

BUREAU OF RECLAMATION
CHERRY CREEK REPORT

April 1938

UNITED STATES
DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary

BUREAU OF RECLAMATION
John C. Page, Commissioner
R. F. Walter, Chief Engineer
E. B. Debler, Hydraulic Engineer

REPORT ON
CHERRY CREEK PROJECT-COLORADO

By
A. N. Thompson-Engineer.

April-1938.

Reservoir operation and maintenance, together with overhead costs for collection of project costs and distribution of water, are estimated at \$1.00 per acre with the Castlewood development and \$1.25 per acre with the smaller Cherry Creek Reservoir development, leaving \$2.50 and \$2.25 per acre per year, respectively to apply on construction costs.

On this basis, assuming a forty year repayment period without interest, the investment results are as follows:

	:Castlewood: :Reservoir : with : flood con- : trol	:Cherry Creek: : Reservoir : with flood : control	:Cherry Creek: : Reservoir : without full : flood control
Total Cost	: \$ 876,500	: \$ 637,000	: \$ 512,500
Irrigation Repayment	: 429,500	: 309,000	: 309,000
Cost not met by irrigation	: \$ 447,000	: 328,000	: \$ 203,500

Denver was first settled in 1857 and since then there have been a number of damaging floods in Cherry Creek of which those of 1864 and 1933, are outstanding. The 1864 flood did heavy damage to a small town; the 1933 flood due in part to failure of the Castlewood Dam, resulted in tangible damages of \$1,000,000 and undetermined intangible damages. The Kenwood flood control dam, constructed since 1933, was intended to control floods of 100 year or less frequency, to pass them safely through the Denver floodway channel of 10,000 second feet capacity. Larger floods would not be so controlled.

The Castlewood Dam will provide complete flood control at its site. The degree of such control reduces downstream through Cherry Valley but it will be very material even at Kenwood Dam and through Denver. Control at Cherry Creek damsite would be less complete as the drainage area controlled is reduced from 168 to 130 square miles. The smaller dam at the upper site would furthermore fail to control large floods to the degree desirable. Flood control benefits have not been determined but are being considered by Army Engineers in connection with a flood control survey. It is believed, however, that flood control benefits, particularly with the Castlewood Dam, will fully equal the costs which irrigators could not be expected to pay.

The estimates presented contain nothing for liquidation of any rights or claims which former owners and operators may have in the Castlewood site, excepting only for rights of way to be used, as nothing usable remains of the dam.

The lack of stream flow records makes it highly desirable that one or more gaging stations be immediately installed and continuously operated for several years to provide more reliable information on water supplies.

PROJECT LANDS

Location

The project lands are located in Douglas and Arapahoe Counties from 6-25 miles southeast of Denver, Colorado. Towns in the area are Parker and Franktown with Castlerock and Sedalia located about eight miles west on the Plum Creek watershed.

The area classified as arable and amounting to 6400 acres, extends from a point in Cherry Creek valley, two miles south of Franktown, north a distance of 20 miles to the Kenwood flood detention dam and includes only the bottom lands along the streams, between State Highway No. 83 on the east and the foothills on the west. It is larger than that which can be provided with a full irrigation supply from Cherry Creek.

