Hydrology Report

Colorado River Hydrologic Evaluation

Task Order No. 16

Granby to the State Line

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1.0 Introduction

The Colorado River is one of the largest and most well-known rivers in Colorado, both due to its name and the amount of flow the river carries each year. The river is a lifeline, with hundreds of thousands of users on both the west and east slope of the Rocky Mountains. Water from the river is diverted for a variety of uses from the peach orchards in Palisade to domestic water supplies for towns and cities. Downstream users in Utah, Arizona, Nevada, California, and Mexico are also highly dependent on these flows due to the arid regions the river flows through.

Typically, peak flows in the Colorado River are seen in the spring to early summer, during the time when snowmelt is occurring; however, high intensity thunderstorms are possible and can cause significant localized flooding on some of the smaller tributaries, though rarely causing flooding on the Colorado River itself. Although constructed for water supply and irrigation, the Colorado-Big Thompson Project (completed in the 1950's) (USBR, 2017a) and the Colorado River Storage Project (completed in the 1970's) (USBR, 2017b) along with many other similar reservoir construction projects have had considerable storage and attenuation impacts that have changed the Colorado River's hydrologic response. In addition, many diversion structures have also been installed along the river which divert flows for municipal and agricultural uses. When examining the latest gage data, a downward trend in annual floods along the Colorado River is observed. This is particularly evident since the 1950's, and is likely the result of man-made river controls.

No in-depth study has directly examined the impacts of these structures on flood flows in the Colorado River Basin and whether they impact the estimated peak flows at various return periods. This study examined the gage records from 15 gage stations along the Colorado River and performed a hydrologic flood frequency analysis (FFA) to examine the impacts of these structures on the overall flows in the Colorado River and whether they attenuate some of the major flooding events the river has historically experienced, despite none of the control structures being specifically designed for flood control.

The science behind flood prediction is not, in any form, exact. Using statistical models, with traditionally short data records, to predict high flows in extreme events with any decent level of precision is troublesome at best. Add in the number of variables along the stream such as reservoir detention, supply diversions, flow attenuation, variations in demand over time, and evaporation/infiltration rates, and the whole process becomes even more complicated.

The purpose of this study was to achieve the following three primary objectives:

1. *Analyze annual observed peak flow records, assuming each annual record is an independent observation, with no further analysis into the mechanisms causing the recorded flows. Meaning that peak flows in sequential years are treated equally, even if there is evidence that the flows in one of those years were influenced by the snowpack of the previous year or other factors (non-independent observation).*

2. *Evaluate whether peak flows in the upper Colorado River Basin (within Colorado) are inherently different following the construction of numerous upstream reservoirs and diversions.*

3. *Develop new flows using the methodologies outlined in Bulletin 17C at existing and potential future Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) locations.*

1.1 Background

The Colorado River Basin has been studied for the past 110 years, including multiple FFAs and updates to local FIS documents. All of the hydrology for these documents was completed in the 1960's which did not provide enough time for the impacts of the constructed reservoirs and diversions to be seen in the gage records or FFAs. As such, the peak flows from these existing studies is likely not representative of the current conditions within the basin. In addition, there is considerably more gage data available than there was for previous analyses. Most of the existing FIS documents along the Colorado River and its tributaries use a regional approach based on gage analysis; however, each discrete analysis was limited to the general area of the tributary with no examination of how flows compared to other gages along the Colorado River or other tributaries.

As part of this investigative study, a database of existing hydrologic documents was compiled. These documents included Colorado River Storage Project annual reports, reservoir information, drainage master plans, flood hazard inventory (FHI) studies, floodplain information reports (FIR), floodplain management studies (FMS), and floodplain studies (FS), among others. Most of these documents provided a localized analysis of individual areas of the Colorado River Watershed. These documents were reviewed and used to provide context and verification of the developed hydrology in this report. Most of the studies occurred between 1975 and 2002, with a few areas having more recent FIS analyses. None of these studies included updates to the hydrology within the basin and referenced the flows developed in the 1960's.

This study examined the impact of storage facilities (reservoirs) and noteworthy diversion projects, from and to the Colorado River, along with their impacts on the hydrologic peak flows and their impact on the flood recurrence intervals. Gage data from before and after the completion of these reservoir construction projects has been subjected to multiple Log-Pearson Type III (LPIII) analyses to determine the impacts of the constructed detention and diversion structures along the Colorado River, and their overall impact on projected hydrologic peak flows for various return periods. LPIII was used due to its applicability with hydrologic data and the ability to analyze skewness of the data.

Furthermore, the intent of the analysis was to take advantage of the newly released Bulletin 17C, which includes a new approach to addressing potentially-influential low floods (PILFs) by adjusting the low outlier threshold (LOT) as well as incorporates the Expected Moments Algorithm to allow for interval data. In addition, this report provides updated hydrologic language and results for use in FIS documents for Mesa, Garfield, Grand, and Eagle Counties as well as hydrologic results to use in future modeling or related studies in the affected communities. The proposed language for the FIS documents, along with the hydrologic results, is included in Appendices D through G of this report. As the update to the Garfield County FIS is currently underway, the language was made to match the 2014 FIS template. All other counties are using the latest 2016 FIS template, per guidance from FEMA.

For this analysis, gage data was extracted from 14 locations along the Colorado River, extending from Granby, CO, to the Colorado-Utah border. An additional gage near Cisco, Utah was included in the analysis to help tie this study to the downstream segment. Large reservoirs within the contributing area to each gage have been included in the descriptions for each gage. More information on the impacts of these reservoirs and the large diversions along the Colorado River are provided in Section 2.0.

1.2 Gage Information

The following stream gages, from most upstream to most downstream, have been included as part of the statistical analysis. Figure 1-1 shows the location of the gages as well as other diversions within the Colorado River Basin.

USGS Gage 09019000 – Colorado River below Lake Granby, CO

This gage, operated by the U.S. Geological Survey (USGS), was located just below the outlet works at Lake Granby, approximately 0.3 miles downstream from the dam crest. The drainage basin area for this gage is 312 square miles and is at an elevation of 8,050 feet referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29). The gage has 32 years of peak stream flow values dating from June 1951 to June 1982. The gage is no longer recording current flow data. The entire record of this gage is under the influences of Shadow Mountain Lake and Lake Granby, which were both constructed prior to the gage being put in operation.

USGS Gage 09019500 – Colorado River near Granby, CO

This gage, operated by the USGS, is located upstream of the U.S. Highway 34 bridge above Granby, approximately 0.3 miles upstream from the bridge. The drainage basin area for this gage is 323 square miles and is at an elevation of 7,960 feet (NGVD 29). The gage has 79 years of peak stream flow values dating from June 1908 to June 1911 and May 1934 to Present. This gage began recording data prior to the construction of both Shadow Mountain Lake and Lake Granby and is the nearest gage to provide information from both before and after these reservoirs went into operation.

USGS Gage 09034250 – Colorado River at Windy Gap, near Granby, CO

This gage, operated by the USGS, is located at the downstream side of the Colorado Highway 57 bridge west of Granby, approximately 1.1 miles downstream of Windy Gap Reservoir. The drainage basin area for this gage is 788 square miles and is at an elevation of 7,790 feet (NGVD 29). The gage has 35 years of peak stream flow values dating from July 1982 to Present. In addition to the upstream reservoirs, the entire record of this gage is under the influence of Willow Creek Reservoir, which was constructed prior to the gage being put in operation.

USGS Gage 09034500 – Colorado River at Hot Sulphur Springs, CO

This gage, operated by the USGS, was located downstream of the U.S. Highway 40 bridge northeast of Hot Sulphur Springs, approximately 0.5 miles downstream from the bridge. The drainage basin area for this gage is 825 square miles and is at an elevation of 7,670 feet (NGVD 29). The gage has 86 years of peak stream flow values dating from June 1905 to June 1994. The gage is no longer recording current flow data. The later years of record at this gage are influenced by the upstream reservoirs.

USGS Gage 09058000 – Colorado River near Kremmling, CO

This gage, operated by the USGS, is located downstream of the Colorado Highway 9 bridge at Kremmling, approximately 6.0 miles downstream from the bridge. The drainage basin area for this gage is 2,379 square miles and is at an elevation of 7,320 feet (NGVD 29). The gage has 68 years of peak stream flow values dating from June 1905 to June 1918 and May 1962 to Present. This gage began recording data prior to the construction of Williams Fork Reservoir, Wolford Mountain Reservoir, Green Mountain Reservoir, and Dillon Reservoir. The gap in the data between 1919 and 1961 covers the period when Green Mountain Reservoir, Williams Fork Reservoir and Dillon Reservoir went into operation. Wolford Mountain Reservoir went into operation after 1962 so its effect on flows is also seen within the data of this gage.

USGS Gage 09070500 – Colorado River near Dotsero, CO

This gage, operated by the USGS, is located downstream of the I-70 bridge at Dotsero, approximately 1.6 miles downstream from the bridge. The drainage basin area for this gage is 4,390 square miles and is at an elevation of 6,130 feet (NGVD 29). The gage has 76 years of peak stream flow values dating from May 1941 to Present. This gage provides data from both before and after Homestake Reservoir went into operation.

USGS Gage 09072500 – Colorado River at Glenwood Springs, CO

This gage, operated by the USGS, was located upstream of the Grand Avenue bridge (Colorado Highway 82), approximately 0.25 miles upstream from the bridge. The drainage basin area for this gage is 4,558 square miles and is at an elevation of 5,721 feet (NGVD 29). The gage has 67 years of peak stream flow values dating from May 1900 to May 1966. The gage is no longer recording current flow data. As this gage operated prior to 1966, most of the records are not influenced by the majority of reservoirs as they were constructed after the gage ceased operation.

USGS Gage 09085100 – Colorado River below Glenwood Springs, CO

This gage, operated by the USGS, is located downstream of the Devereux Road Bridge, approximately 0.2 miles downstream from the bridge. The drainage basin area for this gage is 6,014 square miles and is at an elevation of 5,701 feet (NGVD 29). The gage has 50 years of peak stream flow values dating from June 1967 to Present. Ruedi Reservoir went into service sometime between 1966-1968, so 1967 was selected to start the gage record for the analysis.

USGS Gage 09093700 – Colorado River near De Beque, CO

This gage, operated by the USGS, was located upstream of the I-70 bridge near De Beque, approximately 3.1 miles upstream from the bridge. The drainage basin area for this gage is 7,370 square miles and is at an elevation of 4,940 feet (NGVD 29). The gage has 31 years of peak stream flow values dating from May 1967 to June 1997. The gage is no longer recording current flow data. This gage provides information for when Rifle Gap Reservoir went into operation until the gage was decommissioned.

USGS Gage 09095500 – Colorado River near Cameo, CO

This gage, operated by the USGS, is located upstream of the I-70 Beavertail Tunnel, which is located at mile marker 50.4, approximately 4.9 miles northeast of Cameo. The gage is located approximately 4.0 miles upstream from north entrance of the tunnel where the Colorado River crosses under the highway. The drainage basin area for this gage is 7,986 square miles and is at an elevation of 4,814 feet (NGVD 29). The gage has 83 years of peak stream flow values dating from May 1934 to Present. No nearby large upstream reservoirs are present at this gage.

USGS Gage 09106000 – Colorado River near Palisade, CO

This gage, operated by the USGS, was located upstream of the I-70 bridge above Palisade, approximately 0.3 miles upstream from the bridge. The drainage basin area for this gage is 8,738 square miles and is at an elevation of 4,740 feet (NGVD 29). The gage has 32 years of peak stream flow values dating from May 1902 to June 1933. The gage is no longer recording current flow data. The entire record of this gage is prior to the influence of Vega Reservoir.

USGS Gage 09106150 – Colorado River below Grand Valley Diversion near Palisade, CO

This gage, operated by the USGS, is located downstream of the G Road bridge in Palisade, approximately 0.75 miles downstream from the bridge. The drainage basin area for this gage is 8,813 square miles and is at an elevation of 4,670 feet (NGVD 29). The gage has 26 years of peak stream flow values dating from June 1991 to Present. The entire record includes the influence of Vega Reservoir.

USGS Gage 09153000 – Colorado River near Fruita, CO

This gage, operated by the USGS, was located just upstream of the Maple Street bridge at Fruita. The drainage basin area for this gage is 17,100 square miles and is at an elevation of 4,490 feet (NGVD 29). The gage has 17 years of peak stream flow values dating from a single entry for July 1884 and then June 1908 to May 1923. The gage is no longer recording current flow data.

USGS Gage 09163500 – Colorado River near Colorado-Utah State Line

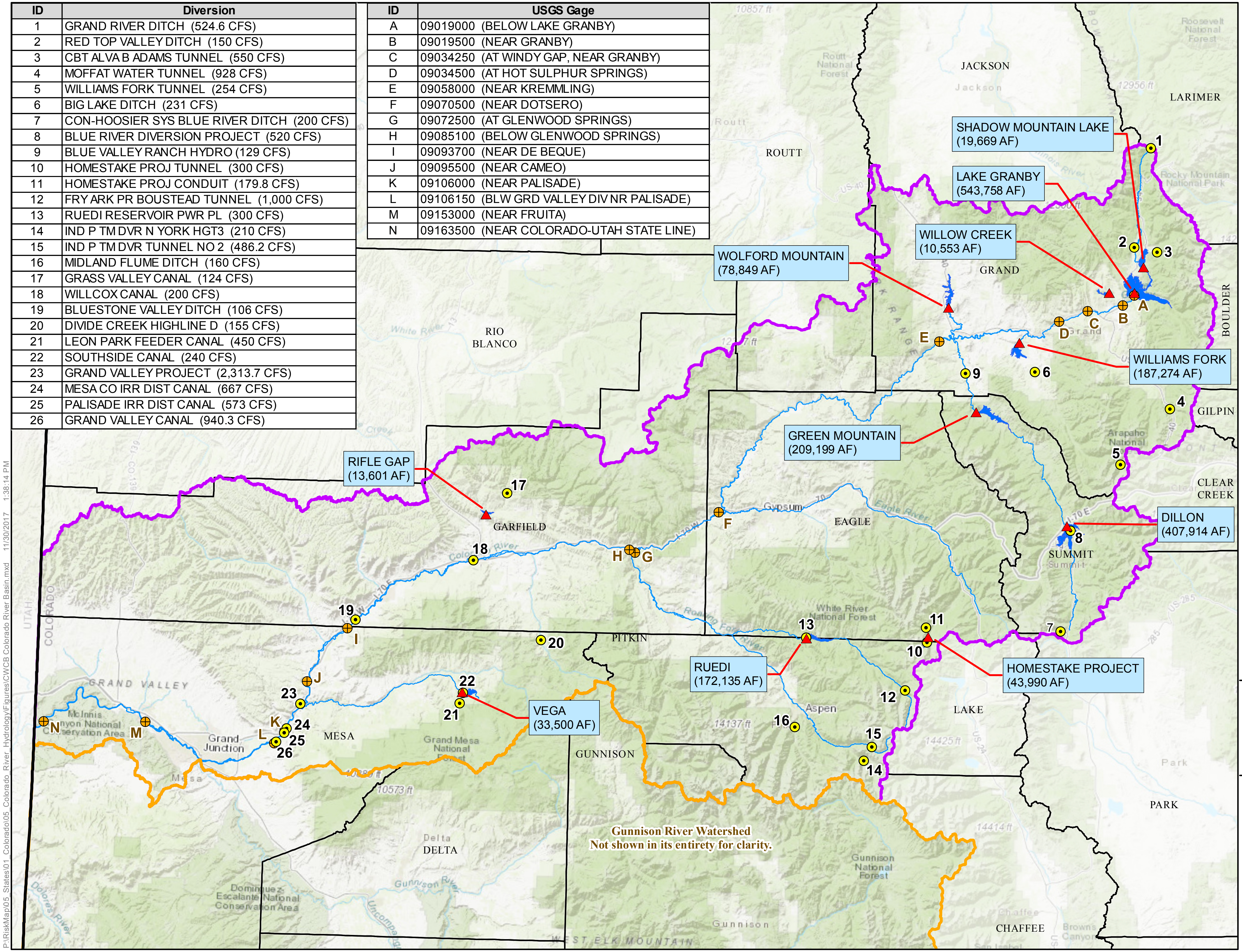
This gage, operated by the USGS, is located 2.1 miles upstream from the Colorado-Utah border. The drainage basin area for this gage is 17,849 square miles and is at an elevation of 4,325 feet (NGVD 29). The gage has 66 years of peak stream flow values dating from June 1951 to Present.

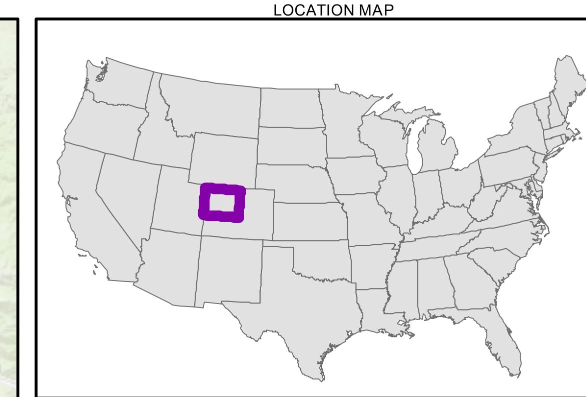
USGS Gage 09180500 – Colorado River near Cisco, UT

This gage, operated by the USGS, is located 0.75 miles upstream from the State Highway 128 bridge near Dewey, UT. The drainage basin area for this gage is 24,100 square miles and is at an elevation of 4,090 feet (NGVD 29). The gage has 99 years of peak stream flow values dating from July 1884 to Present. There is a gap in data between 1885 and 1913 which is the time between the historic 1884 event and the systematic gage record starting in 1914.

