

CHAMP Phase III, Mineral County, Colorado Hydrologic Analyses Report

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COLORADO

**Department of
Natural Resources**



FEMA

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List of Abbreviations

CDOT	Colorado Department of Transportation
CHAMP	Colorado Hazard Mapping Program
CWCB	Colorado Water Conservation Board
DEM	Digital Elevation Model
EMA	Expected Moments Algorithm
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
HEC-HMS	Hydrologic Engineering Center – Hydrologic Modeling Software
HEC-SSP	Hydrologic Engineering Center – Statistical Software Package
LOMA	Letter of Map Amendment
LPIII	Log-Pearson Type III
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
USDA	United States Department of Agriculture
USGS	United States Geological Survey

Introduction

Wood is working with the Colorado Water Conservation Board (CWCB) to develop data in the Flood Risk Project for the Colorado Hazard Mapping (CHAMP) Phase III project for the Federal Emergency Management Agency (FEMA) that may or may not result in new or updated Flood Insurance Rate Maps (FIRM) and Flood Insurance Study (FIS) reports.

Scope

New detailed hydrology for portions of Willow Creek and approximate hydrology for Rio Grande extending the county limits was developed within Mineral County. All analyses were developed using Bulletin 17C stream gage analysis. Table 1 shows a summary of each of the reaches within Mineral County. The scoped Zone A and Zone AE reaches in Mineral County are displayed in Figure 1.

Table 1 – Detailed Study Summary of Methods

Flooding Source	Reach	Stream Miles	Hydrologic Methodology
Rio Grande	From Rio Grande/Mineral County Boundary to Hinsdale/Mineral County Boundary	42.9	Bulletin 17C Stream Gage Analysis
Willow Creek	From confluence with Willow Creek to Platte Valley Trolley Railroad	1.7	Bulletin 17C Stream Gage Analysis

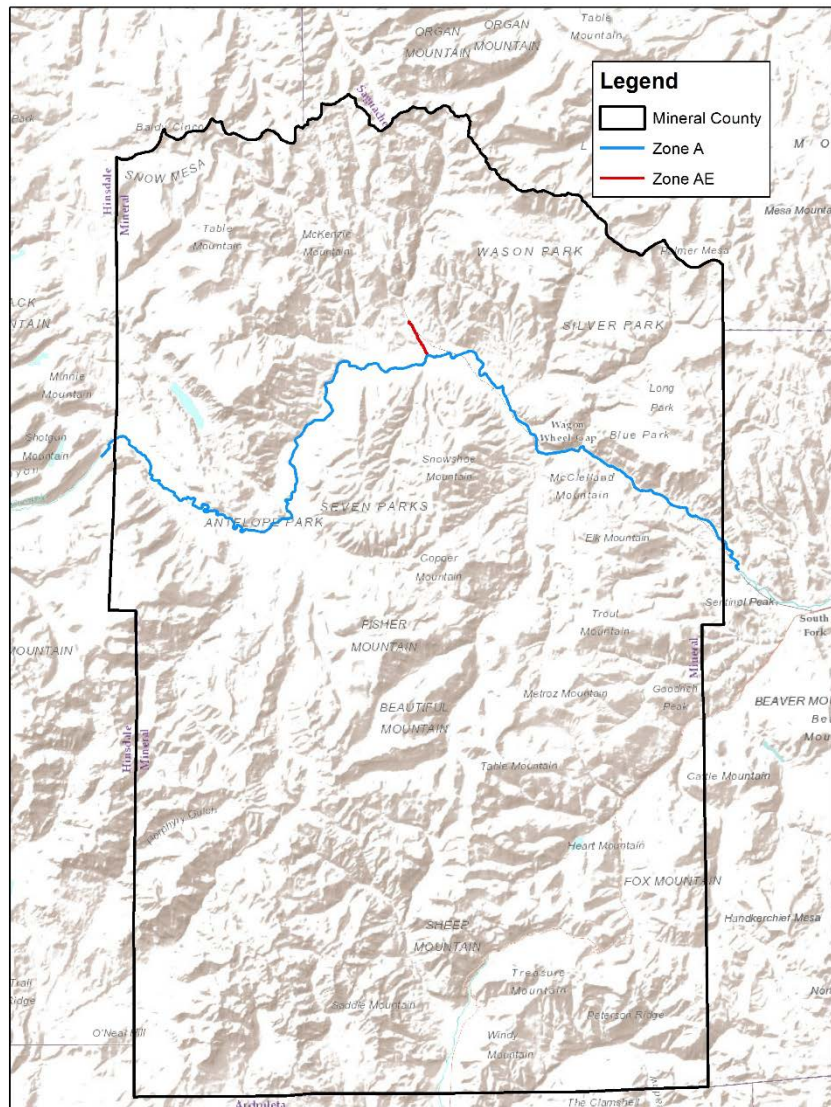


Figure 1 – Zone A and Zone AE reaches in Mineral County

Existing Hydrology

Flood Insurance Study

The current Mineral County, Colorado studies all mapped flooding sources as Zone A.