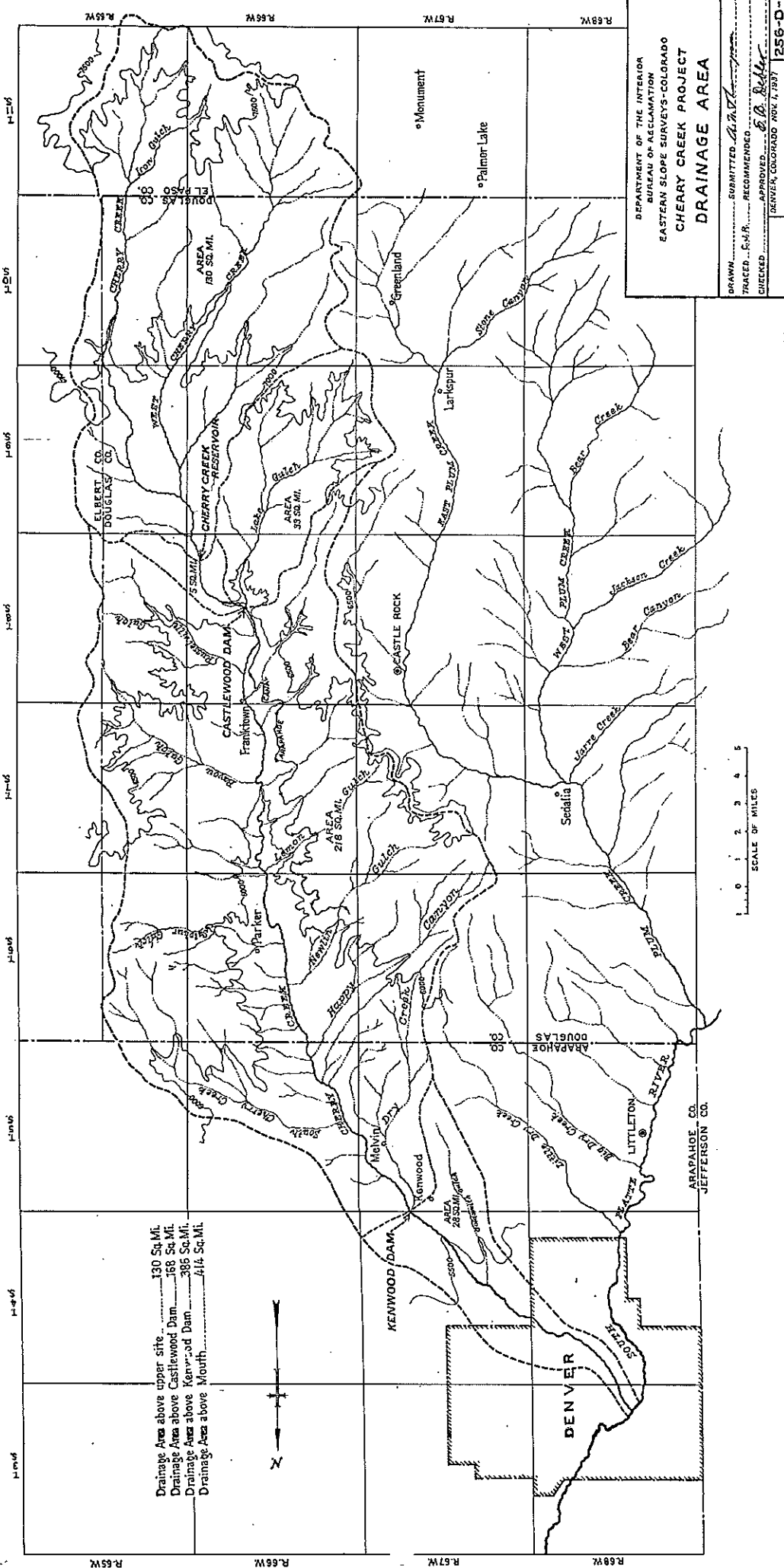
Climate.

The average elevation of the project is about 5500 feet above sea level, and the climate is classed as semi-arid with a mean annual temperature of 47 degrees, varying between extremes of -30 degrees and 101 degrees.

Precipitation at Parker, Colorado, in inches.

Month	1930:	1931:	1932:	1933:	1934:	1935:	1936:	1937 :	Mean	
Jan.	:	0.02:	0.27:	0.02:	0.09:	T :	0.19:	0.11:	0.10	
Feb.	:	0.60:	0.24:	0.07:	1.87:	0.54:	0.18:	0.29:	0.54	
March	:	0.83:	0.65:	0.83:	0.36:	0.14:	0.01:	0.56:	0.63	
April	:	1.02:	1.28:	3.73:	1.03:	1.89:	1.07:	0.80:	1.55	
May	:	1.48:	2.07:	1.34:	1.20:	4.94:	2.80:	1.65:	2.21	
June	:	0.74:	2.95:	0.84:	0.09:	1.92:	2.36:	3.80:	1.81	
July	:	3.11:	0.80:	2.72:	1.63:	1.09:	1.95:	1.04:	1.73	
Aug.	:	2.94:	1.56:	1.39:	0.93:	1.28:	1.86:	2.45:	1.69	
Sept.	:	0.33:	0.23:	0.98:	2.83:	0.45:	1.21:	3.02:	0.80:	
Oct.	:	0.81:	0.70:	0.85:	T :	T :	0.61:	1.28:	0.37:	
Nov.	:	1.89:	0.29:	0.38:	0.35:	0.52:	0.11:	0.08:	0.39:	
Dec.	:	1.03:	0.02:	0.17:	1.39:	0.33:	0.08:	0.32:	0.53:	
Total	:	*10.11:	8.29:	13.95:	13.96:	8.31:	15.25:	15.80:	11.94:	13.05

* Partial year records.