ID	Diversion
1	GRAND RIVER DITCH (524.6 CFS)
2	RED TOP VALLEY DITCH (150 CFS)
3	CBT ALVA B ADAMS TUNNEL (550 CFS)
4	MOFFAT WATER TUNNEL (928 CFS)
5	WILLIAMS FORK TUNNEL (254 CFS)
6	BIG LAKE DITCH (231 CFS)
7	CON-HOOSIER SYS BLUE RIVER DITCH (200 CFS)
8	BLUE RIVER DIVERSION PROJECT (520 CFS)
9	BLUE VALLEY RANCH HYDRO (129 CFS)
10	HOMESTAKE PROJ TUNNEL (300 CFS)
11	HOMESTAKE PROJ CONDUIT (179.8 CFS)
12	FRY ARK PR BOUSTEAD TUNNEL (1,000 CFS)
13	RUEDI RESERVOIR PWR PL (300 CFS)
14	IND P TM DVR N YORK HGT3 (210 CFS)
15	IND P TM DVR TUNNEL NO 2 (486.2 CFS)
16	MIDLAND FLUME DITCH (160 CFS)
17	GRASS VALLEY CANAL (124 CFS)
18	WILLCOX CANAL (200 CFS)
19	BLUESTONE VALLEY DITCH (106 CFS)
20	DIVIDE CREEK HIGHLINE D (155 CFS)
21	LEON PARK FEEDER CANAL (450 CFS)
22	SOUTHSIDE CANAL (240 CFS)
23	GRAND VALLEY PROJECT (2,313.7 CFS)
24	MESA CO IRR DIST CANAL (667 CFS)
25	PALISADE IRR DIST CANAL (573 CFS)
26	GRAND VALLEY CANAL (940.3 CFS)

ID	USGS Gage
A	09019000 (BELOW LAKE GRANBY)
B	09019500 (NEAR GRANBY)
C	09034250 (AT WINDY GAP, NEAR GRANBY)
D	09034500 (AT HOT SULPHUR SPRINGS)
E	09058000 (NEAR KREMMLING)
F	09070500 (NEAR DOTSERO)
G	09072500 (AT GLENWOOD SPRINGS)
H	09085100 (BELOW GLENWOOD SPRINGS)
I	09093700 (NEAR DE BEQUE)
J	09095500 (NEAR CAMEO)
K	09106000 (NEAR PALISADE)
L	09106150 (BLW GRD VALLEY DIV NR PALISADE)
M	09153000 (NEAR FRUITA)
N	09163500 (NEAR COLORADO-UTAH STATE LINE)





LEGEND

- Dams
- Diversions
- USGS Gage Number (Approx. Location)
- Rivers
- Reservoir Name (Decreed Volume [acre-ft])
- Colorado River Basin
- Gunnison River Basin
- Counties
- States

0 7.5 15 30 Miles

FIGURE 1
Gage, Dam, and Diversion Locations
Colorado River
November 2017

amec foster wheeler

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

P:\RiskMap\05_States\01_Colorado\05_Colorado_River_Hydrology\Figures\CWCB Colorado River Basin.mxd 11/30/2017 1:38:14 PM

1.3 Existing Hydrological Information

The Colorado River flows through four counties, three of which have their own effective county-wide FIS.

- Grand County and Incorporated Areas, effective January 2, 2008
- Eagle County and Incorporated Areas, effective December 4, 2007
- Mesa County and Incorporated Areas, effective October 16, 2012

At the time of publication of this report, Garfield County did not have an effective county-wide FIS. Instead, there are community-based effective FIS documents for several municipalities within the county.

- City of Glenwood Springs, effective October 15, 1985
- Garfield County Unincorporated Areas, effective August 2, 2006
- Town of Parachute, effective September 27,1991
- Town of Silt, effective August 2, 2006
- Town of Carbondale, effective February 5, 1986
- City of Rifle, effective January 3, 1986

Language and data from the November 23, 2016 Preliminary FIS for Garfield County and Incorporated Areas is referenced in this report. Subsequent revisions to the preliminary study may have occurred since this publication.

The following sections detail background information on hydrologic methods performed on the Colorado River in each of the above-mentioned FIS reports, as well as other reports collected and analyzed during this study.

1.3.1 Grand County

Hydrology for the Colorado River within Grand County has never been compiled within any formal FIS document. All previous FIS documents outline effective peak flows for tributaries to the Colorado River, but do not contain flows for the Colorado River. This is believed to be due to the high level of regulation in this area of the basin provided by Lake Granby and the other reservoirs within Grand County, as well as the lack of large communities adjacent to the Colorado River within the county.

1.3.2 Eagle County

The only Colorado River study available for Eagle County is an approximate four-mile reach between the county line and the I-70 bridge. It is suspected that due to the level of regulation on the Colorado River and the lack of large communities adjacent to the Colorado River in the county, no detailed hydrologic analysis was ever performed for the other stretches of Colorado River.

The Eagle County FIS references a 2003 FIR compiled by Matrix Design Group (MDG) in conjunction with Eagle County and the Colorado Water Conservation Board (CWCB). The 2003 FIR then references a study entitled Eagle River Flood Hydrology by Water Resource Consultants, LLC of Rifle in 2002. The Water Resource Consultants analysis included a LPIII FFA in accordance with Bulletin 17B and used available hydrologic data through 1996 from the 09070500 Dotsero gage (56 years). The final suggested flow values in the report indicate that the Log-Pearson is for 1941-present (which was assumed to be 1996). The study also referenced flows used for a Conditional Letter of Map Revision (CLOMR) application performed for the Two Rivers Village in Dotsero, Colorado by Wright Water Engineers, Inc. on June 15, 1998.

The previous design discharges presented in the 2002 Water Resource Consultants report, the 1998 Two Rivers Village CLOMR, and the flows used in the effective FIS for the area are shown in Table 1-1. Despite the differences in flows shown in the effective FIS, no additional detail is available regarding the development of these flows or why they are different. As such, the conflicting flows shown are not understood.

Table 1-1 - Eagle County Peak Flows from Previous Reports

Source	Location	Drainage Area (sq mi)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
1998 CLOMR	Colorado River near Dotsero, above confluence with Eagle River	-	-	-	26,000	29,500
Effective FIS	Colorado River Upstream of Eagle River	3,400	14,649	19,685	21,650	25,933
Effective FIS	Colorado River Downstream of Eagle River	4,344	18,950	24,900	27,140	31,830
1998 CLOMR	Colorado River near Dotsero, below confluence with Eagle River	4,394	22,090	29,351	32,100	37,800
2002 WRC Report	Colorado River near Dotsero, CO	4,394	16,400	21,600	23,600	25,500

1.3.3 Garfield County

For most areas of Garfield County, the flows along the Colorado River came from the January 1986 effective FIS report. The flows shown in the FIS reference United States Army Corps of Engineers (USACE) Report entitled: “Hydrology, Report, Colorado River from Glenwood Springs to DeBeque Canyon, Colorado” from September 1985. Based on numerous inquiries, all copies of this USACE report have gone missing. (Other documents, including the 1995 FIR from Rifle to the State Line prepared by the CWCB have referred to this report as “Unpublished”.) Flows for the Glenwood Springs area are referenced in the FIS to the Glenwood Springs FIR prepared in 1977 by Gingery Associates Inc. In the Gingery Associates report, the report states that hydrologic analyses were performed to establish peak discharge frequency relationships using gage data. The gages used were Colorado River at Glenwood Springs, 1900-1966, Colorado River at New Castle, 1966-1972, and Colorado River Below Glenwood Springs, 1966 – present (assumed to be 1976). Statistical data was calculated using the LPIII Method for stations with more than 12 years of record. Peak flows were then developed using HEC-1 and compared to the regional frequency curves developed using the LPIII Method. (Note, the 1977 Glenwood Spring FIR references a June 1976 USACE Flood Insurance Study that was unable to be located.)

Concurrently, three other Flood Hazard Information (FHI) Reports were published around the same time in 1976 by the USACE for Palisade, Grand Junction, and Fruita. Information from the Palisade FHI is found here, while information from the Grand Junction and Fruita FHI reports are found in the next section.

In the Palisade FHI, 10 miles of the Colorado River between the I-70 bridge east of Palisade to 32 Road were studied. No detailed hydrology calculations are presented in the report, however peak flows for the 1%- and 0.2%-annual-chance-exceedances were provided in the narrative as being calculated using regional envelope curves developed from discharge frequency data from earlier studies. The peak flows from the 1986 FIS for Garfield County and the Palisade FHI report is shown in Table 1-2.

Table 1-2 - Garfield County Peak Flows from Previous Reports

Source	Location	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
1986 Garfield (UA) FIS	Colorado River at Rifle	23,900	37,900	45,000	65,000
1986 Garfield (UA) FIS	Colorado River at New Castle	22,900	34,800	41,000	56,800
1986 Garfield (UA) FIS	Colorado River at Glenwood Springs	21,500	29,000	32,500	41,000
1976 Palisade FHI	Upstream of I-70 Bridge east of Palisade	-	-	63,000	82,000

1.3.4 Mesa County

Hydrology for the Colorado River within Mesa County has historically been developed from four documents, the most recent being a Hydrology Report performed by J.F. Sato & Associates in May 1989. The second is a reference in the most recent FIS which eventually leads back to the missing 1985 USACE report however, some useful information from the 1985 USACE report is included in the 1989 J.F. Sato & Associates report. Finally, two FHI Reports were prepared by the USACE in 1976 (Grand Junction and Fruita) which provided some additional hydrologic analysis.

In the Grand Junction FHI, 12 miles of the Colorado River between 22 Road and 32 Road were studied. Gaged flows through 1985 were analyzed and frequency curves were developed from the 1921 flood which was determined to have a recurrence interval of 250 years. To establish projected flows on the Colorado River, a 150 percent value of the 1921 flood flows at Palisade was determined and then reduced by 8,000 cfs to account for upstream reservoirs.

In the Fruita FHI, 12 miles of the Colorado River between the vicinity of 13 Road and the Vicinity of 22 Road were studied. Snowmelt flows were analyzed and frequency curves were developed using the same method as the Grand Junction FHI with the 1921 flood event at Palisade. These flows were then added to the flows developed using a similar methodology with the 1921 flood event on the Gunnison River to develop the standard project flow at Fruita.

The 1989 J.F. Sato report performed a LPIII FFA in accordance with Bulletin 17B and used available hydrologic data through 1985 for the 09095500 Cameo (52 records), 09106000 Palisade (32 records), 09153000 Fruita (13 records), and 09163500 State Line (35 records) gages. The analysis was run using the “Hydrodata” system developed by US West Optical Publishing, and the companion program “fffreak” in 1989. Based on a desktop search at the time this document was written, the model program could not be found to be downloaded. Table 1-3 provides the previous design discharges presented by both the 1989 J.F. Sato report and the 1985 USACE Report used in the previous FIS for the area.

Table 1-3 - Mesa County Peak Flows from Previous Reports

Source	Location	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
1989 J.F. Sato	Colorado River near Cameo Gage *	31,600	42,400	47,000	58,000
1989 J.F. Sato	Study area above mouth of Gunnison	32,900	44,400	49,300	61,000
1985 USACE	Study area above mouth of Gunnison	40,000	56,400	63,000	82,000
1976 GJ-FHI Table GJ-1	Colorado River Above Mouth of Gunnison River	40,000	56,000	63,000	82,000
1989 J.F. Sato	Study area below mouth of Gunnison	50,600	73,100	83,700	111,400
1985 USACE	Study area below mouth of Gunnison	55,000	73,000	82,000	107,000
1976 GJ-FHI Table GJ-1	Colorado River Below Mouth of Gunnison River	55,000	73,000	82,000	107,000
1976 Fruita FHI	Colorado River Fruita Gaging Station	-	-	82,000	107,000
1989 J.F. Sato	Colorado River near State Line	51,200	69,700	77,400	95,000

* Data based on fffreak results reported in the 1989 J.F. Sato Report Appendix. The report text shows different flows.

2.0 Hydrologic Analysis

2.1.1 Standard Operations

None of the reservoirs within the Colorado River Basin were designed to provide flood control. Most of the reservoirs were constructed to collect snowmelt runoff after the peak flows have passed. As such, during expected peak flows, the reservoirs are at low levels and are designed allow the peak flows to pass unimpeded. Frequent flood events are collected and are highly attenuated by the reservoirs. In addition, despite not being designed to do so, these reservoirs do have a noticeable impact on the less frequent (~4%, 2%, or even the 1% annual chance) flooding events. Based on gage data, these reservoirs appear to attenuate flow as nearly all the gages examined in this study have a noticeable drop in peak flows from those observed prior to the reservoir construction versus those observed after.

Dillon Reservoir

The operation of Dillon Reservoir employs good neighbor practices in that they attempt to manage flows upstream of Silverthorne as much as possible to reduce adverse flood flow impacts downstream. At Dillon Reservoir, the diurnal is flat with inflows typically peaking at approximately 2,500 cfs with an outflow of approximately 1,800 cfs. (The valley of the diurnal may be considerably less than 1,800 cfs in many situations and the daily average will be much flatter as the flow reaches the Colorado River).

Lake Granby

The primary outlet from Lake Granby outlet is capped at 75 cfs. With Lake Granby being so large, there is significant natural attenuation of flood flows. For outlet flows to exceed 75 cfs, the dam must be full and the primary spillway active. This results in the attenuation of all small and some “medium” sized flooding events. Without these intermediate data points, the FFA for the Granby Gage, and theoretically for some distance downstream, is having its data split between very low flows and overtopping high flows which impacts the calculated frequency curve.

Ruedi Reservoir

Ruedi Reservoir is capped at a maximum discharge of 850 cfs due to flooding concerns in downstream developments. This could result in flooding issues should any uncontrolled flood releases of Ruedi Reservoir occur; however, to date this has not happened as Ruedi Reservoir is not fully utilized and can moderately regulate some of the more frequent flooding events. It will not have a measurable impact on the less frequent events.

Adams Tunnel

The Adams Tunnel has a capacity of 550 cfs, however when there is significant snow pack in the South Platte River Basin, no flow is diverted through the Adams Tunnel as less water from the Colorado basin is required to meet eastern slope demand. Horsetooth and Carter reservoir levels dictate operations at Lake Granby with regards to the Adams Tunnel and other diversions.

Coordinated Reservoir Operations

Since 1997, DWR – District 5 has implemented their Coordinated Reservoir Operations (CROS) which supplements water in the lower part of the basin by increasing releases from reservoirs in the upper part of the basin. This augmentation happens when flows near Cameo are between 12,600 cfs and 25,000 cfs and they are supplemented to reach 25,000 cfs. If flows are outside of this window, no diversion is made. No diversion is also made if there is any chance that the reservoir might not make its required water supply yield. Figure 2-1 shows the volumetric record of these diversions between 1997 and 2015. Figures highlighting the impacts of the CROS releases in 2010, 2015, and 2016 measured at the Colorado River near Palisade gage are included in Appendix A.

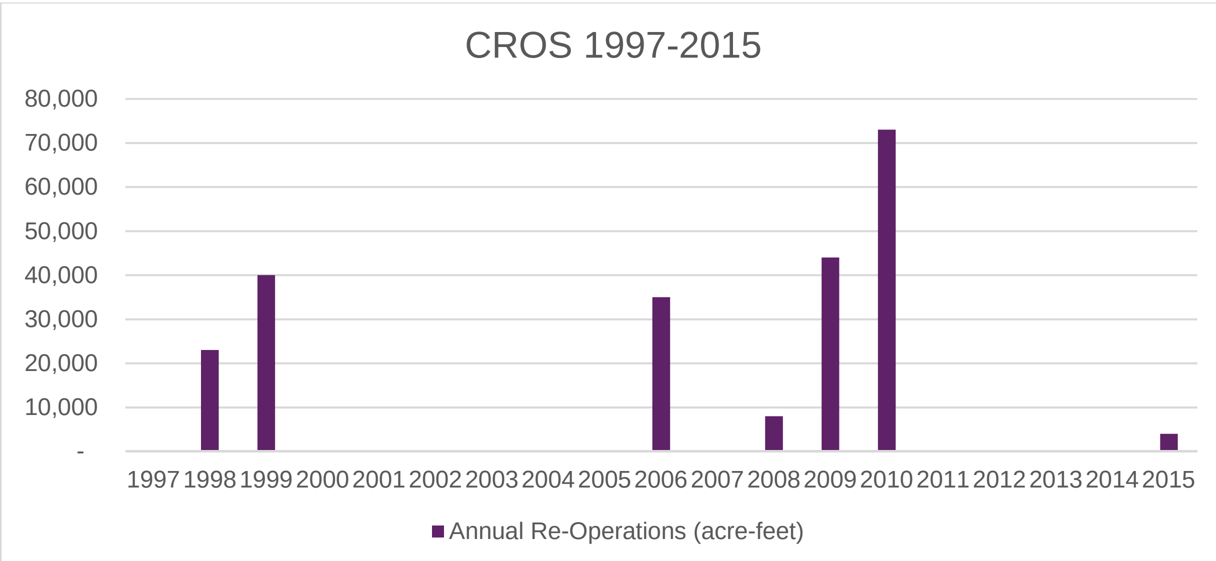


Figure 2-1 – CROS Diversions 1997-2015

Under standard operating procedures, how the flow in the Colorado River is managed depends on upstream reservoir water levels which may be driven by the snowpack of the previous year, water levels in reservoirs in the Platte Basin, CROS diversions or any other coordinated reservoir releases, water diversions by any of the water rights holders along the stream, consumptive use patterns and a host of other variables. All of these factors demonstrate the need for the simplifying assumption of assuming the flow values from each year are independent observances and could happen in any given year.

2.1.2 Flood Flow Operations

During high flood flows, most of the operational control that the reservoirs have is eliminated. In many cases, if there are high flows in the Colorado Basin due to excessive or rapid snowmelt, there are also high flows in the South Platte River Basin due to high snowmelt so none of the diversions over the Continental Divide will be operating. None of the reservoirs within the basin provide substantial amounts of attenuation for the less frequent storm/runoff flows and will all be bypassed based on operational control by DWR. However, when examining the data, especially at the gages in the upper part of the basin, there is a noticeable drop in moderate to extreme events after the reservoirs were constructed. This appears to indicate that the reservoirs do have an impact on the more extreme flooding events, although the reservoirs are not designed to have this impact. The following section investigates this trend further and explains how this influence appears to decrease the further downstream and the point at which this analysis assumes this impact becomes negligible.

2.1.3 Overall Hydrologic Impacts

For this flood frequency analysis, the events of concern are the more infrequent events such as the 2%-, 1%-, and 0.2%-annual-chance events. For these size events, it is assumed that minimal flood control will be provided by any of the reservoirs or diversions within the basin and would be limited to the first part of the hydrograph, however some attenuation of the peak flow is likely to occur as the peak passes through the outlet structure of the reservoirs. For the 10% annual chance event, some attenuation may be caused by reservoir operation, but it is highly unlikely. Diversion flows will also not likely have a meaningful impact during the 10% annual chance event or during the larger events.

For the lower flow events (events with a higher than 10%-annual-chance of recurrence), reservoir operation will have a large impact on the flows. Looking closely at the data from the Colorado River near Granby gage data, of the 79 data points, all the 38 potentially influential low floods (PILFs) censored during the Multiple Grubbs Beck test occurred in 1950 or later, after both Shadow Mountain Lake and Lake Granby were completed and in operation. The operation of these two reservoirs further attenuated the peak flows to levels below historic values. Figure 2-2 shows the annual flow data from the Colorado River near Granby gage versus time. The vertical line on the graph indicates the approximate time when most upstream detention was completed. The difference in magnitude before and after the construction of the reservoirs is evident.

