damages at some location on each of these tributary streams.

<u>Effect of Irrigation Diversions on Floods.</u> Irrigation is practiced estensively between the foothills and the South Platte River, and along both sides of the River east of Greeley. The runoff from the spring rains and snowmelt is diverted directly on to the farm lands or in to one of hundreds of off-stream storage reservoirs in the Basin. The demand for water is greater than the supply on all streams, except during a series of high runoff and heavy rainfall years. The flow in the mountain tributary streams is rapidly depleted after leaving the mountains. The water in the lower South Platte River is primarily from irrigation return flows and local storm runoff. These continued low flows permit willows and trees to encroach upon the stream channels. During normal diversions the

irrigators divert more water than their decreed right, and in order to reduce silting of their reservoirs, flush sediment back into the river with the excess water. The streams therefore carry an extremely large amount of bed load during flood period, so the irrigators usually close their gates at such times until the flood has passed. Thus during a flood, there is not necessarily always a reduction in flood volume by diversions as the flood moves downstream.

Urban Areas Subject To Flooding. Since practically all cities and towns in the South Platte River Basin are situated along some stream, each urban area is subject to flooding to some degree. Metropolitan Denver is located on both banks of the South Platte River at the mouth of Cherry Creek. The South Platte River channel has been improved to where the flood of record (22,000 c.f.s. in 1933) could be accommodated with not too serious damages, however studies by the Corps of Engineers in their South Platte River Survey Report, 1945, indicates a flood potential from the uncontrolled drainage area above Denver of about 85,000 c.f.s. Although the probability of a flood of this magnitude is very remote, there is a good chance of the occurrence of lesser floods which are in excess of the capacity of the improved channel. Within the South Platte River flood plain are extensive railroad yards, wholesale and retail warehouses, housing developments and other improvements too numerous to mention, which would be inundated by a major flood. Cherry Creek, which in the past years produced damaging floods, is now controlled by the Cherry Creek flood control dam, completed by the Corps of Engineers in 1951. This dam gives complete protection to Denver from floods originating in 386 square miles of the total 414 square miles of Cherry Creek drainage.

Tributary dry gulches within the Denver Metropolitan Area have become problem areas within the past decade. Harvard Gulch, a right bank tributary of the South Platte River, Weir Gulch and Sanderson Gulch, left bank tributaries are prime examples of inadequate land use planning and zoning. These gulches carry only occasional high flows and may be dry for long periods. As the city grew, there was a gradual encroachment into these natural waterways by dwellings and commercial establishments. The extreme case is Harvard Gulch drainage which is entirely improved, and the only waterway provided to handle storm runoff is a small ditch winding between dwellings and apartment houses. A series of local cloudbursts over Harvard Gulch in 1956 produced about 3.4 inches of precipitation in three evenings out of four. The estimated flood damages caused by the resulting flood was $5,000,000. Similar storm drainage problems now exist in Metropolitan Denver due to poor zoning regulations.

The City of Boulder is subject to damages from Boulder Creek which flows through the center of the city. The flood of 1894, the only major flood of record, inundated a wedge shaped area along the stream. There has been a gradual movement into the Boulder Creek flood plain until at present the City Municipal Building, a bank, school house, shopping center and over three hundred residential buildings are now situated within the limits of the 1894 flood. The city has also expanded over dry gulches leading from the mountains with little or no provision made to handle the rapid flood runoff following local storms.

Flood-damage potential similar to Denver and Boulder described above, exist on the Cache la Poudre River at Ft. Collins and Greeley, Bear Creek at Morrison and at Sheridan, Little Dry Creek at Littleton, Sand Creek at Commerce Town and many other urban areas too numerous to mention.

Flood Control Plans. The Corps of Engineers completed a Survey Report for the South Platte River and Tributaries in 1945 which recommended a flood control dam at the Chatfield Site on the South Platte River 11 miles upstream from Denver and channel improvements and a levee system on the South Platte from the Chatfield Dam to the mouth of St. Vrain Creek. It was also recommended to protect Boulder from floods on Boulder Creek equal to the flood of record (1894) by constructing a levee system through the city and improving the channel. The plan of improvements recommended in the Survey Document were authorized for construction by Congress in 1950, but no construction funds have been appropriated due to lack of local support for the projects.

The Corps of Engineers has been authorized to review their Survey Document in view of the changed conditions in the South Platte River Basin and develop, if justified, alternate plans for flood protection.

The Soil Conservation Service in cooperation with the Corps of Engineers, is studying the Sand Creek flood problems north and east of Denver. It is hoped that some plan of improvement can be justified which will protect this fast growing area.