FLOOD CONTROL

Data prepared by Mr. Charles A. Davis, Sanitary Engineer, City and County of Denver, published in the Engineers Bulletin of Colorado, for April, May, and June 1935, give the most complete flood history of Cherry Creek. It is therein indicated that from 1859 to 1935 fifteen flows have been sufficient in size to be considered as floods with five of these (1864, 1878, 1885, 1912 and 1933) of major importance.

Past Floods of Record

Discharge estimates are based largely on flood stages and high water marks along Cherry Creek and adjacent streams, and records of gain on the South Platte River between gaging stations at Waterton and Denver. A brief description of the major floods (abstracted largely from data prepared by Charles A. Davis above described) follows:

May 19-20, 1864 - Flood caused by heavy rainfall and hail on upper watershed over the Cherry Creek-Plum Creek Divide. Discharge of both streams reached Denver at the same time, resulting in considerable property damage. Nineteen persons were drowned in the flood. Peak rate of discharge unknown.

May 22, 1878 - No information available as to the origin of this flood, although reported to have been as large as that of May 1864. No great damage occurred since the channel had been partially improved and buildings had been removed from the floodway.

July 26, 1885 - Peak discharge at Denver estimated at 20,000 second-feet. No information pertaining to the portion of the watershed on which the flood originated. All railroad bridges over Cherry Creek were washed out and west Denver flooded.

July 14, 1912 - The result of general rains over the entire watershed with storm center in vicinity of Parker. Castlewood reservoir gained 800 acre-feet, indicating a less rainfall intensity on the upper watershed. Peak discharge at Denver estimated at 14,500 second-feet with about 25,000 second-feet immediately below Parker. Damage within the City of Denver was estimated at \$300,000.

June 28, 1922 - Rains of 1" to 4" over an area of 90 sq. miles from Parker to Franktown, Colorado, resulted in a flood of 17,000 second-feet estimated discharge at Parker and reducing to about 6,000 second-feet at Denver. No damage reported.

August 3, 1933 - Flood caused by intense rains at the extreme upper end of the watershed with volume at the Castlewood Reservoir estimated at 2640 acre-feet. This flood overtopped and caused failure of the Castlewood Dam. Peak discharges along Cherry Creek are estimated as follows:

Location	:Peak Discharges:	
	: Second-feet	: Remarks
Above Castlewood Reservoir	11,000	:Estimated from cross- :sections by writer.
Castlewood Dam	*126,000	:Estimate by Ivan E. Houk, : U. S. B. R.
Kenwood Damsite	* 34,000	:Estimate by State Engi- : neer M. C. Hinderlider
Mouth of Creek at Denver	16,000	:Estimate by State Engineer : M. C. Hinderlider

* Peak due to sudden release of storage caused by failure of dam.

Damages from the flood about \$1,000,000 in the valley below the dam including Denver.

May 30, 1935 - Storm of unprecedented proportions centered on the high divide, separating the South Platte and Arkansas River Watersheds in El Paso and Elbert Counties. Effects of this storm were felt on Cherry Creek although the center was to the east on Kiowa Creek drainage area.

From information obtained by the State Engineer's office the maximum rainfall at the extreme upper end of the watershed was 8", reducing to a light precipitation above Castlewood Dam. Examination of the gage record on South Platte River at Denver shows a peak discharge of 12,000 second-feet and a total volume of 700 acre-feet. Valley losses probably reduced runoff very materially by the time it reached Denver.

Storage increases in the Castlewood Reservoir for the period 1912 to 1933 indicate that about 12 flows occurred which

might have resulted in floods in the valley below, if uncontrolled. The volumes of these inflows range from 500 to 1600 acre-feet in a single day and in the main are the result of heavy rain.

Storms over Cherry Creek Watershed

Storms that affect this area are of two distinct and different types. The usual type is the general storm, occurring several times in practically all years. Such storms extending from the eastern slope of the mountains far into the plains, often reaching into Kansas and Nebraska, covering from 10,000 to 50,000 square miles, are recorded at many weather bureau stations. It is characteristic of these to have one or more centers of concentrated precipitation more frequently along the foothills - the rainfall diminishing with decrease in elevation toward the plains. Precipitation ranges in depth from one-half inch to three or four inches, over a time interval of several days - usually from one to three days.