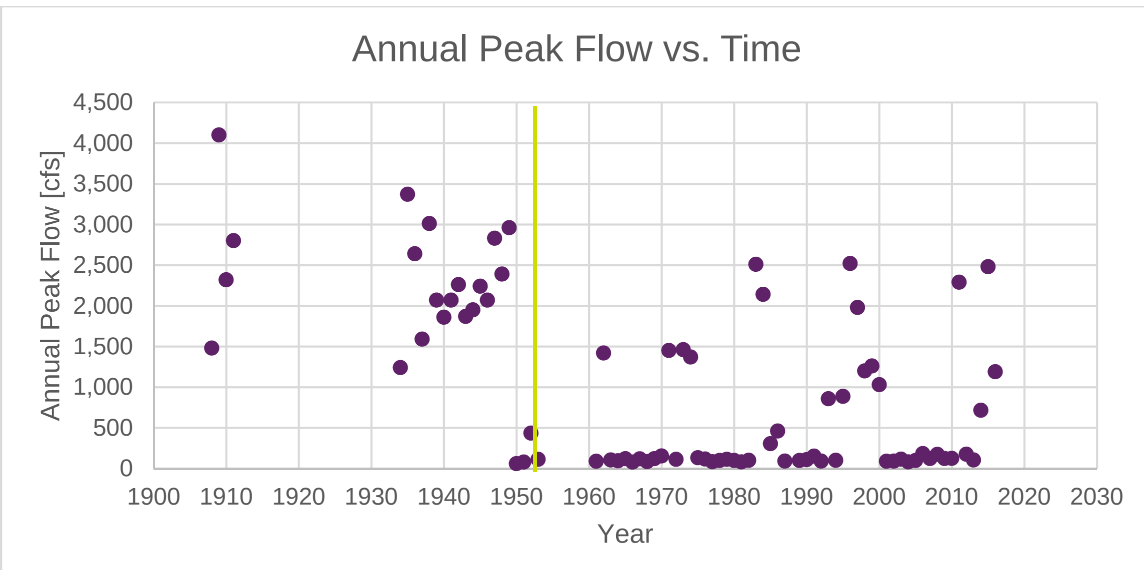


Figure 2-2 – Annual Peak Flow Data for Colorado River near Granby

To further assess the impacts of the reservoirs, a cumulative flow analysis was performed which summed the annual peak flow for each subsequent year. The slope of this graph then indicates the consistent magnitude of flow recorded at the gage. A steeper slope would indicate consistently higher flows, while a flatter slope would indicate consistently lower flows. Figure 2-3 shows the cumulative flow at the Colorado River near Granby gage.

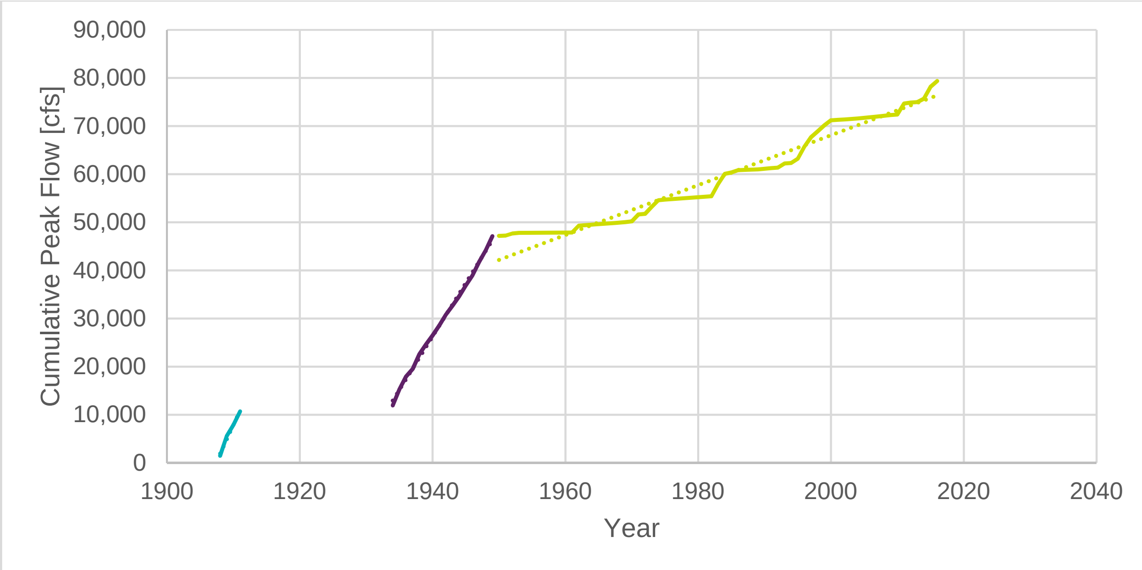


Figure 2-3 – Cumulative Flow Plot at Colorado River near Granby

While this impact is likely more extreme in the upper parts of the watershed, it's effects are seen throughout the watershed as other reservoirs also began operating at nearly the same time. The effects are dampened further downstream due to the lower percentage of tributary area regulated by reservoirs. Figure 2-4 and Figure 2-5 show the effects at the Kremmling gage.

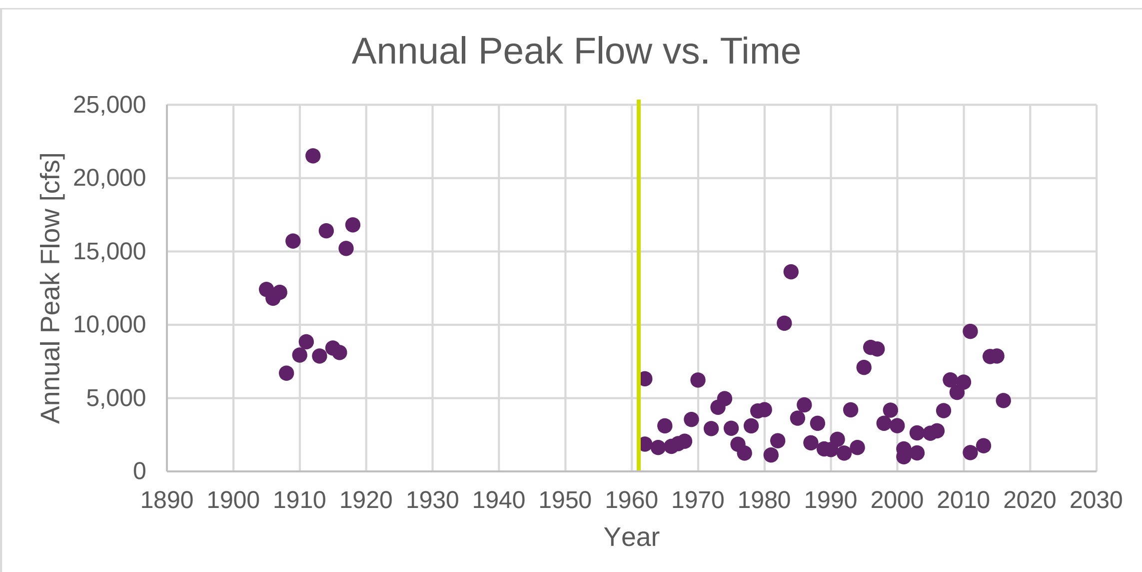


Figure 2-4 – Annual Peak Flow Data for Colorado River at Kremmling

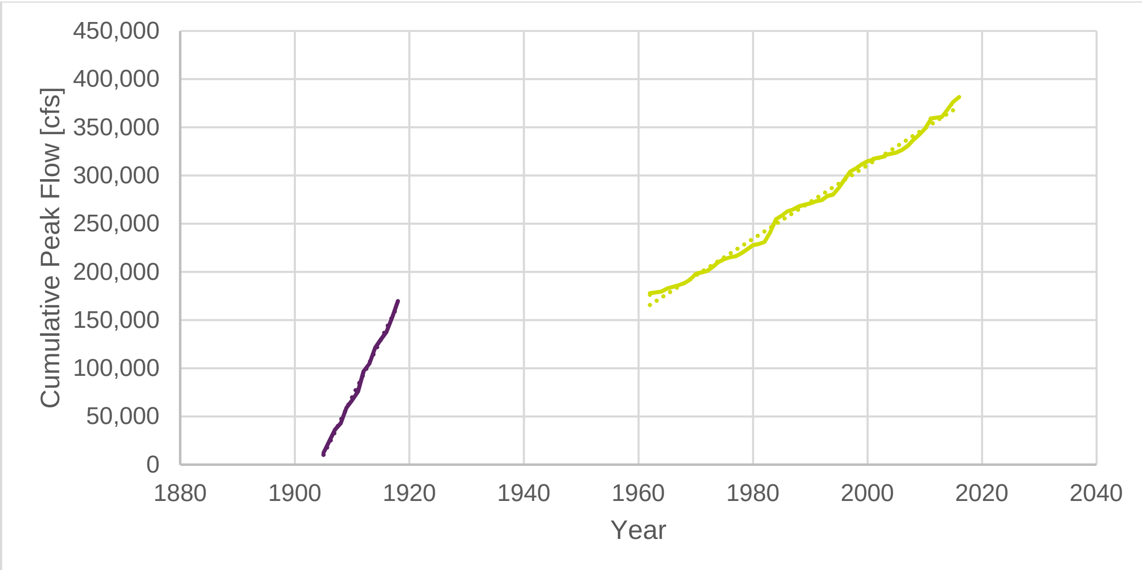


Figure 2-5 – Cumulative Flow Plot at Colorado River at Kremmling

This trend continues further downstream in the basin, but becomes less pronounced near the confluence between the Roaring Fork River and the Colorado River. Full detail of this cutoff point is covered in Section 2.2.6. Figure 2-6 shows the length of record for each of the gages, from upstream to downstream, as well as the date when the major reservoirs went online and their relative location between gages.

Colorado River - Granby to State Line

START DATE	END DATE	GAGE #	STREAM GAGE NAME	Gage Record (Years)
	1945		SHADOW MOUNTAIN LAKE	
	1950		LAKE GRANBY	
6/13/51	6/1/82	09019000	COLORADO RIVER BELOW LAKE GRANBY, CO	32
6/17/08	6/22/16	09019500	COLORADO RIVER NEAR GRANBY, CO	79
	1952		WILLOW CREEK	
7/3/82	6/23/16	09034250	COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO	35
6/8/05	6/1/94	09034500	COLORADO RIVER AT HOT SULPHUR SPRINGS, CO	86
	1959		WILLIAMS FORK	
	1995		WOLFORD MOUNTAIN	
	1942		GREEN MOUNTAIN	
	1963		DILLON	
6/4/05	6/9/16	09058000	COLORADO RIVER NEAR KREMMLING, CO	68
	1967		HOMESTAKE	
5/15/41	6/10/16	09070500	COLORADO RIVER NEAR DOTSERO, CO	76
5/30/00	5/8/66	09072500	COLORADO RIVER AT GLENWOOD SPRINGS, CO	67
	1968		RUEDI	
6/5/67	6/8/16	09085100	COLORADO RIVER BELOW GLENWOOD SPRINGS, CO	50
	1967		RIFLE GAP	
5/26/67	6/5/97	09093700	COLORADO RIVER NEAR DE BEQUE, CO	31
5/11/34	6/11/16	09095500	COLORADO RIVER NEAR CAMEO, CO	83
	1960		VEGA	
5/17/02	6/2/33	09106000	COLORADO RIVER NEAR PALISADE, CO	32
6/15/91	6/8/16	09106150	COLO RIVER BELOW GRAND VALLEY DIV NR PALISADE, CO	26
6/13/08	5/29/23	09153000	COLORADO RIVER NEAR FRUITA, CO *	17
6/23/51	6/9/16	09163500	COLORADO RIVER NEAR COLORADO-UTAH STATE LINE	66

*Additional Data point exists for 7/4/1884

- Gage data available   - Construction completed

Summary of Gage Years of Record and Construction of Structural Controls

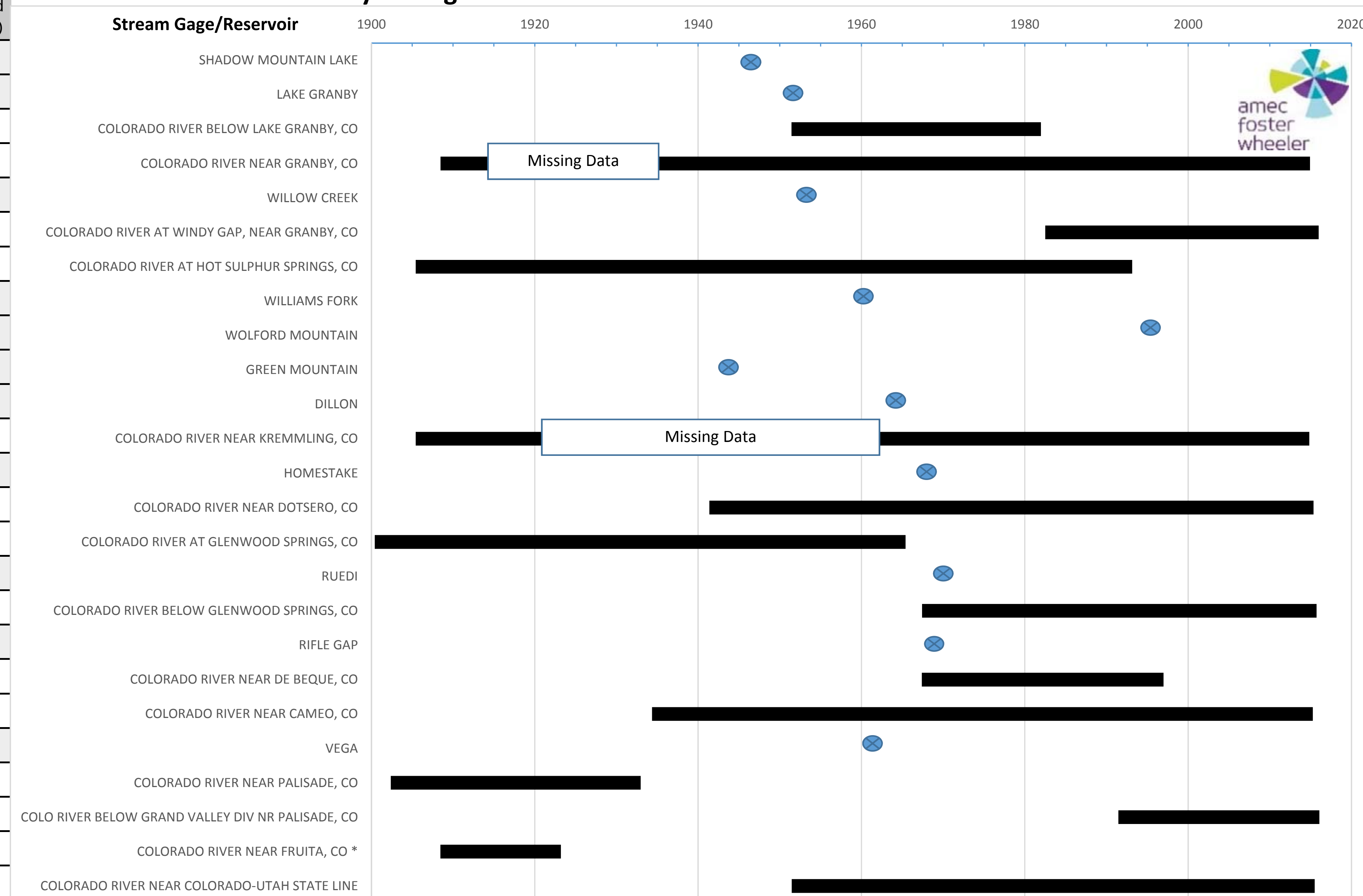


Figure 2-6 – Summary of Gage Years of Record and Construction of Structural Controls

2.1.4 Overall Reservoir Approach with Bulletin 17C

For this study, it is reasonable to assume that the post-reservoir-construction gage data is representative actual river conditions that could occur in any given future year. As such, individual variables (as outlined in Section 2.1.1), were not considered. These reservoirs are anticipated to remain in operation indefinitely and appear to impact both low frequency storm events and high frequency storm events. The reservoirs have a decreasing impact on flows the further downstream in the basin, but still have an unknown impact on larger snowpack years due to lack of post-reservoir extreme data points at the gages, especially in the upper part of the basin.

Because of this, the post-reservoir-construction data points (flow records from years after construction of upstream reservoirs was completed) are used, and are then scrutinized under the Multiple-Grubbs Beck Test. The PILFs, likely influenced by reservoir and diversion reductions, are censored. The analyses used in this report follows the standard methodology and process of the Bulletin 17C procedures. Deviations from the standard procedures are outlined in detail for each specific gage in the following section as applicable.

The changes between Bulletin 17C (Recommended Draft – April 2017), and Bulletin 17B (published September 1981) are fairly pronounced.

- A new statistical approach called the Expected Moments Algorithm which allows the user to add “interval estimates” or data ranges, rather than individual explicit data points.
- An improvement to the Grubbs-Beck Test allowing for multiple outliers to be censored.
- An improvement to the method used to compute confidence intervals.

The Bulletin 17C manual specifically states that the procedures do not apply to “watersheds where flood flows are appreciably altered by reservoir regulation…”. As described in Section 2.1.3, this analysis has determined that the reservoirs appear to impact both high and low flows. To compensate for the impacts on high flows, upper gages within the basin are censored to only use their post-reservoir data. To address the impacts on the low and moderate flows, the Multiple Grubbs Beck approach to handling PILFs is exceptionally useful.

2.2 Flood Frequency Analysis

The fifteen gages selected for analysis in this study and are listed in Table 2-1. The span of recorded information along the entire reach of the Colorado River within the state of Colorado and into Utah is from 1884 to present with the latest data being used from water year 2016.

Table 2-1 - Colorado River Gaging Stations

Gage Number	Begin Date	End Date	Years	Gage Name
09019000	6/13/1951	6/1/1982	32	Colorado River below Lake Granby, CO
09019500	6/17/1908	6/22/2016	79	Colorado River near Granby, CO
09034250	7/3/1982	6/23/2016	35	Colorado River at Windy Gap, near Granby, CO
09034500	6/8/1905	6/1/1994	86	Colorado River at Hot Sulphur Springs, CO
09058000	6/4/1905	6/9/2016	68	Colorado River near Kremmling, CO
09070500	5/15/1941	6/10/2016	76	Colorado River near Dotsero, CO
09072500	5/30/1900	5/8/1966	67	Colorado River at Glenwood Springs, CO
09085100	6/5/1967	6/8/2016	50	Colorado River below Glenwood Springs, CO
09093700	5/26/1967	6/5/1997	31	Colorado River near De Beque, CO
09095500	5/11/1934	6/11/2016	83	Colorado River near Cameo, CO
09106000	5/17/1902	6/2/1933	32	Colorado River near Palisade, CO
09106150	6/15/1991	6/8/2016	26	Colorado River below Grand Valley Diversion near Palisade, CO
09153000	7/4/1884	5/29/1923	17	Colorado River near Fruita, CO
09163500	6/23/1951	6/9/2016	66	Colorado River near Colorado-Utah State Line
09180500	7/4/1884	6/9/2016	99	Colorado River near Cisco, UT

The 10-, 2- 1-, and 0.2-percent-annual-chance-exceedance peak flow rates were developed using the United States Army Corps of Engineers HEC-SSP Software Version 2.1.00.137. This software calculates peak discharges using the guidance as outlined in the preliminary Guidelines for Determining Flood Flow Frequency Bulletin 17C (Bulletin 17C). Historic and paleoflood data points were analyzed for their usefulness in each of the analyses and PILFs are handled per the guidance included in Appendices 5 and 6 in Bulletin 17C. Historical information was obtained from the USGS gage records as well as other sources found during the data collection task of this project.