Letters of Map Change

As of November 2017, there are no documented Letters of Map Change within Mineral County.

Proposed Hydrology

Method Selection

Bulletin 17C stream gage analysis was used in determining the hydrology for all studied reaches in Mineral County.

Bulletin 17C Stream Gage Analysis using Log-Pearson Type III and EMA

Three U.S. Geological Survey (USGS) gaging stations were evaluated in the Hydrologic Engineering Center's Statistical Software Package) HEC-SSP Version 2.1.1) using Log-Pearson Type III (LP III) and Expected Moments Algorithm (EMA) outlined in Bulletin 17C. The gages analyzed were Rio Grande at Thirtymile Bridge near Creede (08213500), Rio Grande at Wagon Wheel Gap (08217500) and Willow Creek at Creede (08216500). The annual peak flow data was extracted directly from the USGS websites when performing the HEC-SSP Bulletin 17C analysis. Skew is a measure of the asymmetry of the probability distribution of a real-valued random variable about its mean. Station Skew option is based solely on computing a skew from the data points contained in the dataset. Station skew is chosen due to the significant record length at the gages and the reaches in question being on major streams and not smaller tributaries.

USGS Qualification Codes

USGS qualification codes were available for all data downloaded from the USGS website. Table 2 shows the codes encountered in the gage data for the Arkansas River, Purgatoire River, and Horse Creek along with an approach of how they were incorporated into the FFA.

Table 2 – USGS Qualification Codes and Approach

Code #	Description	Approach
1	Discharge is a Maximum Daily Average	All records with this code were outside of the years used in the analysis.
6	Discharge affected by Regulation or Diversion	No change in approach. Reservoirs have been in operation for a long enough time that data points used in the FFA represent actual conditions and are the best available data for the location.

- Qualification codes were not available for the Willow Creek at Creede gage.

Gage Projection

The methodology outlined in the Water Resources Investigations Report (WRIR) 99-4190 “Analysis of the Magnitude and Frequency of Floods in Colorado” was consulted to project gage results to locations on the same stream for the purposes of developing FIS flow change locations. The equation outlined in the report is:

$$Q_{T(u)} = Q_{T(g)}(A_u/A_g)^x$$

Equation (3): Peak Discharge Projection

Where $Q_{T(u)}$ is the peak discharge, in cubic feet per second, at the ungaged site for T-year recurrence interval; $Q_{T(g)}$ is the weighted peak discharge, in cubic feet per second, at the gaged site for T-year recurrence interval; A_u is the drainage area, in square miles, at the ungaged site; A_g is the drainage area, in square miles, at the gaged site; and x is the average exponent for drainage area. The Rio Grande and Willow Creek Basins lie completely within the Rio Grande Region and have an exponent (x) of 0.88 as used in Equation (3), as defined in WRIR 99-4190. The limit of this projection is between 0.5 and 1.5 times the drainage area of the projected gage. The peak discharge projection was used to project the Bulletin 17C flows. To ensure consistency, all drainage areas for this process were obtained from the USGS StreamStats tool.

Rio Grande Flows

There are two USGS gaging stations on the Rio Grande within Mineral County. The first gaging station at Wason has annual peak flow data from 1907-1954 while the second gaging station downstream at Wagon Wheel Gap has data from 1951-2000. Based on the period of record at the Wason gage, it was determined that the Wason flow data is not representative of current conditions due to reservoir development upstream in the basin and was not used in this analysis. The Wagon Wheel Gap flow data is post-reservoir and representative of current conditions, however, the gage cannot be projected to the upstream extents of the study reach because the reduction in drainage area exceeds the recommended maximum of 50%. The nearest upstream gage on the Rio Grande (excluding Wason) is at Thirtymile Bridge in Hinsdale County, just below Rio Grande Reservoir. Since the Thirtymile Bridge gaging station is immediately downstream a reservoir, it is not recommended to project flows derived from a FFA. This removes the possibility of projecting the FFA results from the Thirtymile Bridge downstream to the upstream extents of the study reach. Instead, a weighted average of the FFA results from Thirtymile Bridge and the FFA results from Wagon Wheel Gap was applied to section of the study reach between the Mineral-Hinsdale county line (upstream extents) and the Wagon Wheel Gap gaging station. Three flow change locations were determined necessary for this section based on a 10% change in flow between each flow change location. The FFA results from Wagon Wheel Gap were projected downstream (site Analysis of the magnitude and frequency of flood in Colorado equation 4) for the section of the study reach between the Wagon Wheel Gap gaging station and the Mineral-Rio Grande county line. Table 3 shows the results from the FFA along the Rio Grande.

Willow Creek Flows

Willow Creek is a minor tributary to the Rio Grande that flows through the town of Creede. Flow data for the Creede gage extends back to 1951. An analysis performed by the Natural Resources Conservation Service (NRCS) report an estimate for flood flows that occurred in 1911, 1921, 1927, 1941, 1948, and 1949 as determined by William Mullen, PE and were cited from an older USACE study. The flows for the listed years are shown in Table 3 which was reproduced from the NRCS report.