The other type of storm concerning which little is known, is the so-called "cloudburst", rarely recorded by weather bureau stations because of their limited extent. That they occur with extreme intensity over local areas is known chiefly by floods they produce. It is this type of storm which has produced the larger floods in Cherry Creek, notably those of 1912, 1922, 1933 and 1935. No precipitation station around the entire drainage area recorded sufficient rainfall to produce the resulting floods of these years - yet all had peak discharges greater than ever experienced from any of the general storm type previously described. It is this latter type storm of great intensity and short duration

which will probably cause the maximum floods from the area and justify protective measures.

Samples of severe floods caused by "cloudbursts" are found in the Pueblo flood on the Arkansas and Fountain Rivers, Colorado, in June 1921, and the Republican River (Kiowa) flood of May 1935, both of which are discussed elsewhere.

Flood Analysis

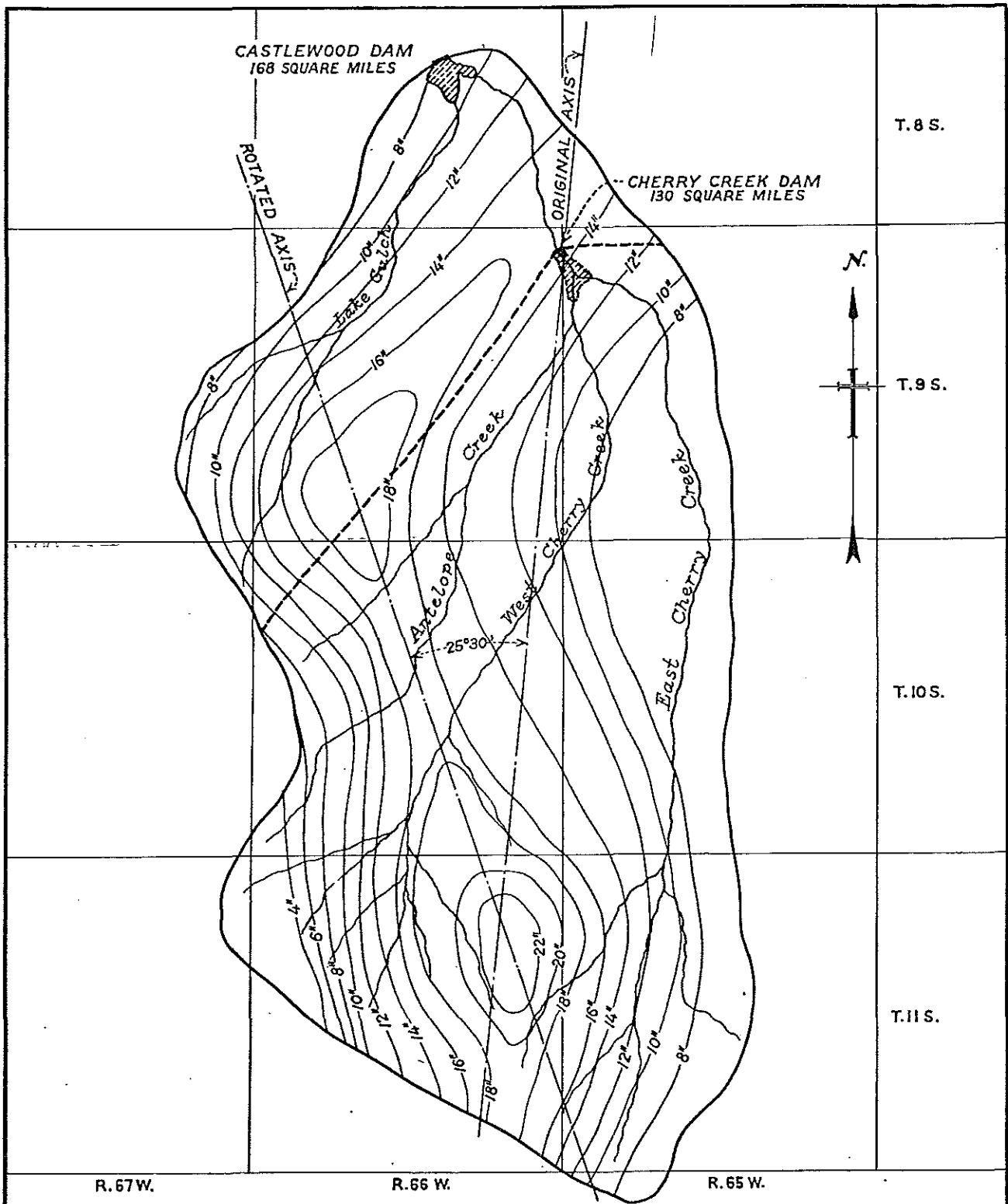
Cherry Creek rises on the secondary divide between Colorado Springs and Denver at an elevation of 7600 feet and drops about 1100 feet in approximately 23 miles or slightly less than 50 feet to the mile. The average width of the drainage area is 7.6 miles, with areas of 168 and 130 square miles above the Castlewood and Cherry Creek damsites respectively (see drawing 256-D-27).