2.2.1 Flood History

Several significant floods of note have been observed on the Colorado River. The largest flood on record estimated using high water marks in the vicinity of the gage near Fruita, occurred in June/July of 1884 and was approximately equal to 125,000 cfs in magnitude at its peak. This event was caused by the melting of the very heavy snow cover (Follansbee and Sawyer, 1948).

The second highest flood was in 1921. While 1921 did have substantial rains, it was mostly in the Arkansas Basin (Follansbee and Sawyer, 1948), and rainfall data in the Colorado River Basin don't support the notion that rainfall contributed substantially to peak flows. Though peak separations weren't done by the USGS for the Colorado River (because of regulations), the peak discharge for the Colorado River at Hot Sulphur Springs was 8-days after the rain event ended. As such, the peak was caused primarily by snowmelt runoff, with perhaps a very small rainfall component (Elliott, Jarrett, Ebling, 1982). A study in the Yampa River basin (Jarrett and Tomlinson, 2000), also confirmed that the rainfall component of the June 1921 event was small. The recorded flows for the 1921 event are shown below in Table 2-2 (Follansbee and Sawyer, 1948).

Table 2-2 – Recorded Peak Flows from the 1921 Flood

Location	Drainage Area (mi^2)	Peak Flow (cfs)
Below the confluence with the Roaring Fork River	6,020	44,000
Near Palisade	8,790	50,800
Near Fruita	17,100	81,100

Additionally, 1983 and 1984 were also large discharge years with flows of 62,100 cfs and 69,800 cfs at the Colorado-Utah State Line. The 1984 flood is typically included in the systematic record for the gages, however, it was required to be projected and added to the gage record as a historic event for the below Grand Valley Diversion Gage due to that gage becoming operational after 1984. All recorded extreme events appear on gages in the lower part of the basin with few appearing on gages within the upper part of the basin. This causes the FFA analyses for the lower gages to have more of a bias towards these extreme events. In the future, it may be worthwhile to introduce a regional skew or other correction to help alleviate this difference, however, for this analysis no correction was made.

2.2.2 Incorporation

For this analysis, the 1884 flood estimate of 125,000 cfs was assumed to be recorded at the gage near Fruita (drainage area 17,100 square miles). It was also projected to the gages below Grand Valley Diversion and near Colorado-Utah State Line, as both fall within the applicable projection distance based on the Water-Resources Investigations Report (WRIR) 99-4190 Equation 3 for projecting gage data to other sites on the same stream (Vaill, 2000). Although the gage near Cisco has nearly 30% more contributing drainage area than the gage near Fruita, the 1884 flow was also recorded as 125,000 cfs. For this reason, the 1884 Fruita gage flow was also projected to the gage near Cisco using the procedures outlined in WRIR 99-4190 (Vaill, 2000), replacing the 125,000 cfs in the USGS record with a new value of 155,700 cfs.

The 1921 flood was applied directly to the gages at Fruita, near Palisade, and below Glenwood Springs and was projected to others nearby within the projection of the WRIR 99-4190 equation (Vaill, 2000). For gages that fell within two other gages with recorded values (such as De Beque), projections were taken from both upstream and downstream and were averaged to determine the anticipated historical flow. The 1921 flood was not applied to the gage at Glenwood Springs or any gage upstream of the Roaring Fork, because the gage at Glenwood Springs had a systematic record of 29,000 cfs listed as the peak for 1921. This is consistent with the USGS report, which describes most of the recorded peak flow coming in from the Roaring Fork (Follansbee and Sawyer, 1948).

A +/- 25% uncertainty was assigned to all the projected 1884 and 1921 records to account for errors in reporting, projection and flow location.

2.2.3 Incorporation of Paleoflood data

Paleo- comes from the Greek word palaios which means “ancient”. In the context of a paleoflood, not all paleofloods are ancient. Paleofloods are those that are derived from the method of using geologic or other markers in the field to determine high water marks. The elevations of these highwater marks are recorded and dated using a variety of methods, an estimate is made of the channel dimensions at the time, and the data is put into HEC-RAS or a similar standard step method program to estimate the flow which would correspond to that highwater mark.

Downstream Paleoflood Data

No paleoflood studies have been performed on the mainstem of the Colorado River. The closest study on the Colorado River was published in 2014 near Moab, Utah by Greenbaum et al. This study projected significantly higher peak flows than are determined by this analysis. The approaches taken by the 2014 study were inherently different than the approaches used in this report. To start, the 2014 study used pre-reservoir data in their flood frequency analysis as that was determined to more closely match the paleo conditions. As described previously, the approach used in this analysis primarily looks at the post-reservoir flows. It should be noted that both the 2014 analysis and this analysis determine the construction of the reservoirs to be a significant enough event to modify how data is used in each analysis.

The second difference between this analysis and the 2014 paleoflood analysis is the FFA methods used. This analysis uses the Expected Moments Algorithm (EMA) as part of the Bulletin 17C methodology, whereas the 2014 study uses a Bayesian maximum likelihood procedure by using the FLDFRQ3 software. A good description of the two approaches is in the Guidelines for Evaluating Hydrologic Hazards – 2006 report put out by the Bureau of Reclamation. A link to this document is included in the references section of this report. The difference in results between the two methods is shown in Figure 2-7 and Figure 2-8. Figure 2-7 is taken from the 2014 Greenbaum et al report which used the FLDFRQ2 model and did not include any of the paleoflood points taken as part of the study. Figure 2-8 was developed using HEC-SSP and the Bulletin 17C EMA analysis using the same data error bounds and information as was used in the FLDFRQ3 analysis. Note the location of the 1884 flood in both figures. The FLDFRQ3 model places the flood at approximately a 50-year recurrence interval, whereas the EMA analysis, with the same exact data, places the event at approximately a 150-year recurrence interval. There is a large inherent difference between how the two approaches calculate recurrence intervals, and thus projected flow. The data from FLDFRQ3 in this example is much more conservative than that from the EMA analysis. It should also be noted that at the time of this publication, FLDFRQ3 was not available on the United States Bureau of Reclamation page and any referenced mirrors in past documents are no longer active. Because of this, FLDFRQ3 analyses on the Colorado River Basin data could not be performed.

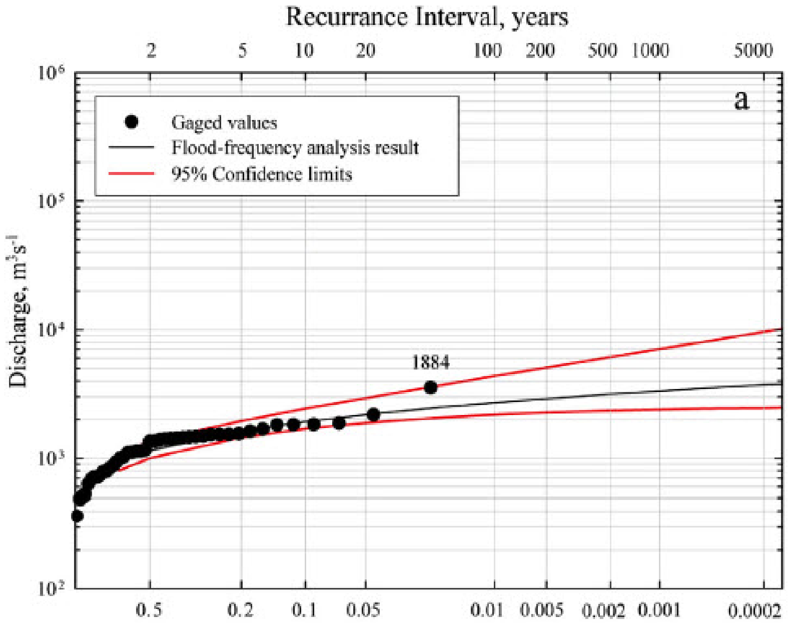


Figure 2-7 – FLDFRQ3 Recurrence Interval Plot for the Colorado River near Moab

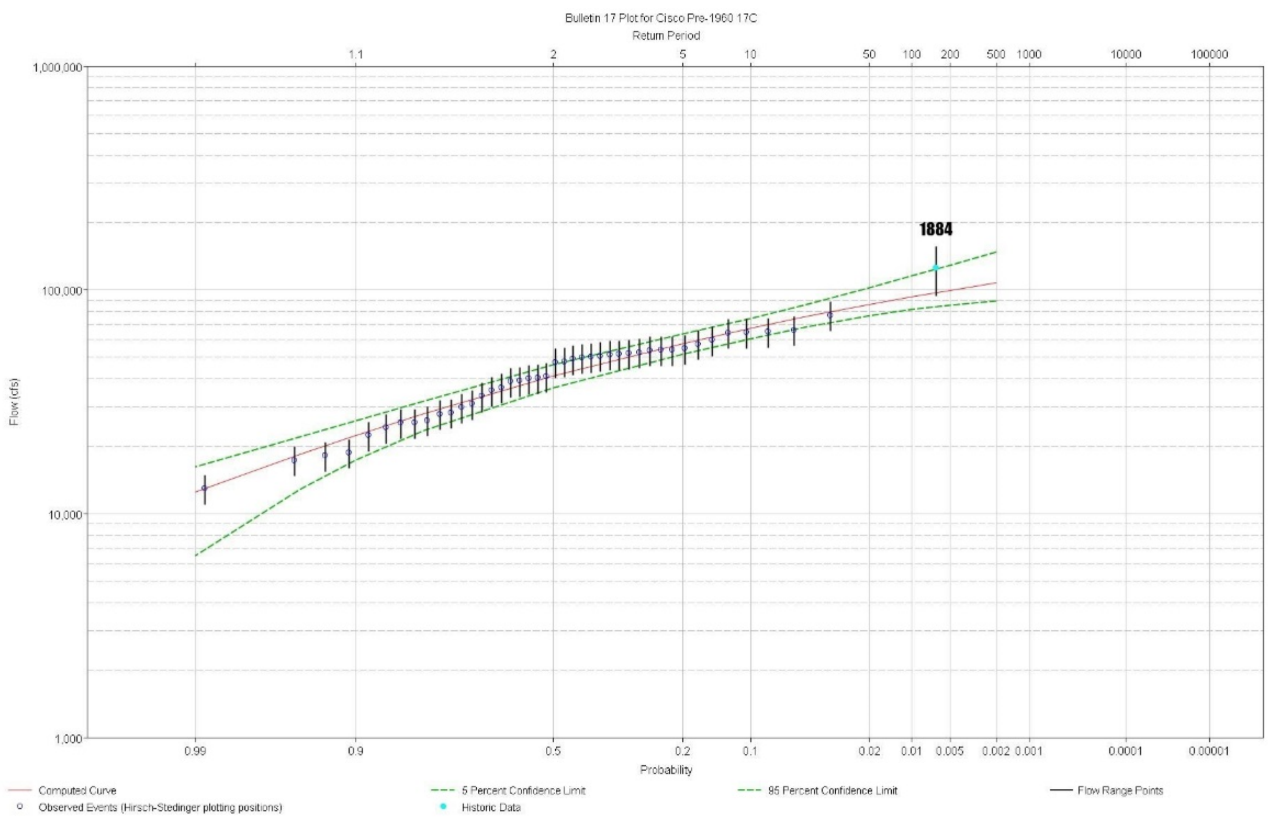


Figure 2-8 – EMA Recurrence Interval Plot for the Colorado River near Moab

An effort was made to incorporate the paleoflood data from the Moab study to determine how much it would impact predicted flows at the three lowest gages in this study. To mitigate the differences in the two models, the raw input data was requested from the authors of the study near Moab. This data was then analyzed and the largest recorded paleoflood (325,000 cfs) and its associated approximate date (126 BC) were projected using the WRIR 99-4190 methodology (Vaill, 2000) to the State Line Gage as this gage is the lowest gage within Colorado and had a longer record than the Fruita gage.

This analysis resulted in an increase of over 20% in peak flows over the previously calculated values and were at least 15% higher than the previously published FIS values at the Gunnison River Confluence and Cisco, Utah. In addition, these flows would be higher than the combined flows on the Gunnison, Dolores and Colorado Rivers if all three rivers had the peaks of their hydrographs hit at the same time. Without additional paleoflood points to compare to, there is no way to determine whether the Moab results are relevant for use in this study or if the Dolores River has a large impact on flows. Because of these issues, this paleoflood data was not incorporated into the analysis.

In addition to the high flows, some limitations of the current version of HEC-SSP were noted. Version 2.1.1 has a limitation on the record years available. Flows can only be recorded between the years 1000 and 5300. This was problematic as the largest paleoflood point from the Moab study was estimated to have occurred in 126 BC. This 4300-year limit also makes it impossible to correctly impose a Probable Maximum Flood or a Non-Inundation Surface estimate as these should be applied to theoretically an infinitely long stretch of time. This software issue will be addressed in a future release of HEC-SSP.

Upstream Paleoflood Data

In addition to using the Moab study, paleoflood data was obtained by Dr. Bob Jarrett in the upper part of the Colorado River Basin near Granby. Attempts were made to collect data in the middle of the basin, however due to river conditions as well as the level of development in these areas (e.g. Glenwood Springs Bike Path and Union Pacific Railroad) finding safe and suitable paleoflood points proved to be impossible.

The paleoflood study performed by Dr. Bob Jarrett generally confirmed the results of the preliminary FFA for the 09019500 Colorado River near Granby gage prior to adding paleoflood data.

Table 2-3 shows the comparison between the estimated paleoflood reconstructions and the corresponding FFA results from the near Granby gage. In the table, Qnis(ave) is defined to be the averaged flow corresponding to the non-inundation surface observed at the three paleoflood sites. Per the paleoflood study “these NISs have no fluvial erosional or depositional evidence and are determined to be stable surfaces”. Qmax(ave) is defined to be the averaged flow corresponding to the maximum paleoflood observed at the three paleoflood sites. Qhwm is defined to be the recent high-water mark with one point taken for post-reservoir floods (designated as “older”) and one taken for recent floods (designated as “2017”).

Table 2-3 – Comparison of Paleoflood Data and FFA Results for the Colorado River near Granby

	Paleoflood Reconstruction (cfs)	Near Graby Gage Non-Paleoflood FFA Estimate (cfs)
Q_{nis}(ave)	5,100	-
Q_{max}(ave)	4,100	4,100
Qhwm(older)	2,400	2,520
Qhwm(2017)	1,200	1,320

This data was added to the FFA analyses for both 09019000 Colorado River below Lake Granby and 09019500 Colorado River near Granby as they were the only gages within the projection threshold outlined by WRIR 99-4190 methodology (Vaill, 2000). Due to the three paleoflood investigation sites being averaged together to develop the reconstruction flows, and the small difference in drainage area, no projection was applied to the Q_{nis}(ave) or Q_{max}(ave) flows. To incorporate the data, the Q_{nis}(ave) value was added as a historic point at the year 100 (earliest year possible in HEC-SSP) and given a 10% uncertainty bound based on the estimated uncertainty listed in Dr. Jarrett's report. For the years between year 100 and the start of the systematic record, the perception threshold was set to 4,100 cfs to match Q_{max}(ave). The incorporation of these points reduced the projected flows and narrowed the confidence limits especially for the more extreme events. Further analysis is provided in Sections 3.1 and 3.2.The complete draft paleoflood report from Dr. Bob Jarrett is included in Appendix B.

As this paleoflood data confirms the gage records and the limitations on accurately projecting a Non-Inundation flow value within the current version of HEC-SSP, and the fact that the current results provide a more conservative result than the result used with incorporating the paleoflood points, the paleoflood data was not incorporated into the FFA.

Paleoflood Recommendations

Due to the limitations of software, lack of paleoflood data in the middle of the basin, and questions surrounding the consistency between this analysis and the Moab paleoflood study, the following determinations surrounding the paleoflood data have been developed

- The paleoflood study performed by Dr. Robert Jarrett have confirmed the gage records at the near Granby gage. No paleoflood points have been added to the analysis due to the uncertainty around applying a non-inundation surface to only 4,300 years of available flood record in HEC-SSP.
- No paleoflood data was able to be obtained from the middle part of the study area due to high river conditions and the amount of development present around the stream (highway, railroad and bike path). It may be prudent for a future study to include paleo points in this area as stream conditions allow.
- Due to differences in calculation methods, the paleoflood study from Moab is referenced but not included in this study. The projected flows have a large impact on the non-paleoflood FFAs and without confirmation of these paleoflood points, it was determined to not incorporate this data at this time. Based on the Moab study, several historical floods have likely occurred in the lower part of the basin within Colorado and incorporating paleoflood data for these areas would likely be prudent. This data could

provide insight to determine non-inundation surface levels or maximum flow surfaces which would help constrain the confidence limits on the extreme events. Should additional paleo studies be performed in this part of the basin, this part of the study should be reexamined for possible supplementation.

2.2.4 Skew

Many of the gages have station skews which differ by more than 0.5 from the regional skew value provided on Plate 1 in Bulletin 17B. Based on the Bulletin 17C guidance, large deviations between station and regional skew may indicate that the flood frequency characteristics of the water-shed are different from those used to develop the regional skew. It is recommended to give greater weight to the station skew after consideration of the data and flood-producing characteristics of the basin. In general, where the station skew is reasonable, the station skew was used for all gage analyses within the Colorado River Basin. This is due to the high level of storage in the basin and the substantial length of record at most of the gages within the basin. In the following sections, gages that did not use the station skew have a description of what skew was used in their respective gage summary section below.

Because of the approach listed in Section 2.1.3 regarding low reservoir-influenced flows values, many of the results from the upper parts of the basin have moderately high negative skew values. This indicates that the data points used in the analysis tend to be above the median and are skewing the data towards more infrequent storm events. This is understandable, given that for most of these upper sites, the low values are being censored out due to the influence of the reservoir. This leaves only the more extreme flow events in the analysis. Depending on the remaining data, this can cause the projected flows to increase or decrease. This approach was determined to be preferable to including the artificially low flow, reservoir-influenced, values which caused unreasonably high flows in the more extreme event projections.

2.2.5 USGS Quality Codes

USGS quality codes were available for all data downloaded from the USGS website. Table 2-4 shows the codes encountered in the gage data for the Colorado River along with an approach of how they were incorporated into the FFA. All the gages within the Colorado River Basin are impacted by regulation or diversion, however the general approach will remain the same.

Table 2-4 - USGS Qualification Codes and Approach

Code	Description	Approach
1	Discharge is a Maximum Daily Average	Values are investigated further and possibly increased based on other peak vs. average daily discharge comparison points.
2	Discharge is an Estimate	Data treated as if it were not an estimate due to lack of clear error bounds of each individual sample.
5	Discharge affected to unknown degree by Regulation or Diversion	No change in approach. This is addressed by assumptions 1 and 2.
6	Discharge affected by Regulation or Diversion	No change in approach. This is addressed by assumptions 1 and 2.
7	Discharge is an Historic Peak	Data type changed to historical in HEC-SSP
9	Discharge due to Snowmelt, Hurricane, Ice-Jam or Debris Dam breakup	No change in approach as these codes are assumed to imply snowmelt which is understood to be the primary flow component of the peak flows.
B	Month or Day of occurrence is unknown or not exact	No change in approach as this is assumed to not impact the annual peak reporting.