Design Considerations. In addition to the normal problem of obtaining economically adequate rights-of-way for channel improvements or reservoir projects, consideration must be given to the rights of the water users in the Basin. The diversions of water from the natural streams in Colorado are made in accordance with the date of priority of appropriation held by the water user, first in time is first in right. Thus consideration must be given to the probable effect the flood control project will have on the regimen of the stream. On a regulated stream it is possible for stored flood waters to be released at a rate so low that the senior appropriator can legally call for and divert all the stream flow, thereby depriving the junior appropriators of water that normally would have been available to them during the higher flows of an unregulated stream. A project on a minor intermittant stream usually can be designed so as to satisfy most water users, but a major project must stand a critical review by many water users.

An excellent illustration of the review made by the water users of a proposed project is the Cherry Creek Project near Denver. Public hearings were held by the Corps of Engineers to acquaint the public of the proposed plan of improvement. The water users took exception to the small capacity of the outlet works, and requested that the outlet be capable of passing flood peaks up to damaging proportions (5,000 c.f.s.) with a minimum of reduction by the reservoir. The State of Colorado approved the Project for construction only after the outlet was redesigned to satisfy the water users' request.

Channel improvements become costly in this irrigation region because provisions must be made for modification or replacement of the many diversion dams and headworks along the streams. Often it is desirable, from an engineering standpoint, to change the location of a diversion dam and headworks. Since a Court decree for an appropriation also designates the point of diversion, it requires Court action to change the point of diversion to another location. It is apparent, then, that, unless the water users gain materially from a flood control project, they will take the "status quo" attitude and reject the project.

Few of the streams in the South Platte River Basin have had floods approaching the flood potential of the drainage area as indicated by the major storms that have occurred in the region. One of the major considerations in the design of a flood protection project, especially for the protection of urban areas, is the degree of protection to be provided. In most areas the improvements have encroached upon the flood plains which would be inundated by a flood of the magnitude of the floods of record, thus a serious right-of-way problem develops when the project is designed for the maximum probable flood. Also, there is considerable local opposition to a project designed to provide protection against floods in excess of those remembered by the local people.

Discussion. The rapid growth in recent years in the South Platte River Basin has resulted in encroachment into flood plains and watershed drainage that should have been reserved for flood flows. However, the varied interests of the water users, and the increasing demand for water for domestic and commercial uses complicates the planning of any water resources project in the Basin. All water resources planning agencies and the local people recognize that water stored in reservoirs for control of floods should also be put to beneficial use. Federal laws require that local interests contribute to the construction of multiple-use projects in proportion to the benefits received, except for the flood control features of the project. The water users as individuals or a conservancy district cannot afford to pay for an undependable supply of water. The problem then is to plan the water resources projects in such a manner as to meet the needs of as many as possible at a cost that they can afford, or are willing to pay.

Summary. Flood problem areas do exist in the South Platte River Basin, and many of these areas are expanding, as well as new problem areas being developed, with the rapid growth of Colorado. A flood control program should:

(1) Provide adequate flood control for existing problem areas, and

(2) Prevent the future development of problem areas.

The existing Federal Flood Control, and Flood Prevention Laws provide for the construction of justifiable flood control projects at Federal expense. However, it has been very difficult to justify many projects economically, primarily because of the infrequency of flooding. Also there is very little local support for a project unless conservation storage is provided in a reservoir at a nominal price.

The problem of growth into flood potential areas is a local problem. Therefore, there should be established by the State a Central Agency, authorized and charged with the responsibility for zoning flood plains and potential flood ways. The Agency should establish the design criteria to be used in determining water way capacities, and work through county or local groups to accomplish their purpose.

All water resources projects, including flood control, should consider inclusion of conservation storage in proposed reservoirs. Since flood flows are not a dependable source of water and at present cannot be economically justified, some provision should be made either by the Federal government or State government to finance the construction of such projects and recover the construction cost by the sale of flood waters, to areas of short supply. Public Law 500, 85th Congress, S. 3910, Title III - Water Supply Act of 1958 may assist in this type of planning. Briefly, it provides for storage of water for municipal and industrial uses in multiple purpose projects up to 30 percent of the total cost of the project. The law provides that when a portion of such storage capacity is first utilized, then repayment for that portion will be started and repaid within the life of the project, but not to exceed 50 years.

Water always has been a valuable commodity in the semi-arid West, and is becoming more valuable as the area grows. We must make a special effort to control and put to beneficial use all of our flood water or we will limit our growth unnecessarily.

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