Volume and frequency of the maximum and the more frequent floods of lesser magnitude have been estimated from a consideration of:

- (a) Total rainfall
- (b) Absorptive capacity of watershed.
- (c) Form of hydrograph as determined from recorded floods.

Maximum Storms of Record

The storm of Memorial Day, 1935, is the heaviest that has occurred anywhere near Cherry Creek within the history of the State, and probably the heaviest in this general region. It centered just east of the watershed on the Kiowa Creek drainage



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ISOHYETAL MAP
MAXIMUM STORM

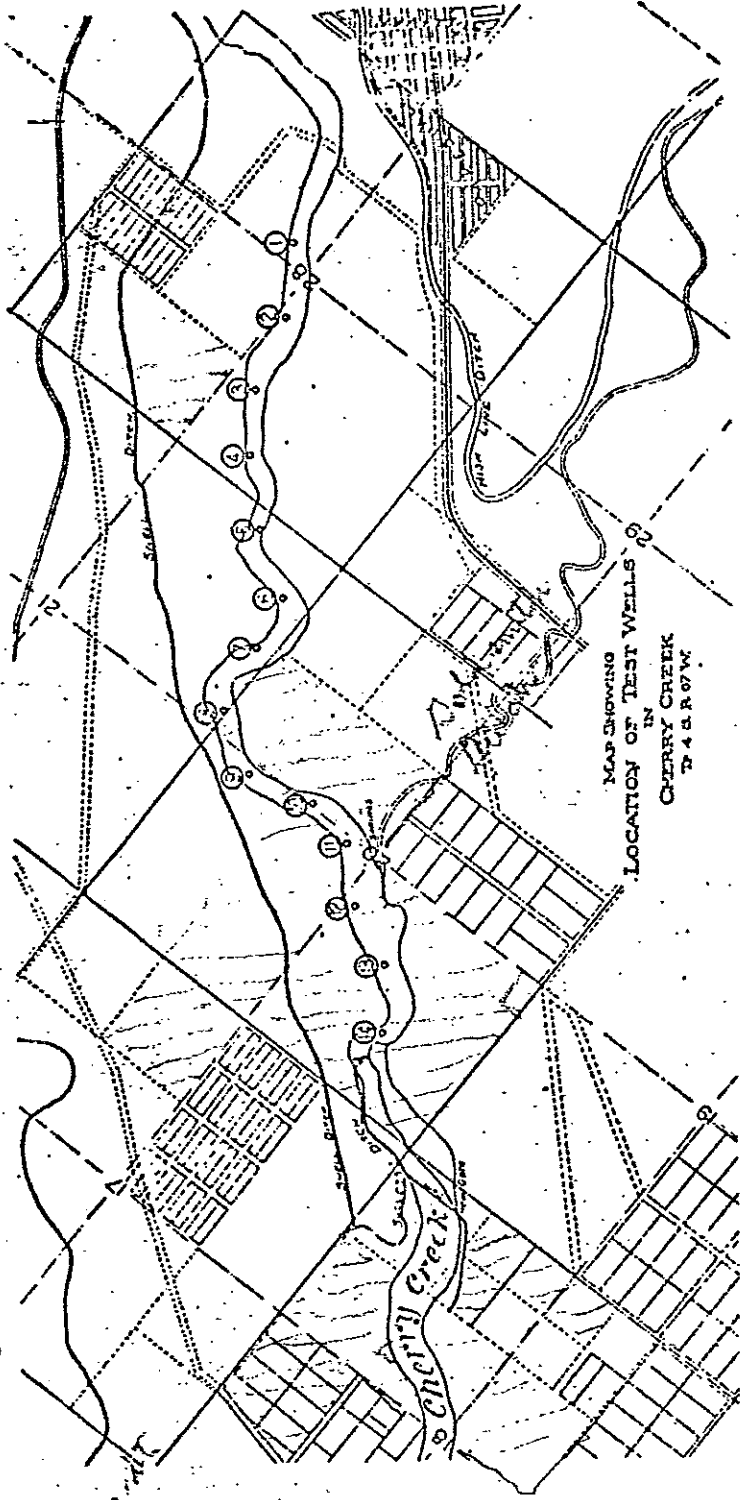
DRAWN..... SUBMITTED *A. N. Thompson*
 TRACED...G.R. RECOMMENDED
 CHECKED..... APPROVED *E. B. Deblor*