2.2.6 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. The Colorado River Basin crosses both the Mountain and Northwest Hydrologic Regions with exponents (x) of 0.69 and 0.64, respectively as used in Equation (3), as defined in WRIR 99-4190. These exponents were used in Equation (3) from the Water Resources Investigations Report. The selected exponent was based on the location of the gage being projected, so all gages upstream and including the Kremmling gage used the exponent for the Mountains Region and all gages downstream and including the Dotsero gage used the exponent for the Northwest Region.

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

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 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 existing flow change locations as identified in the existing FIS documents.

2.2.7 1%-Plus Calculations

The 1%-plus-annual-chance exceedance values were calculated using the upper 84% confidence limit of the 1%-annual-chance for all analyzed gages as part of this study ad calculated by HEC-SSP. In some cases, especially in the upper parts of the watershed, these values surpassed the 0.2%-annual-chance exceedance values likely due to the level of uncertainty with the reservoirs and diversion structures present in this part of the watershed.

2.2.8 Approach

As discussed in Section 2.1.3, most of the reservoirs within the Colorado River Basin were constructed by the 1960s and have a pronounced impact on the hydrology of the basin. Most of the previous FIS flows were based on hydrology that was calculated before the reservoirs were constructed and do not include any of the influence of these manmade structures on the projected flow values. To accurately assess the impacts of these reservoirs the general approach of the FFA was split into two areas: the areas heavily influenced by the reservoirs and the area not heavily influenced by the reservoirs.

As shown in the figures in Section 2.1.3, the portion of the basin above the Roaring Fork River has shown a significant hydrological change with the construction of the reservoirs. The approach in this portion of the basin was to examine the records for each gage and identify the records which are likely influenced by the reservoirs. The largest influence of the reservoirs was seen on the gages closest to the reservoirs in the upper part of the basin and during the more frequent flow events. Because of this, the likelihood of PILFs was extremely likely. Careful attention was paid to the lower end of the flood frequency curves to examine the influence of the flows which might have been arbitrarily lowered by the influence of the upstream reservoirs. As the analyses progressed to the gages further and further downstream, the influence of the reservoirs and the PILF scrutiny was relaxed due to the lower influence of the reservoirs. This trend continues to Glenwood Springs and the confluence with the Roaring Fork River. Figure 2-9 shows the cumulative flow plot at the confluence of the Roaring Fork River. The purple line on the graph is from the Colorado River at Glenwood Springs gage, which was above the confluence with the Roaring Fork and was operational until 1966. In 1967, the Colorado River below Glenwood Springs gage became operational. The neon green line shows the results of this gage. To compare flows only on the Colorado River, average daily peak flow values from the Roaring Fork River at Glenwood Springs were obtained and subtracted from the annual peak flows on the downstream Colorado River below Glenwood Springs gage. This teal line represents these flows and shows that there is still a noticeable influence of the reservoirs on the flows within the Colorado River.

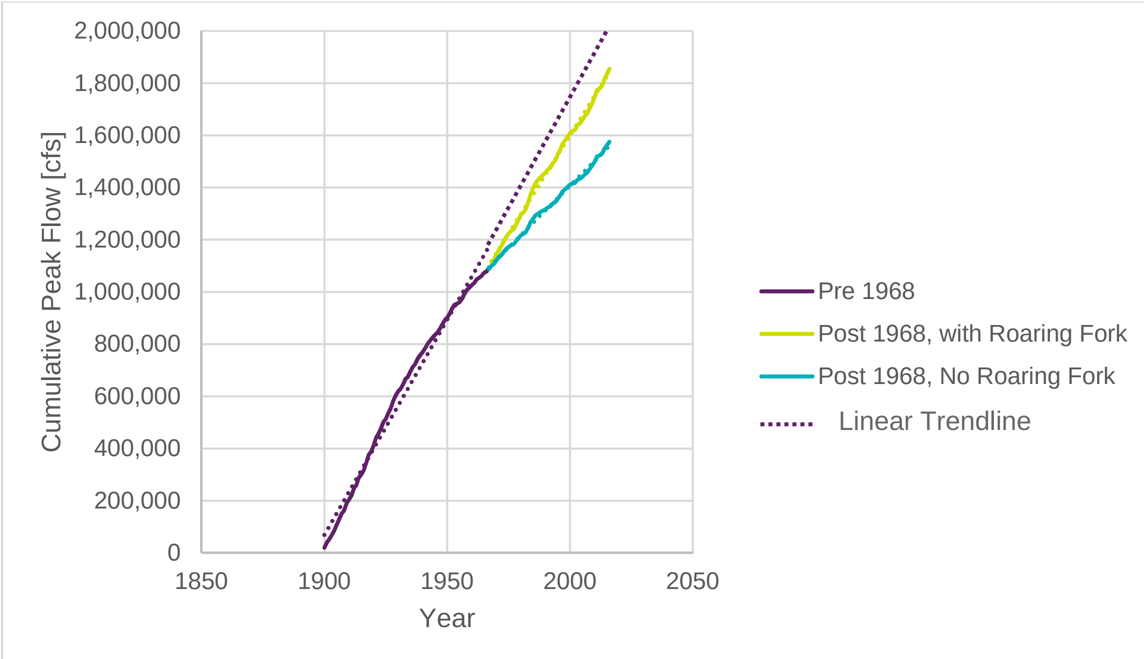


Figure 2-9 – Cumulative Flow Plot at Colorado River below Glenwood Springs

Below Glenwood Springs, the impacts of the reservoirs are still noticeable but there are now post-reservoir recorded flows which eclipse pre-reservoir flows. This stands to reason that the flow levels seen before the construction of the reservoir are still possible after the construction of the reservoir at these locations. The first example which shows both pre- and post-reservoir flow values is at the Colorado River at Cameo gage. Figure 2-10 shows the annual peak flow data for the entire length of record at this gage. The two highest flows on record are the 1983 and 1984, flow values which are both after the reservoirs were constructed in the 1960's. Because of this, this analysis concludes that the limit of influence for the upstream reservoirs ends somewhere between the confluence of the Roaring Fork and the Cameo gage. The Colorado River at De Beque gage is in this reach, however, it only has records after 1967 which are all post-reservoir, so it is unclear as to whether the reservoir influence limit is upstream of downstream of this gage. Below this imaginary influence limit within the Colorado River Basin, the direct influence of the reservoirs is not as high.

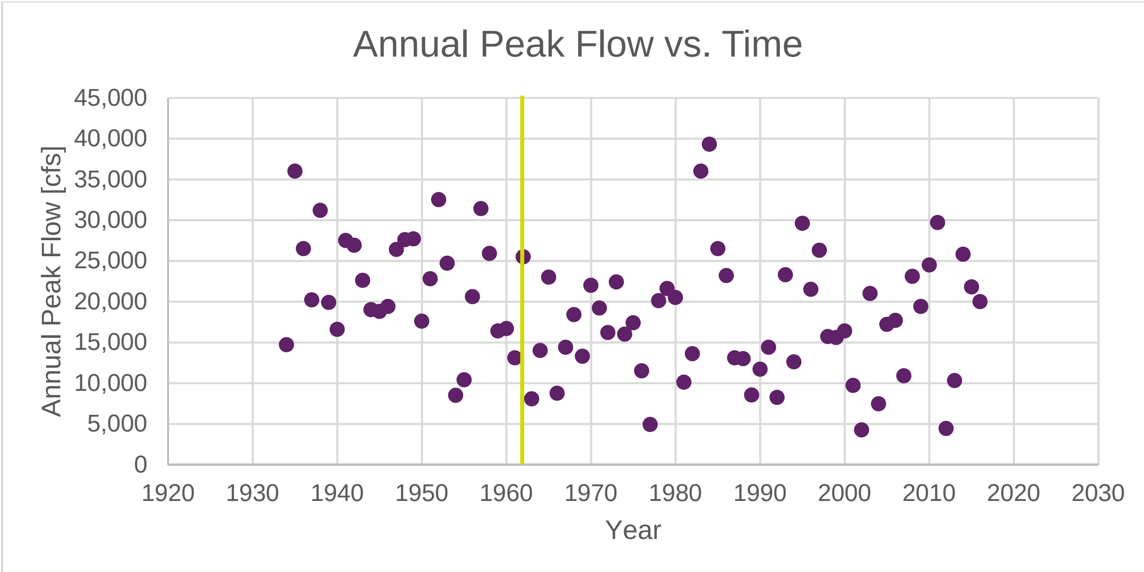


Figure 2-10 – Annual Peak Flow Data for Colorado River at Cameo

Several gages are recommended to not be used for future regulatory or design work for a variety of reasons. Some gages had duplicative flows, which were adequately represented by a nearby gage. Others had data issues including estimated or incomplete data which caused their analyses to be unreliable including the below Lake Granby and near Palisade gages. Of all the gages that were selected to be reliable and determined to be used for future analyses, each of these gages was examined for continuity and consistency when examining the 1-day, 3-day, 7-day, 14-day, monthly, and annual averages against the peak flow flood frequency analyses. This test was performed to verify both the validity of the data and the analysis, and was checked to ensure none of these profiles were crossing. A few of these profiles did cross, but the crossings occurred in the frequent events (> 20%-annual-chance) which were determined to be not of concern for this analysis. A profile was not included for the Colorado River Near Granby Gage as flows at this location are not recorded year-round and monthly or annual averages would not line up with the rest of the data. Projected flows for the 1% chance events were in the 100,000 cfs range which did not make sense when the non-inundation surface from the paleoflood investigation estimated the maximum flow at 5,100 cfs. Copies of the profiles for the selected streamflow gaging stations are found in Appendix C.

3.0 Gage Summary

3.1 09019000 COLORADO RIVER BELOW LAKE GRANBY

The systematic record included 32 years of peak flow data between the years 1951 and 1982. All records have a USGS quality code of 6 - Discharge affected by Regulation or Diversion. The record from 1962 has a USGS quality code of 1 - Discharge is a Maximum Daily Average. This record is the fourth highest in the data set. Since it is not in the top three and the gage is so highly influenced by Lake Granby, the record was treated as an annual peak. The record from 1952 has a USGS quality code of 2 - Discharge is an Estimate. This record was assigned a +/- 25% uncertainty in the listed flow.

The highest flow at the gage below Lake Granby was 1,520 cfs recorded in 1971. All records at this gage were recorded after both Shadow Mountain Reservoir and Lake Granby were constructed. Based on discussions with Alan Martellaro, the Colorado Division of Water Resources District 5 Engineer, discharges from Lake Granby through the main headgate are limited to 75 cfs. All other excess discharge comes from flow over the primary spillway. Because of the high level of regulation by the dam, especially in low flow years, most of the recorded data points are less than 110 cfs.

The station skew at this gage is 1.807 which was deemed to be too large to use on its own. This indicates the data has a high number of low flows with a few high outliers which drive the high positive skew. Although not recommended for use with 17C analyses, a weighted skew was used using the Plate 1 value of -0.18 for the gage location. This was done due to the lack of any local regional skew calculations. This resulted in a final adopted skew of 0.521 which is more reasonable. No low outliers were censored from the data set using the Multiple Grubbs-Beck Test. The resulting estimated flood frequency curve for the Colorado River Below Lake Granby gage is shown in Figure 3-1.

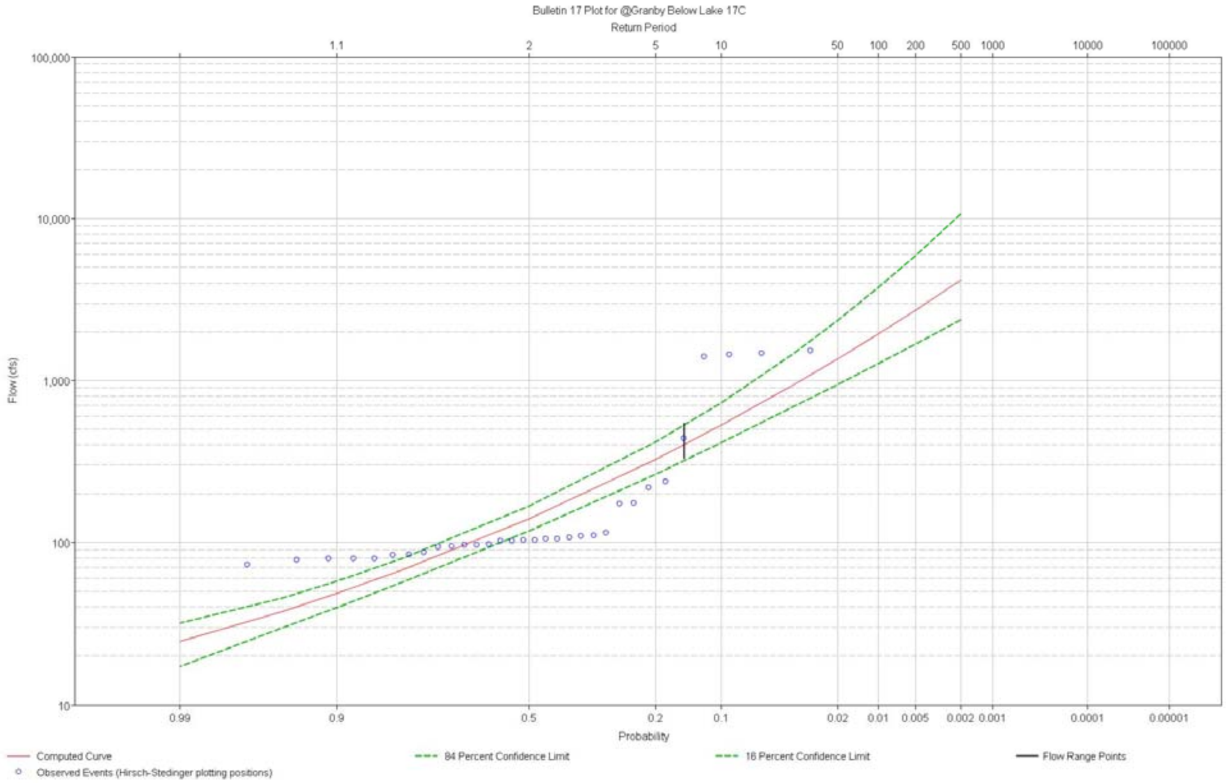


Figure 3-1 – Bulletin 17C Calculated Frequency Curve for Colorado River Below Lake Granby

As shown in Figure 3-1, there is not very good agreement between the computed curve and the actual data. Most of the data is below 150 cfs with only a few points exceeding this value. There are only four events in the data which exceed 500 cfs This is to be expected due to the gage being located immediately downstream of Lake Granby. As described above, the discharge from Lake Granby is regulated by the outlet or spillway during high stage in the lake. Based on the short record at this gage, very few substantial spillway discharges have been recorded. Due to the lack of high flow data at this gage, no additional PILFs could be censored and still have enough data points to perform an analysis. Although the flows determined by the FFA seem reasonable, due to the high percentage of flows being directly impacted by the reservoir, it is not recommended to use this gage for any regulatory or design work. Gage 09019500 Colorado River Near Granby should be used for all analysis. The analysis was still completed without censoring any low outliers and following standard Bulletin 17C methodology. The peak flows from this analysis are shown in Table 3-1 for reference.

Table 3-1 - Peak Flows Colorado River Below Lake Granby

Drainage Area (mi^2)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
312	530	1,360	1,940	4,170

3.2 09019500 COLORADO RIVER NEAR GRANBY

The systematic record included 79 years of peak flow data between the years 1908 and 2016. All records except for 1947, 1948, and 1949 have a USGS quality code of 6 - Discharge affected by Regulation or Diversion. It is likely that the code was omitted from these entries by mistake. The record from 2016 has a USGS quality code of 9 - Discharge due to Snowmelt, Hurricane, Ice-Jam or Debris Dam breakup. The four records from 1908-1911 have a USGS quality code of 2 - Discharge is an Estimate. These records were assigned a +/- 25% uncertainty in each of the listed flows. No data is available for the years between 1912 and 1933, 1954 and 1960, and 1988. For these years a perception threshold was set to 4,100 cfs which was the highest flow seen at the gage.

The highest flow at the gage was 4,100 cfs recorded in 1909, this being one of the early records. The highest modern systematic recorded flow was 3,370 cfs recorded in 1935. The highest flow after Lake Granby and Shadow Mountain Reservoir were constructed is 2,520 cfs in 1996 which was caused by substantial runoff in 1995 in which Lake Granby overtopped and much of this water remained in 1996 during that year's runoff. As mentioned above, discharges from Lake Granby through the main headgate are limited to 75 cfs. All other excess discharge comes from flow over the primary spillway. Because of the high level of regulation by the dam, especially in low flow years, most of the recorded data points are less than 176 cfs, the LOT specified by the Multiple Grubbs-Beck Test. 38 of the 79 records were censored from the data due to being classified as PILFs. All 38 of these outliers were from after Lake Granby and Shadow Mountain Reservoir were constructed. This resulted in a skewing of the FFA resulting in considerably higher flows in the less-frequent return periods. The initial estimated flood frequency curve for this scenario is shown in Figure 3-2.

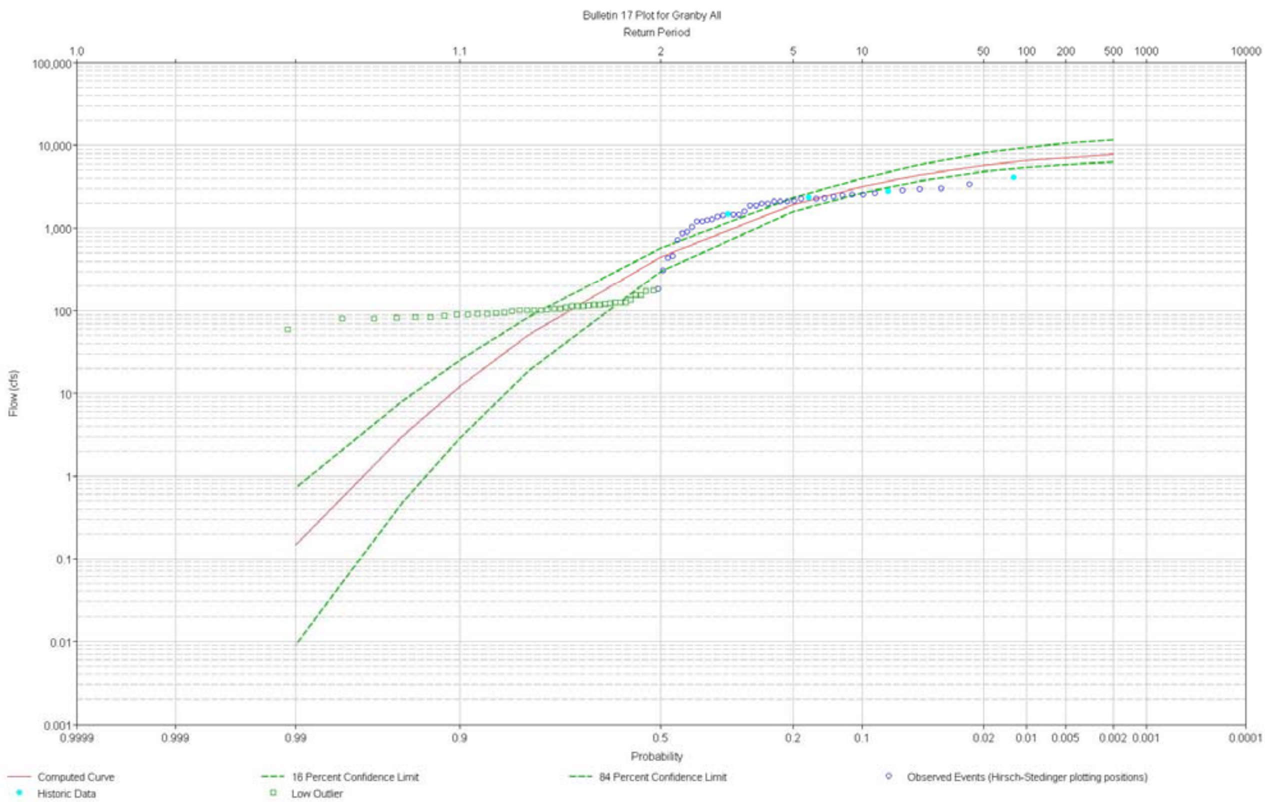


Figure 3-2 – Preliminary Calculated 17C Frequency Curve for Near Granby (All Data)

Examining the data more closely, these results do not correspond well to the results from further downstream and this analysis appears to be over estimating the less frequent events. Looking closely at Figure 3-2, it is clear the computed curve and confidence limits do not follow the data well due to the influence of the lower frequency events, skewing the FFA resulting in considerably higher flows for the low frequency storms. Comparing the results with upstream and downstream gages, the projected flows are considerably higher than both the upstream and downstream gages. Table 3-2 shows the peak flows under this scenario.