Table 3 – Flood events occurring before USGS gage installation (Mullen, 1986)

Year	Estimated Peak Flow (cfs)	Event Type
1911	1,800	Rain
1921	1,400	Snow
1927	1,400	Rain on Snow
1941	1,400	Snow
1948	1,200	Snow
1949	1,300	Snow

Estimated peak flows are from a COE study. Supporting computations have not been found.

The NRCS report states that for the historic flow values, “(*t)he supporting computations for these values have not been found” (Hyde, 2002), and ultimately recommended discharges for the Confluence of Willow Creek and the Rio Grande from the NRCS Report are shown in Table 4.

Table 4 – Flows from NRCS Report for Willow Creek

Location	Discharge (cfs)			
	10%	4%	2%	1%
Willow Creek at Confluence with Rio Grande	689	888	1,046	1,213

In performing this gage analysis, research was performed to try to determine the validity of these historic flows and no information was found. Additionally, no upstream regulation has been implemented on this stream to justify a basin change that would permanently decrease the recorded peak flow as is seen in post-1951 flows. However, based on correspondence with Colorado paleoflood expert Bob Jarrett (Retired USGS) these flows were likely overestimated for a variety of reasons. In documentation that Dr. Jarrett provided, it states that one of the major reasons for these overestimations was the selection of manning’s “n” values being too low for the boulder bed channels typically encountered. This resulted in Froude numbers far exceeding 1 (Jarrett, 1987) (Jarrett, 1985). Because of this, many of the historic peak flow estimates were overestimated by as much as 40% (Jarrett, 1994). Following this methodology, the observed peak flows were reduced by 40% as shown in Table 5:

Table 5 – Historic Peak Flow Reduction

Year	Estimated Peak Flow (cfs)	Reduced Peak Flow (cfs)
1911	1,800	1,100
1921	1,400	840
1927	1,400	840
1941	1,400	840
1948	1,200	720
1949	1,300	780

In order to count for uncertainty, a 20% +/- error bounds were added to these peak flows in the statistical model. The 20% lower error bound was added to account for further uncertainty in the measurement from other sources, and the 20% upper bound was added to the original flows to account for uncertainty in the measurement and the flow reduction itself. During the years where no flow was recorded in between these six peaks, a peak flow range of 0-576 cfs (the lowest of the historic peaks with error bounds) was assumed with the rationale that if a flood event greater than that did occur, there would have been some historical record of it that could be found.

A paleoflood study was also performed by Dr. Jarrett in the Summer of 2019 to attempt to gather paleoflood evidence to verify the magnitude of these historic floods. Due to channel disturbances from mining activities and other development, no suitable paleoflood sites were found which would provide flow data prior to when the gage went offline in 1982. From the paleoflood evidence that was present, a historic maximum flow post 1982 was estimated to be 1,040 cfs. This estimate was used as a threshold for all years between 1983 and 2018. The paleoflood investigation also estimated the peak flow for 2019 as 660 cfs. This value was given +/-20% error bounds and was also added to the analysis.

Skew values of 0.11 with a mean squared error (MSE) of 1 were used as the regional skew as these were taken from the NRCS Report. A weighted skew was developed using the regional skew and the station skew and was applied to the analysis. Final skew values for the analysis were -0.101 with an MSE of 0.116. The low outlier threshold for the analysis was set to 120 cfs which censors out data points which don't reflect the overall trend in the less frequent events.

Final flows from the FFA analysis on the Creede gage are shown in Table 6.

Table 6 – Bulletin 17C Stream Gage Analysis

Gage #	Gage/Location Name	Zone	Drainage Area (mi ²)	Projection Area Ratio	Gage Analysis/Projected Flows						Change in 1% Flow
					10%	4%	2%	1%	1% Plus	0.20%	
	Rio Grande at Rio Grande/Mineral County Line	A	892	1.14	4,980	5,590	6,000	6,390	7,120	7,230	
08217500	Rio Grande at Wagon Wheel Gap	A	780	1.0	4,430	4,960	5,330	5,680	6,320	6,420	-11%
	Rio Grande at CR 806	A	622	---	3,870	4,390	4,770	5,130	5,860	5,990	-10%
	Rio Grande Upstream of confluence of Red Mt. Creek	A	472	---	3,350	3,850	4,230	4,620	5,420	5,580	-10%
	Rio Grande Upstream of confluence of Clear Creek	A	260	---	2,610	3,080	3,470	3,890	4,800	5,000	-16%
08213500 ¹	Rio Grande at Thirtymile Bridge		163	---	2,270	2,730	3,120	3,550	4,520	4,740	
	Willow Creek at Confluence with Rio Grande	AE	39	1.11	591	831	1,030	1,250	1,600	1,840	10%
08216500 ¹	Willow Creek at Creede		35	1.0	540	759	943	1,140	1,460	1,680	

¹ Gage/Location was used for analysis but is outside the stream study extents.

MIP Submittal File Structure

All hydrologic data development TSDN files have been submitted digitally along with this TSDN. The contents have been structured according to the May 2017 Data Capture Standards (DCS) Technical Reference.

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