DENVER, COLORADO JUNE 8, 1938

256-D-87

1912

REPORT OF CHERRY CREEK FLOOD COMMISSION



MAP SHOWING
LOCATION OF TEST WELLS IN
CHERRY CREEK
T. 4 S. R. 67 W.

Wasson's Cove

S. Duck Lake

Clamada Creek

Hollydale



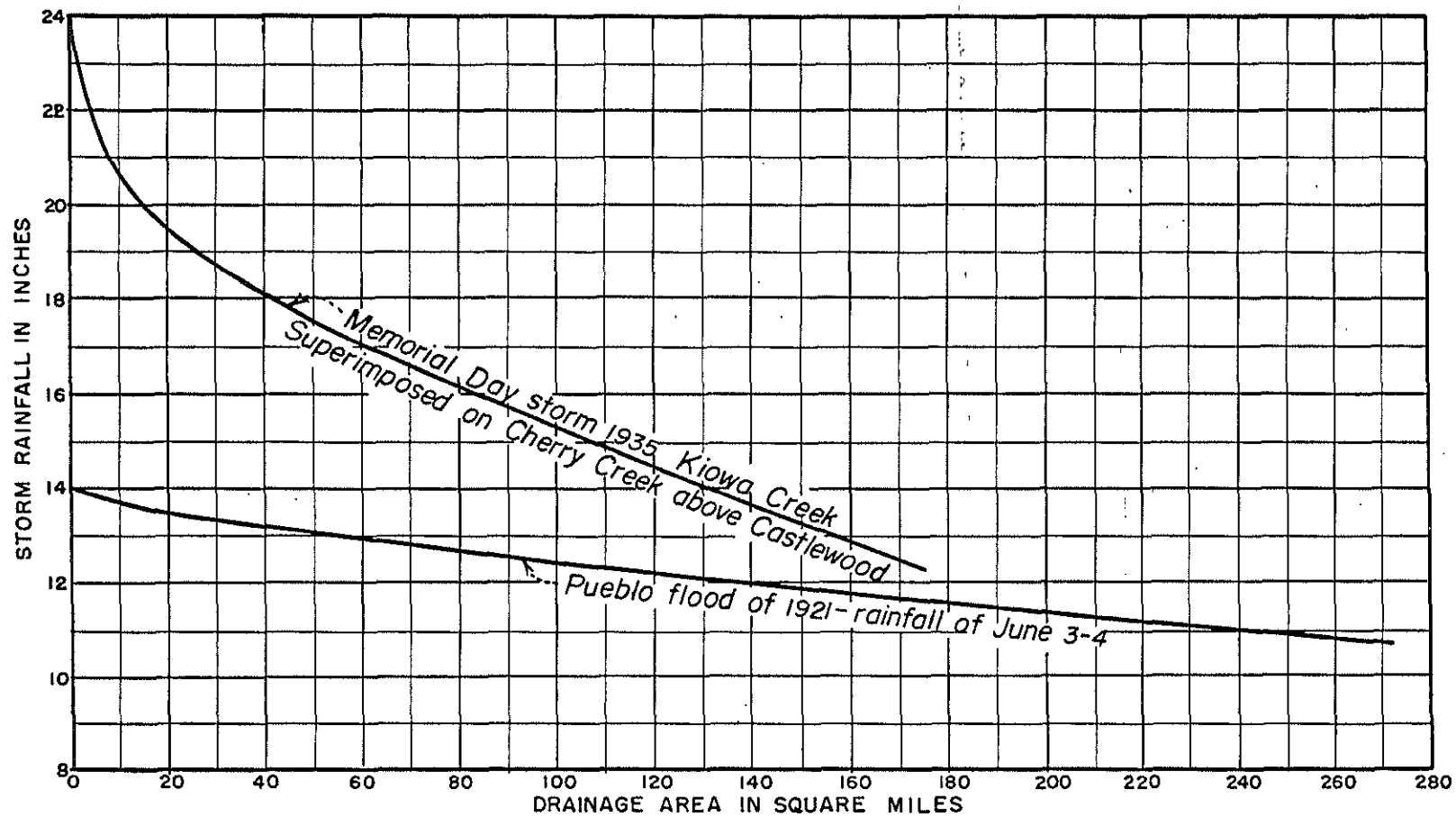
area. Basic rainfall data for the storm were obtained from Water Supply Paper 776-B and the State Engineer's office from which an isohyetal map was prepared.