Table 3-2 - Peak Flows Colorado River near Granby (All Data)

Drainage Area (mi^2)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
323	3,210	5,760	6,550	7,790

The station skew of the raw data is -1.328 which indicates the high number of low flows (outliers) within the data set. The LOT was raised to 1,600 cfs to try to get a better match between the computed curve and the more infrequent data points. The result is more in line with the results from the FFA results from the downstream gages and provides much better alignment with the computed curve versus the actual data points.

Two other scenarios were run to verify this approach. The first scenario performed a Bulletin 17C analysis on only the 20 data points from before the reservoirs were constructed (1908-1949). The purpose of this scenario is to examine what the stream looked like before the reservoirs went in. This resulted in a projected 0.2%-annual-chance-exceedance peak flow of

4,760 cfs. This result is similar to result from the 1,600 cfs LOT scenario but is contrary to the approach used further downstream.

The second scenario eliminated all the pre-reservoir data and only performed the FFA on the data taken after the reservoir was constructed (1950-present). This scenario was performed to match the logic taken at gages further downstream to separate the pre- and post-reservoir flows as the basin is inherently changed by the addition of reservoirs within the basin. In this scenario, there is not enough high flow data to run a complete analysis when only looking at the post-reservoir data. The multiple low flows substantially skew the upper end of the computed peak flow curve. This result indicates that these flows are PILFs which are distorting the tail end of the computed curve and should be treated as such in the other analyses.

Both scenarios confirm the lower flows have a substantial influence on the distribution due to the impacts of the upstream reservoirs. In addition, these results are confirmed by the paleoflood study performed by Dr. Bob Jarrett as mentioned in Section 2.2.3, which puts the non-inundation limit at 5,100 cfs. Table 3-3 shows the correlation of the four scenarios.

Table 3-3 - FFA Scenario Results for Colorado River near Granby

Scenario	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
Post-Reservoir	1,210	4,650	7,890	25,100
Standard 17C	3,210	5,760	6,550	7,790
LOT – 1,600 cfs	2,580	3,770	4,190	4,980
Pre-Reservoir	3,190	3,900	4,180	4,810

Based on the results of the scenarios above, the highlighted scenario with the LOT set to 1,600 cfs is the most appropriate and best represents how the flows respond to the substantial influence of the reservoirs at this gage. It also corresponds the best with the predicted flows at the gages immediately downstream. The updated calculated frequency curve shown in Figure 3-3 shows the much better fit of the computed curve to the actual data points and provides projected peak flow values that are much more in line with both the upstream and downstream gages and their projected peak flow values. Table 3-4 shows the peak flows.

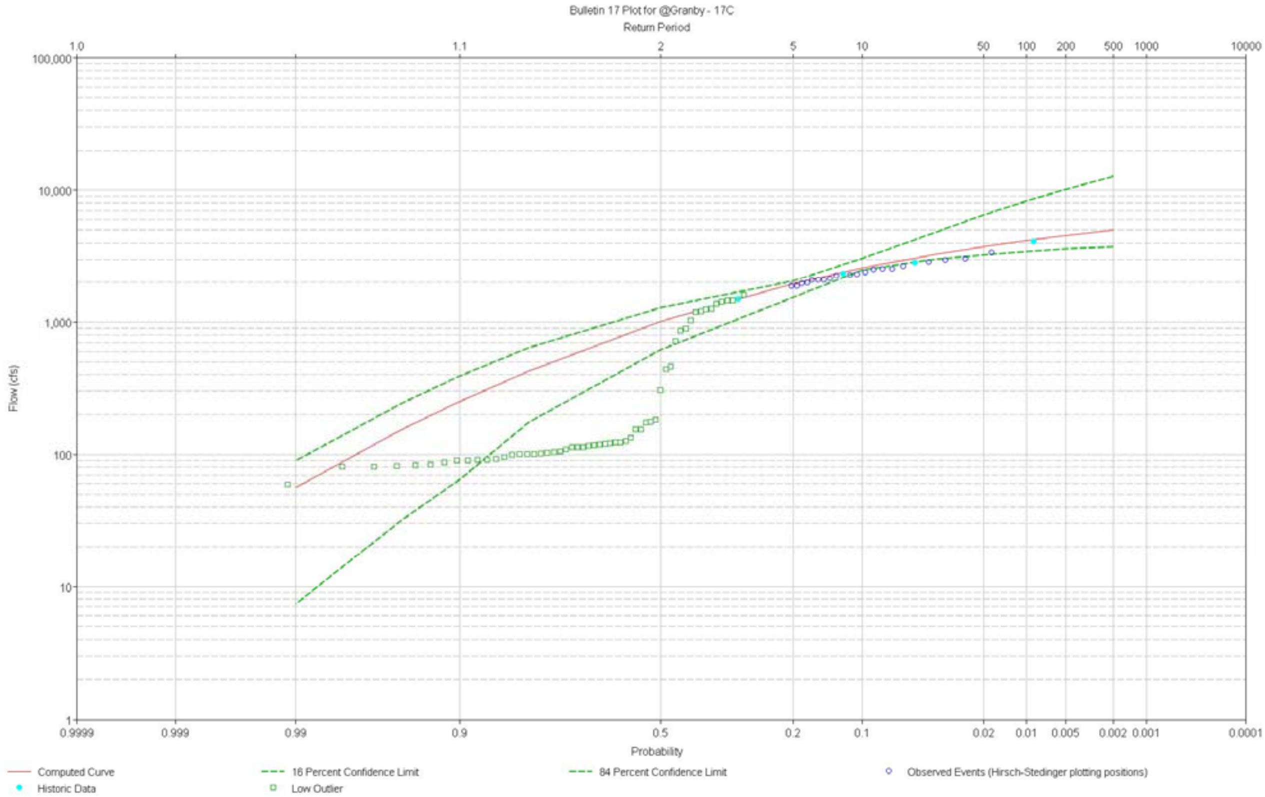


Figure 3-3 – Bulletin 17C Calculated Frequency Curve for Colorado River near Granby (LOT 1,600)

Table 3-4 - Peak Flows Colorado River near Granby (LOT 1,600)

Drainage Area (mi^2)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
323	2,580	3,770	4,190	4,980

3.3 09034250 COLORADO RIVER AT WINDY GAP, NEAR GRANBY

The systematic record included 35 years of peak flow data between the years 1982 and 2016. All the records have a USGS quality code of 6 - Discharge affected by Regulation or Diversion. The record from 2016 has a USGS quality code of 9 - Discharge due to Snowmelt, Hurricane, Ice-Jam or Debris Dam breakup. The highest flow at the Windy Gap gage was 5,260 cfs recorded in 1984. All records at this gage were recorded after Willow Creek Reservoir, Shadow Mountain Reservoir and Lake Granby were constructed. No low outliers were censored from the data set using the Multiple Grubbs-Beck Test. The resulting estimated flood frequency curve for the Colorado River at Windy Gap, near Granby gage is shown in Figure 3-4 with the peak flows shown in Table 3-5. The reader should note that the projected peak flows of this gage are higher than those projected at the downstream Hot Sulphur Springs gage. It is left to the reader’s judgement as to whether this gage is appropriate to use this gage for any regulatory or design work or whether to use the combined gage described in Section 3.5.

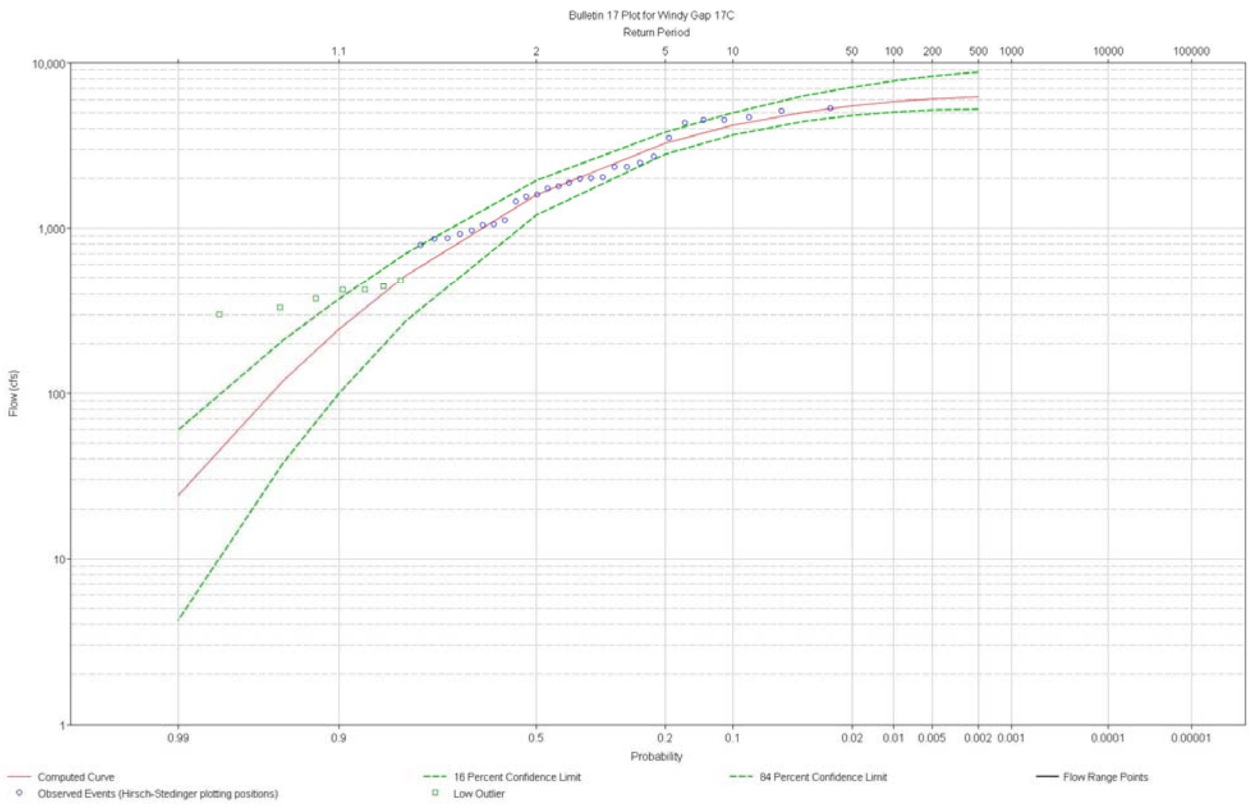


Figure 3-4 – Bulletin 17C Calculated Frequency Curve for Colorado River at Windy Gap, near Granby

Table 3-5 - Peak Flows Colorado River at Windy Gap, near Granby

Drainage Area (mi^2)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
788	4,110	7,310	8,890	13,000

* See Section 3.5 for flows from the combined Windy Gap/Hot Sulphur Springs Gage which is preferred over these results.

3.4 09034500 COLORADO RIVER AT HOT SULPHUR SPRINGS

The systematic record included 86 years of peak flow data between the years 1905 and 1994. All records between 1937 and 1994 have a USGS quality code of 6 - Discharge affected by Regulation or Diversion. Records from 1905 through 1928 all have a USGS quality code of 2 - Discharge is an Estimate. These records were censored from the analysis as they were all from before the reservoirs were constructed so no uncertainty was added.

The highest flow at the Hot Sulphur Springs gage was 10,300 cfs recorded in 1921. The gage record extends back before Willow Creek Reservoir, Shadow Mountain Reservoir and Lake Granby were constructed and includes data from after these reservoirs were in operation. The highest flow after Willow Creek Reservoir, Lake Granby, and Shadow Mountain Reservoir were constructed is 5,720 cfs. Due to the difference in flow regimes and the availability of post-reservoir data, data prior to 1953 was censored and not used in this analysis. By performing this action, no PILFs were eliminated in the analysis and the flows remained similar, albeit lower than the full analysis. The resulting estimated flood frequency curve for the Colorado River at Hot Sulphur Springs gage is shown in Figure 3-5 with the peak flows shown in Table 3-6. The reader should note that the projected peak flows of this gage are lower than those projected at the upstream Windy Gap gage. It is left to the reader's judgement as to whether this gage is appropriate to use this gage for any regulatory or design work or whether to use the combined gage described in Section 3.5.

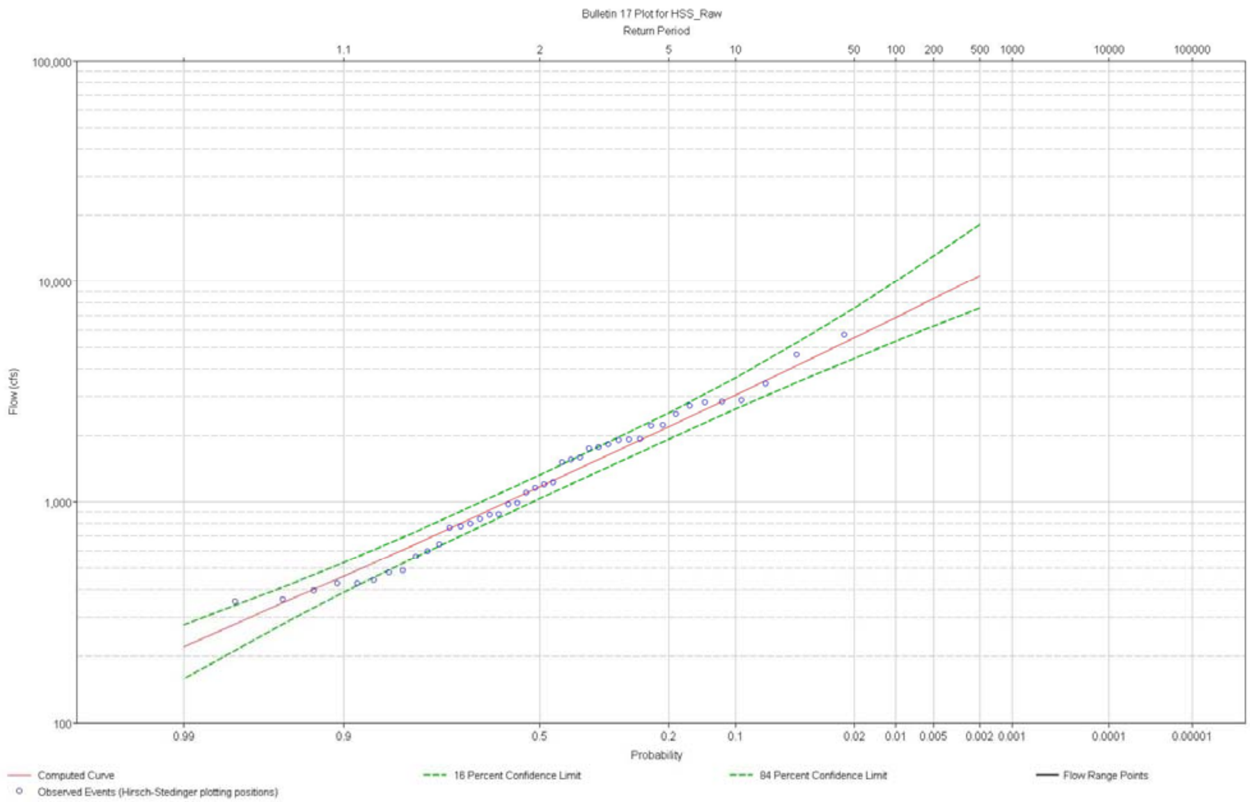


Figure 3-5 – Bulletin 17C Calculated Frequency Curve for Colorado River at Hot Sulphur Springs

Table 3-6 - Peak Flows Colorado River at Hot Sulphur Springs

Drainage Area (mi^2)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
825	3,060	5,540	6,860	10,600

* See Section 3.5 for flows from the combined Windy Gap/Hot Sulphur Springs Gage which is preferred over these results.

3.5 WINDY GAP/HOT SULPHUR SPRINGS COMBINED GAGE

As shown in the two previous sections, there is a discontinuity in flow between the Windy Gap gage and the Hot Sulphur Springs gage. Although the Hot Sulphur Springs gage is below Windy Gap gage, projected peak flows at the Windy Gap gage are higher than those projected at the Hot Sulphur Springs gage. As the Hot Sulphur Springs Gage is no longer active, it is not logical to simply omit the Windy Gap gage and use all data from the Hot Sulphur Springs gage, nor is it logical to omit the extended post-reservoir history of the Hot Sulphur Springs Gage. To resolve this flow continuity error, the overlap between the two gages was examined to determine if the readings from both gages were similar enough to merge them into one composite gage and use that in the analysis. Except for one outlier in 1987, the 13 overlapping years of gage data between the two gages result in less than a 6% difference in gage reading between the Windy Gap and Hot Sulphur Springs gage when the WRIR 99-4190 methodology (Vaill, 2000) is applied to project the Windy Gap gage to the location of the Hot Sulphur Springs gage. Based on this comparison, it is assumed that the gages are similar enough to be represented as a singular gage. Table 3-7 shows the comparison between the two gages.