Although excessive rainfall was not recorded at weather bureau stations, these data show intensities up to 24 inches with the entire storm lasting about 8 hours. With the same storm pattern superimposed upon the Cherry Creek watershed above Castlewood Dam and rotated about 25 degrees counter clockwise to secure maximum concentration (see drawing 256-D-87), a rainfall of 12.3 inches is found for the area above Castlewood Dam. This exceeds by 22% the actual concentration within an equal Kiowa Creek drainage area.

Drawing 256-D-82 presents a comparison of the resulting area intensity curve with that for the center of the Pueblo storm of June 1921. The Pueblo storm rainfall over an area equivalent to Cherry Creek is 11.7 inches, not greatly less than that for the Memorial Day storm of 1935.

No other storms of record in Colorado have approached these for intensity although the flood of September 30, 1904 at Trinidad was caused by severe rainfall following several days of precipitation.

The flood resulting from the adopted shifting of the 1935 storm may well be considered a maximum in that it combines the greatest storm of some 80 years of occupation of the State, with a displacement and rotation to secure maximum effect, a combination which would probably not occur with a frequency of



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 CHERRY CREEK PROJECT

AREA-RAINFALL INTENSITY CURVES

DRAWN J.N.P. SUBMITTED A. W. Thompson
 TRACED E.W.C. RECOMMENDED _____
 CHECKED _____ APPROVED E. B. Deller

DENVER, COLO., JUNE 1938. 256-D-82

less than several thousand years although possible of occurrence in any year. There are even possibilities of a greater storm but there is no justification for consideration thereof.

Runoff-Rainfall Analysis

Analyses have been made of the drainage area of Cherry Creek and the similar drainage area of Plum Creek immediately west thereof. Precipitation stations applicable to these areas, although not one lies actually within the upper Cherry Creek area, are Denver, Edgewater, Kassler, Monument, and Parker.

Runoff from the Cherry Creek area above Castlewood was determined from storage changes for 1912 to 1933 in Castlewood Reservoir, the only information available as to runoff. Inflow may be approximated from these records in periods when the reservoir was not spilling but since no records of spill or release were kept, the figures obtained in some instances represent only a part of the inflow that occurred.

Plum Creek and Cherry Creek runoff, never directly measured, was determined from the flow of the South Platte River at Denver, less the sum of the flow of South Platte River at Waterton, Bear Creek at mouth and an estimated return flow of 50 second-feet between Waterton and Denver. Determination of contributing drainage area was based upon the location of the storm as evidenced by the precipitation at the above Weather Bureau stations. Few storms produce measurable runoff.

Although generally recorded as two day rainfall at weather bureau stations, recording precipitation once daily,

most storms and the resulting flood cover less time as evidenced by the storm of September 9 and 10, 1933, when practically all runoff came from 1:00 A.M., to 1:00 P.M., on the 10th, with rainfall reported for two days, 9-10. This same condition would no doubt apply to Castlewood Reservoir gains recorded but once daily.

Various estimates have been made of the Pueblo flood runoff (1921) ranging from 90,000 acre-feet from the more concentrated rainfall area of 870 square miles to 145,000 acre-feet for the entire storm period of June 2-6 from 1,740 square miles.