Table 3-7 - Overlapping Flow Comparison between Windy Gap and Hot Sulphur Springs Gages

Year	Hot Sulphur Springs Gage Reading (cfs)	Projected Windy Gap Gage Reading * (cfs)	% Difference
1982	1,100	1,084	-1%
1983	4,620	4,624	0%
1984	5,720	5,429	-5%
1985	1.890	1,940	3%
1986	1,740	1,786	3%
1987	**983**	**1,146**	**17%**
1988	1,550	1,641	6%
1989	393	383	-3%
1990	474	495	5%
1991	873	892	2%
1992	439	459	5%
1993	1,910	1,848	-3%
1994	795	811	2%

- *WRIR 99-4190 methodology (Vaill, 2000) applied to move reading downstream.*

For the combined analysis, gage data from the Hot Sulphur Springs gage was used from 1953 until the gage ceased recording in 1994 due to the record length at this gage. The Windy Gap gage data was used to supplement the Hot Sulphur Springs gage data from 1995 to 2016. The LOT for the combined data was set to 500 cfs which resulted in the computed curve most closely representing the combined data points. In addition to creating the best fit curve, this LOT was determined to be acceptable due to the high level of regulation in this part of the watershed by the upstream reservoirs. This resulted in 12 low outliers being censored. The combined systematic record included 65 years of peak flow data between the years 1953 and 2016. All records between 1953 and 1994 have a USGS quality code of 6 - Discharge affected by Regulation or Diversion. The record from 2016 has a USGS quality code of 9 - Discharge due to Snowmelt, Hurricane, Ice-Jam or Debris Dam breakup. The highest flow at the combined gage was 5,720 cfs recorded in 1984 (Hot Sulphur Springs Record). The resulting estimated flood frequency curve for the combined Windy Gap/Hot Sulphur Springs gage is shown in Figure 3-6 with the peak flows shown in Table 3-8.

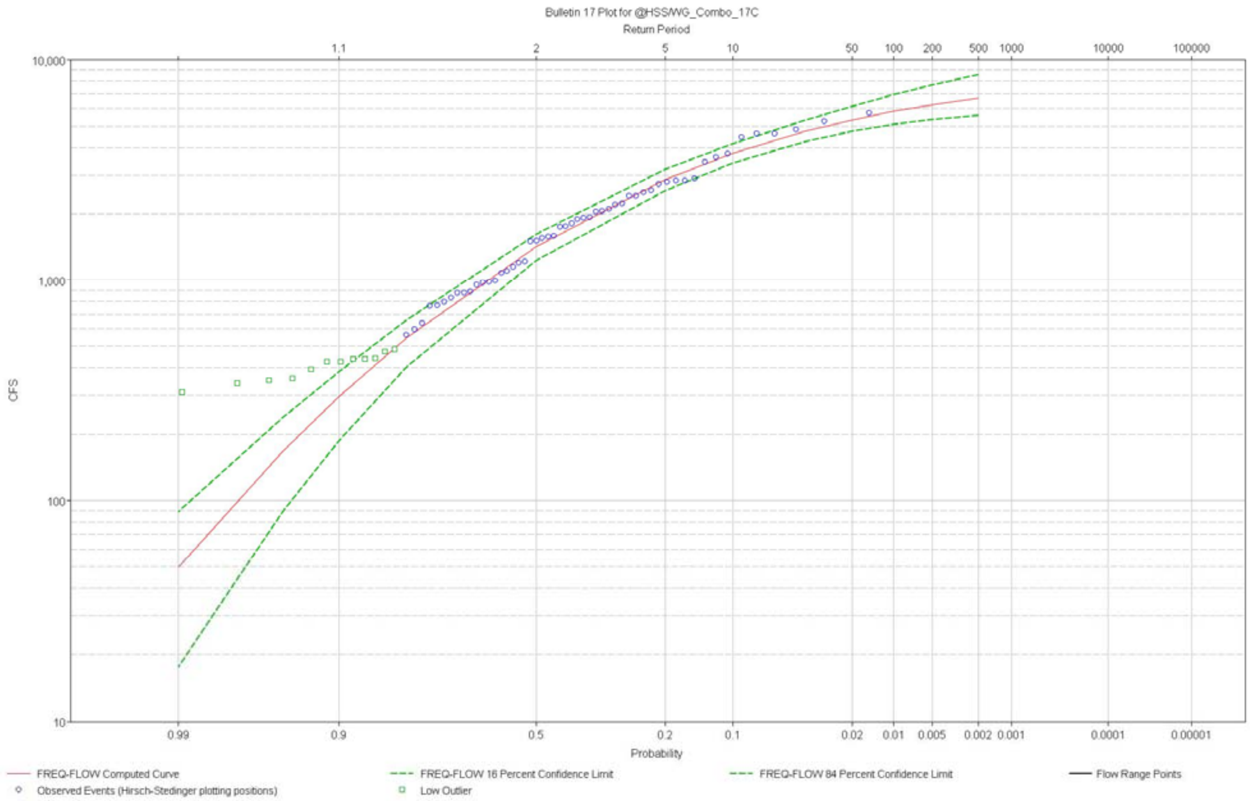


Figure 3-6 – Bulletin 17C Calculated Frequency Curve for Combined Windy Gap/HSS Gage

Table 3-8 - Peak Flows Combined Windy Gap/Hot Sulphur Springs

Drainage Area (mi^2)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
825	3,690	5,280	5,800	6,700

3.6 09058000 COLORADO RIVER NEAR KREMMLING

The systematic record included 68 years of peak flow data between the years 1905 and 2016. All the records except for 1916, 1917, 1918, and 1983 have a USGS quality code of 5 - Discharge affected to unknown degree by Regulation or Diversion. The records from 2015 and 2016 have a USGS quality code of 9 - Discharge due to Snowmelt, Hurricane, Ice-Jam or Debris Dam breakup. The record for 1984 has a USGS quality code of B - Month or Day of occurrence is unknown or not exact. The record for 1916 has a USGS quality code of 2 - Discharge is an Estimate. This flow pre-dates the construction of the reservoirs and was censored in the analysis. The record for 1994 has an USGS quality code of 1 - Discharge is a Maximum Daily Average and 2 - Discharge is an Estimate. This flow is below the set LOT and was censored for the analysis. No change to the value was performed.

There are 14 annual peak flows between 1905 and 1918, with the first post-dam construction systematic reading being taken in 1962. The highest flow at the Kremmling gage was a historical recording of 21,500 cfs made in 1921. The highest modern systematic flow recording was 13,600 cfs made in 1984. One record in 1971 was missing. For this record, the perception threshold was set to 10,100 which is equal to the 1983 peak flow. To remain consistent, with the upstream gages, only the post reservoir flows (54 years) were included in the FFA analysis. The LOT for the recent data was set to 1,875 cfs which resulted in the computed curve most closely representing the remaining data points. In addition to creating the best fit curve, this LOT was determined to be acceptable due to the high level of regulation in this part of the watershed by the upstream reservoirs. This resulted in 15 low outliers being censored. The resulting estimated flood frequency curve for the Colorado River at Kremmling gage is shown in Figure 3-7 with the peak flows shown in Table 3-9.

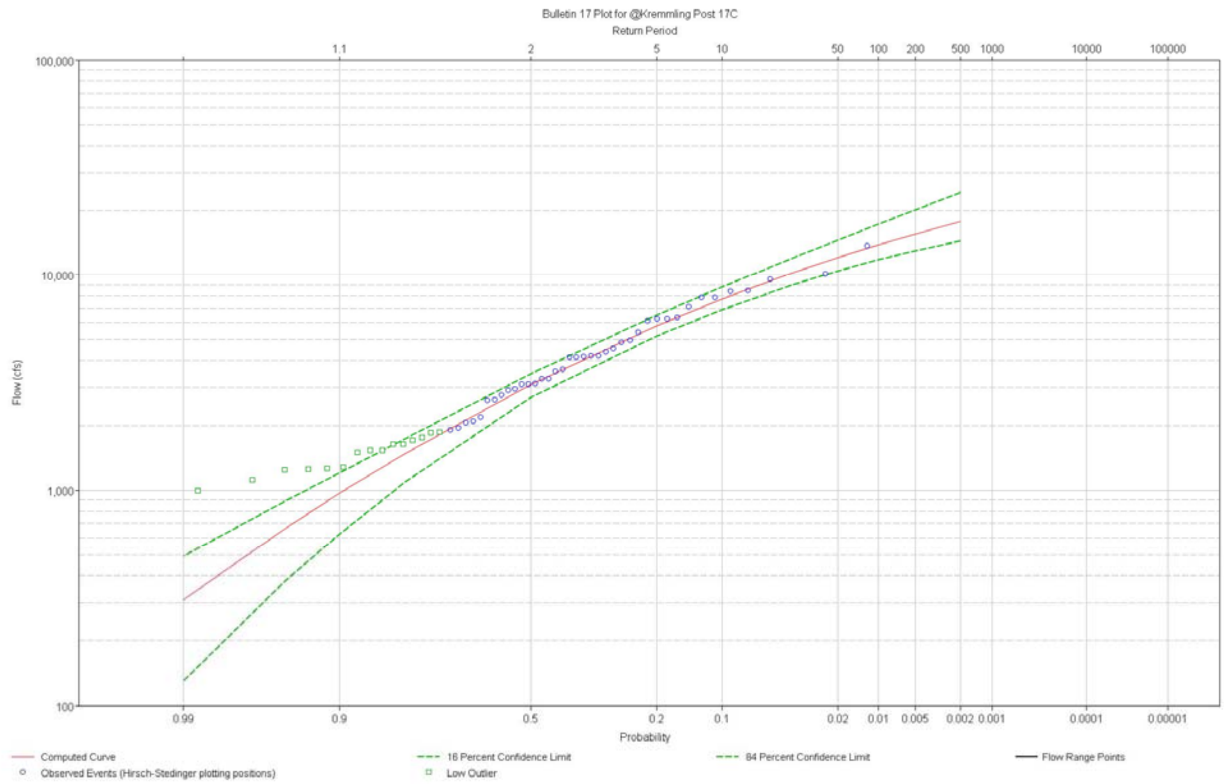


Figure 3-7 – Bulletin 17C Calculated Frequency Curve for Colorado River near Kremmling

Table 3-9 - Peak Flows Colorado River near Kremmling

Drainage Area (mi^2)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
2,379	7,740	12,100	13,800	17,800

3.7 09070500 COLORADO RIVER NEAR DOTSERO

The systematic record included 76 years of peak flow data between the years 1941 and 2016. This supersedes the 56 records used in the previous hydrologic analysis performed by Water Resource Consultants in 2002. All records have a USGS quality code of 6 - Discharge affected by Regulation or Diversion. The records from 1995 and 1996 have a USGS quality code of 1 - Discharge is a Maximum Daily Average. These values are the 6^{th} and 9^{th} largest respectively and therefore are not in the top three. Because of this, the maximum daily average values will be treated as an annual peak. The highest flow at the Dotsero gage was 22,200 cfs recorded in 1984. The gage record extends back before Homestake Reservoir was constructed and before many of the upstream reservoirs were constructed. This gage is immediately downstream of the confluence of the Eagle River which is much less regulated. Because of this, this gage showed less influence from the reservoirs as those gages upstream. However, since the influence from the upstream reservoirs is seen further downstream, the post-reservoir flows (1968 and later) at the Dotsero gage were used in the final FFA to remain consistent within this reach. Four low outliers were censored using the Multiple Grubbs-Beck test. The resulting estimated flood frequency curve for the Colorado River near Dotsero gage is shown in Figure 3-8 with the peak flows shown in Table 3-10.

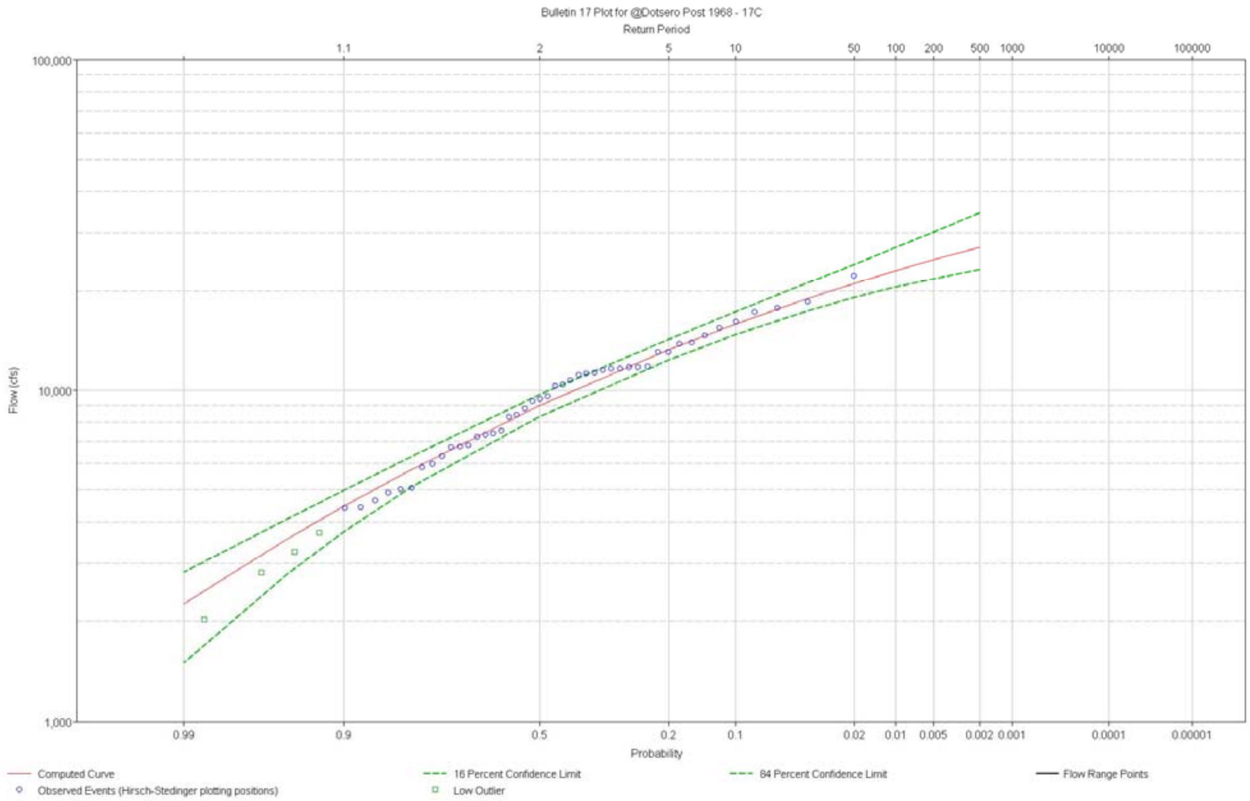


Figure 3-8 – Bulletin 17C Calculated Frequency Curve for Colorado River near Dotsero

Table 3-10 - Peak Flows Colorado River near Dotsero

Drainage Area (mi^2)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
4,390	15,900	21,100	23,000	27,200

3.8 09072500 COLORADO RIVER AT GLENWOOD SPRINGS

The systematic record included 67 years of peak flow data between the years 1900 and 1966. This is the same number of records used in the previous hydrologic analysis performed for the 1977 FIS. Records between 1938 and 1966 have a USGS quality code of 6 - Discharge affected by Regulation or Diversion. The record from 1926 has a USGS quality code of 2 - Discharge is an Estimate. This record was assigned a +/- 25% uncertainty in the listed flow.

The highest flow at the Glenwood Springs gage was 30,100 cfs recorded in 1918. The entire gage record is from before Homestake Reservoir was constructed and before many of the upstream reservoirs were constructed. Flows recorded at this gage remarkably similar to the flows recorded at the gage downstream of the confluence of the Roaring Fork after the reservoirs went in despite the additional 2,000 square miles of tributary area of the Roaring Fork Basin being added. The resulting projected frequency curves for this gage and the gage downstream of the confluence are also very similar. This indicates that flows down the Colorado River were markedly higher at this location prior to all the reservoirs and diversions being constructed upstream. Because this gage only includes the higher flows from before

1966, it no longer accurately reflects current conditions within the watershed. The FFA was still performed; however, it is not recommended to use this gage for any regulatory or design work due to it no longer representing current basin conditions. Gage 09085100 Colorado River Below Glenwood Springs should be used for all analysis.

Four low outliers were censored from the data set using the Multiple Grubbs-Beck Test. The resulting estimated flood frequency curve for the Colorado River at Glenwood Springs gage is shown in Figure 3-9 with the peak flows shown in Table 3-11.

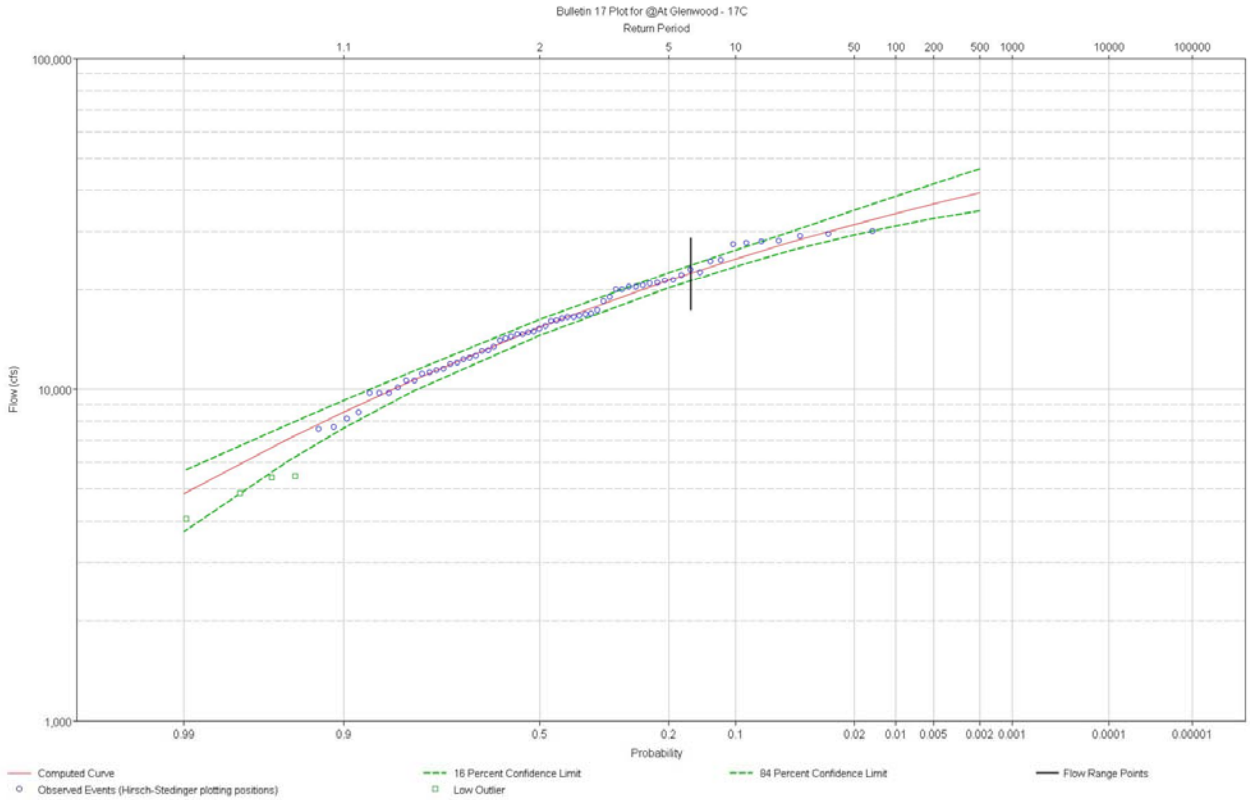


Figure 3-9 – Bulletin 17C Calculated Frequency Curve for Colorado River at Glenwood Springs

Table 3-11 - Peak Flows Colorado River at Glenwood Springs

Drainage Area (mi^2)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
4,558	24,800	31,600	34,100	39,300

3.9 09085100 COLORADO RIVER BELOW GLENWOOD SPRINGS

The systematic record included 50 years of peak flow data between the years 1967 and 2016. This supersedes the 11 records used in the previous hydrologic analysis performed for the 1977 FIS. All records from this gage have a USGS quality code of 6 - Discharge affected by Regulation or Diversion. The record from 1995 has a USGS quality code of 1 - Discharge is a Maximum Daily Average. This flow is the 7th highest in the systematic record and not in the top 3. Because of this, the value is treated as an annual peak. Additionally, from the Floods in

Colorado – Geological Survey Water-Supply Paper 997 published in 1948, a historical flow of 44,400 cfs was described near the location of the gage in 1921. This flow was assigned a 25% uncertainty value in the analysis to account for the potential discrepancies in measurement. The highest systematic flow at the Below Glenwood gage was 31,500 cfs recorded in 1984 and this was set as the EMA threshold for the data gap between 1922 and 1966.