The hydrograph prepared by R. O. Hosea, shown on page 53, Transactions American Society of Civil Engineers, 1922, shows a flood runoff for the period June 3 at 1:00 P.M., to June 5 at 4:00 A.M., of about 90,000 acre-feet, which may be assumed to have been caused by the more intensive rainfall from 1:00 P.M., on June 3 to 6:00 P.M., on June 4. Allowance of 10 hours is made for complete runoff from the rainfall period and for a base flow of 2500 second-feet as indicated by the recorded river stage before and after the storm period. The contributing area was 1,740 square miles, one-half thereof had an average rainfall of 6.86 inches for the two days, varying in intensity from 3" to 14". The balance of the area therefore probably had an average of not to exceed 1.5" in the same period. Assuming that probable runoff was proportionate to rainfall exceeding 1", then 92%, or 87,000 acre-feet came from the area of more intense rainfall and 8% from the other. Available reports on this flood indicate that 50,000 acre-feet may have come from an area of 300 square miles immediately southwest of Pueblo. The intensity of rainfall over such an

area was 10.4 inches while on the above basis the runoff is 3.1 inches.

Table 7.

Rainfall above Castlewood Dam and resulting Runoff, as determined from Reservoir Stage Changes. Drainage Area 168 square miles.

Date of Flood		Rainfall-Inches	Runoff-A.F.	Runoff Inches Depth
July 14,	1912	1.60	804	.09"
July 9-11,	1914	.95	590	.065"
July 11-13,	1918	.95	1030	.113"
July 2-7,	1919	2.19	640	.070"
July 18-20,	1920	.34	580	.064"
July 30-August 2,	1920	.68	830	.091"
May 2-4,	1921	No Record	1825	.201"
August 3-6,	1922	.48	490	.054"
July 11-12,	1923	1.13	990	.109"
July 2-4,	1925	.58	340	.037"
July 5-7,	1926	.57	380	.042"
June 26,	1927	No Record	1100+	.121" +
July 21-23,	1927	1.55	630	.056"
July 27-29,	1927	.80	480	.053"
August 7-8,	1927	.88	730	.080"
March 3-4,	1929	No Record	1700+	.187" +
August 10-18,	1930	1.57	1080	.119"
July 30-31,	1932	1.43	2575+	.283"+
August 12-14,	1932	.76	690+	.076"+
April 24-30,	1933	1.09	1504	.165"
August 3,	1933	1.00	2640	.300"

Rainfall on combined Cherry Creek and Plum Creek watershed and runoff between Waterton and Denver. Drainage area adjusted to area receiving rainfall.

June 28,	1922	No Record	3200	.69
June 11-12,	1927	1.38	2512	.25
May 13-14,	1928	1.47	19,900	.45
September 9-10,	1933	3.55	25,100	1.00
July 6-7,	1933	0.79	1546	.07
May 17-19,	1935	3.90	5500	.65
June 12-13,	1935	1.77	5230	.42
August 23-24,	1935	0.97	582	.06
August 20,	1935	0.55	558	.06

Pueblo Floods of June, 1921.

*June 3-5	1921	6.86	92,000	2.00
**June 3-4	1921	10.4	50,000	3.10

*Estimated Runoff from 870 square miles

**Estimated Runoff from 300 square miles

Table 7 gives pertinent data of rainfall and runoff for areas referred to above which are plotted on drawing 256-D-85. The flatter slopes and more pervious soil cover on Cherry Creek watershed is reflected in an adopted rainfall-runoff relation (drawing 256-D-85), about 80% of that indicated for the Pueblo flood of 1921 for areas of 300 and 870 square miles.

The extension of these data indicates a runoff of 3.2 inches for the adopted maximum storm of 12.3 inches for the Castlewood Dam site.

For the Cherry Creek damsite, with its drainage area of 130 square miles and a mean rainfall of 12.7 inches, runoff of 3.4 inches is similarly indicated.

The Flood Hydrograph

Castlewood storage records are based on daily readings. While adequate to secure the total runoff from storms not producing spill, they will not permit determination of the shape of the inflow hydrograph from small storms lasting but a few hours. Information is more complete on the flood which breached the dam.

The heaviest rain occurred near the headwaters of the stream at about 8:00 to 8:30 P.M., August 2, 1933, according to information supplied by the City Engineer of Colorado Springs. The dam failed at 12:10 A.M. Runoff is estimated by the State Engineer at 2,640 acre-feet. High water marks at a number of sections in the channel at the Cherry Creek damsite indicate a maximum inflow rate of 11,000 second-feet. The hydrograph (drawing 256-D-86) reflects these data. Hydrographs are also