The gage record is almost entirely after the construction of Ruedi reservoir was completed. Four low outliers were censored from the data set using the Multiple Grubbs-Beck Test. The resulting estimated flood frequency curve for the Colorado River Below Glenwood Springs gage is shown in Figure 3-10, including the uncertainty of the 1921 flow, with the peak flows shown in Table 3-12.

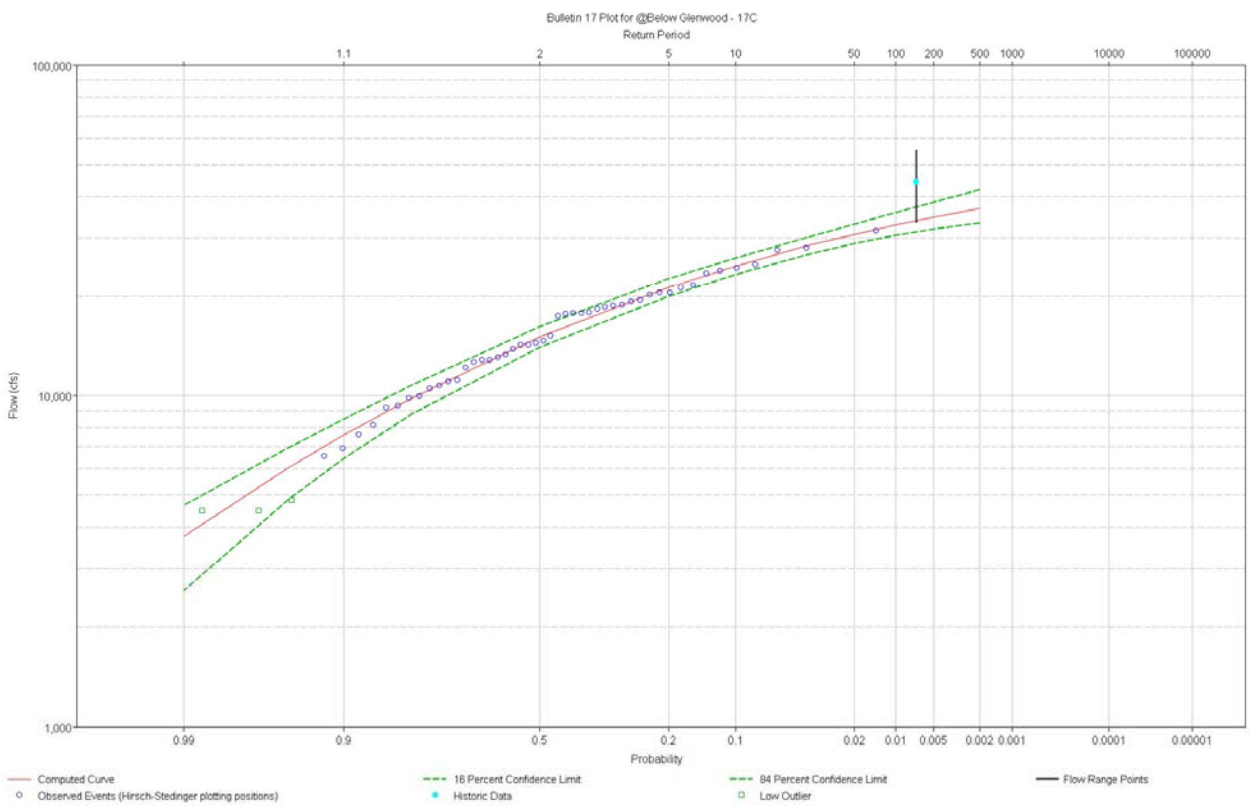


Figure 3-10 – Bulletin 17C Calculated Frequency Curve for Colorado River Below Glenwood Springs

Table 3-12 - Peak Flows Colorado River Below Glenwood Springs

Drainage Area (mi²)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
6,014	24,700	30,800	32,900	36,800

3.10 BELOW GLENWOOD SPRINGS MINUS ROARING FORK

Flows at the confluence of the Colorado and Roaring Fork Rivers were further analyzed to determine the best data available. Based on the proposed analysis, the Dotsero gage would be projected approximately 9,000 feet downstream to the point above the confluence to determine flows upstream of the confluence. As there are gages below the confluence (09085100 Colorado River Below Glenwood Springs) and upstream on the Roaring Fork (09085000 Roaring Fork River at Glenwood Springs) with many overlapping data points, it was determined that using data from the confluence itself was preferred to projecting data nearly two miles downstream.

There is only approximately 3 square miles of drainage area between the Roaring Fork at Glenwood Springs gage and the confluence with the Colorado River, and the runoff from this area was determined to be negligible in this subtraction calculation. The flows upstream of the Roaring Fork confluence were determined by subtracting the daily maximum flow on the Roaring Fork River at Glenwood Springs gage from the corresponding peak flow on the Colorado River Below Glenwood Springs gage. A sensitivity analysis was completed between these developed flows and the projected flows from the Colorado River near Dotsero gage and there was less than a 2% difference in the projected flows. These flows are recommended for use upstream of the confluence of the Colorado and Roaring Fork Rivers to approximately the limits of Glenwood Springs as they are based on recorded gage flows at the confluence rather than projected flows from an upstream gage which is only an estimate. The peak flows for this scenario are shown in Figure 3-11 with the peak flows shown in

Table 3-13. Additional details about this calculation is included at the end of Appendix H.

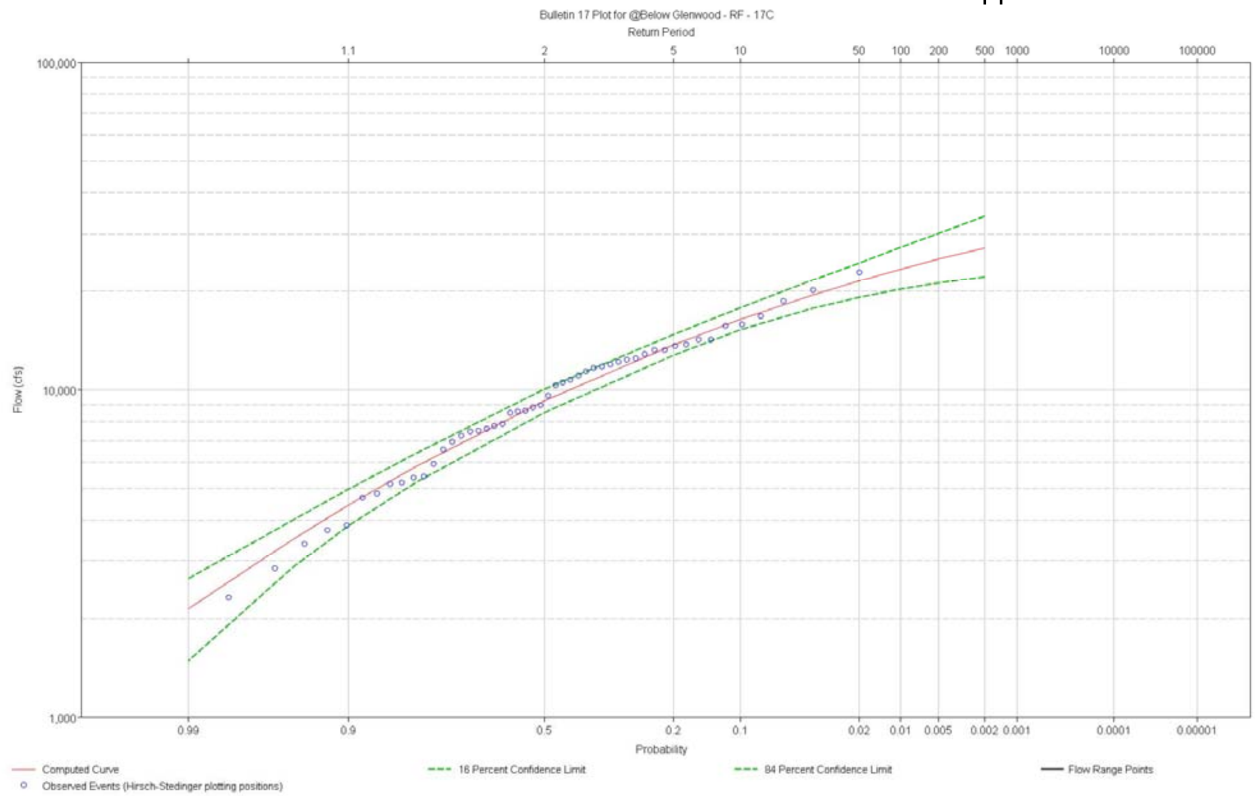


Figure 3-11 – Bulletin 17C Calculated Frequency Curve for Colorado River Minus Roaring Fork

Table 3-13 - Peak Flows Colorado River Minus Roaring Fork

Drainage Area (mi^2)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
4,560	16,400	21,500	23,400	27,200

3.11 09093700 COLORADO RIVER NEAR DE BEQUE

The systematic record included 31 years of peak flow data between the years 1967 and 1997. All records from this gage have a USGS quality code of 5 - Discharge affected to unknown degree by Regulation or Diversion. The records from 1995 and 1996 have a USGS quality code of 1 - Discharge is a Maximum Daily Average. Since the flow in 1995 is the third largest peak on record, this value was investigated to determine the difference between the maximum daily average for the day of the recorded annual peak as compared to these same records in adjacent years. Data from surrounding years was taken and the maximum daily average was compared to the recorded peak. The results are shown in Table 3-14.

Table 3-14 - Annual Peak Vs. Max Daily Average De Beque

Year	Annual Peak Discharge (cfs)	Maximum Average Daily Discharge (cfs)	Percent Difference (%)
1991	14,000	13,200	-6%
1992	7,700	7,990	4%
1993	22,900	22,200	-3%
1994	9,780	11,000	11%
1995	29,500 *	29,100	-1%
1996	20,900	21,100	1%
1997	26,800	25,900	-3%

* Recorded with USGS Quality code of 1 – Discharge is a Maximum Daily Average.

No clear trend emerges between the annual peak discharge and the maximum daily average as the flows range from +11% to -6%. Because of this, the recorded flow of 29,500 cfs was used for the 1995 record and treated as an annual peak.

To account for the 1921 flow, the flow recorded at the Roaring Fork confluence (44,000 cfs) was projected downstream and the flow recorded near Palisade (50,800 cfs) was projected upstream to the location of the De Beque gage. These two projected flows were then averaged and a new historical flow (47,733 cfs) was then added as a historical record in the data set and a +/- 25% uncertainty was applied. For the gap in data between 1922 and 1968, the perception threshold was set to 32,300 cfs which is equal to the flow during the 1983 storm, the second highest in the systematic record, which generally defines the highest point in the rest of the dataset.

The highest systematic flow at the De Beque gage was 38,200 cfs recorded in 1984. The gage record is almost entirely after the construction of Rifle Gap reservoir was completed. One low outlier was censored from the data set using the Multiple Grubbs-Beck Test. The resulting estimated flood frequency curve for the Colorado River Below Glenwood Springs gage is shown in Figure 3-12 with the peak flows shown in Table 3-15.

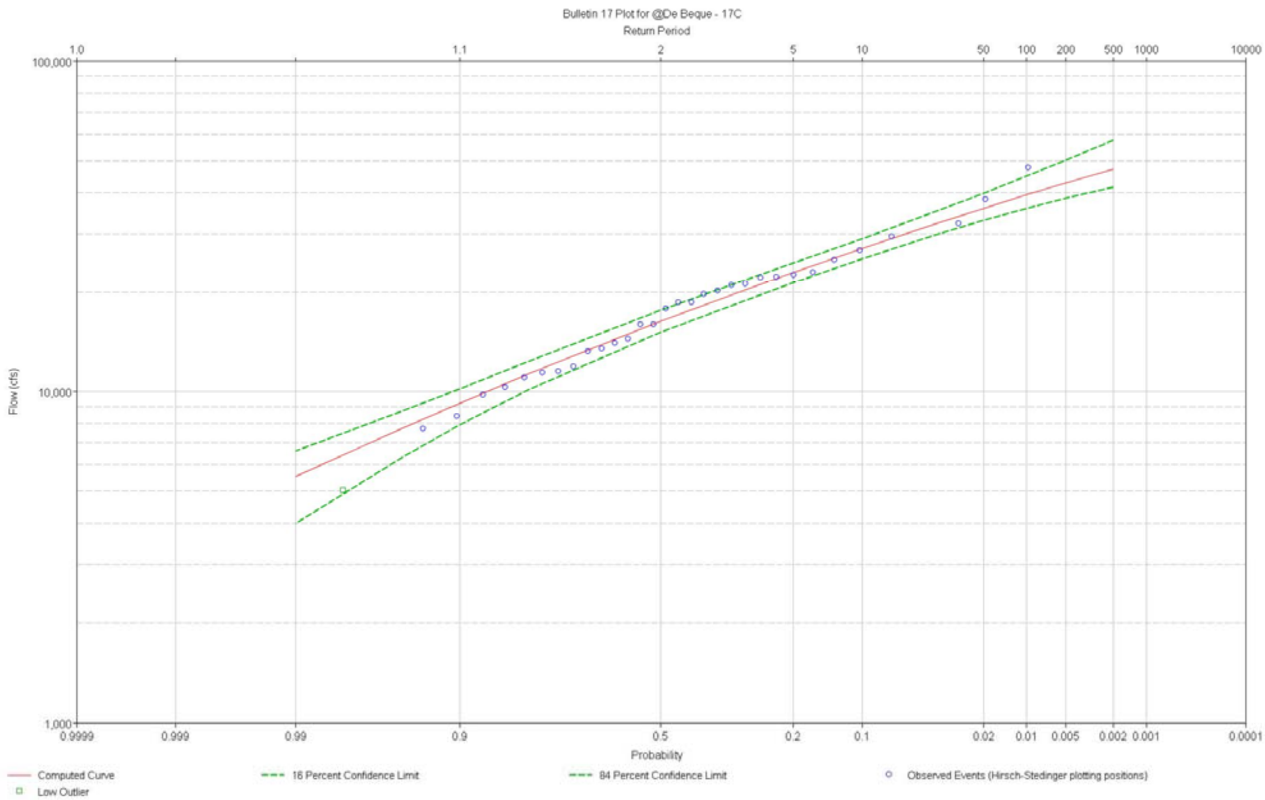


Figure 3-12 – Bulletin 17C Calculated Frequency Curve for Colorado River near De Beque

Table 3-15 - Peak Flows Colorado River near De Beque

Drainage Area (mi^2)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
6,014	27,200	35,900	39,400	47,300

Flows at the De Beque gage are very similar to those recorded at the Cameo Gage as there are no significant inflows between the two gages. At the Cameo gage, an additional 616 square miles of tributary area is added (8% increase over De Beque). Most of this area is below 7,500 feet and does not contribute much flow in the form of snowmelt runoff. Examining the same 31 years of record at both gages, the flows differ by a maximum of 3,700 cfs or 3% on average for the entire length of record when the Cameo gage record is projected to the location of the De Beque gage. Due to the short length of record and the difference in flows between the two gages not exceeding the difference in drainage areas for the 31-year length of record, it is recommended that the 09095500 Colorado River Near Cameo gage be used for any regulatory or design work in this region due to its longer gage record rather than using the De Beque gage.

Table 3-16 shows the comparison between the De Beque gage and the projected Cameo gage with historic events excluded.

Table 3-16 - Peak Flow Comparison De Beque vs. Cameo (1967 – 1997)

Location	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
De Beque	28,200	37,600	41,500	50,100
Cameo	28,843	38,953	43,199	53,047
Difference (%)	2%	4%	4%	6%

3.12 09095500 COLORADO RIVER NEAR CAMEO

The systematic record included 83 years of peak flow data between the years 1934 and 2016. This supersedes the 52 records used in the previous hydrologic analysis performed by J.F. Sato in 1989. All records from this gage have a USGS quality code of 5 - Discharge affected to unknown degree by Regulation or Diversion. The records from 1934, 1995, and 1996 have a USGS quality code of 1 - Discharge is a Maximum Daily Average. As these specific records have magnitudes within the middle of the observed records, the maximum daily average will be assumed to be adequate for this analysis as it is assumed that it will not substantially change the results of the analysis. The record from 2016 has a USGS quality code of 9 - Discharge due to Snowmelt, Hurricane, Ice-Jam or Debris Dam breakup. The record for 2012 has a USGS quality code of 2 - Discharge is an Estimate. This record was initially assigned a +/- 25% uncertainty in the listed flow, however this single change alone dropped the computed flow in the 0.2% annual chance event by 15%. Since this flow is below the low-outlier threshold, even with the 25% uncertainty increase, no uncertainty was added to produce the most conservative computed flow curve.

To estimate the 1921 flow, the flow recorded at the Colorado River downstream of the Roaring Fork confluence (44,000 cfs) was projected downstream and the flow recorded near Palisade (50,800 cfs) was projected upstream to the location of the Cameo gage. These two projected flows were then averaged and a new historical flow (50,249 cfs) was then added as a historical record in the data set and a +/- 25% uncertainty was applied. For the gap in data between 1922 and 1933, the perception threshold was set to 36,000 cfs which is equal to the flow during the 1983 storm, the second highest in the systematic record, which generally defines the highest point in the rest of the dataset.

Flows at Cameo extend prior to other upstream control. The highest systematic flow at the Cameo gage was 39,300 cfs in 1984 – after the reservoirs and diversions were constructed. As described in Section 2.2.6, the Cameo gage was examined for reservoir influence and although it still showed influence of the reservoir, due to the high flows seen in 1983 and 1984, the two highest in the systematic record, it was determined that the chance for extreme events outweighs the influence of the reservoir at this gage. Therefore, the entire length of record was used for the Cameo gage for the final FFA.

26 low outliers were censored from the data set using the Multiple Grubbs-Beck Test. The resulting estimated flood frequency curve for the Colorado River Near Cameo gage is shown in Figure 3-13, including the uncertainty of the 1921 flow, with the peak flow results from the FFA shown in Table 3-17.

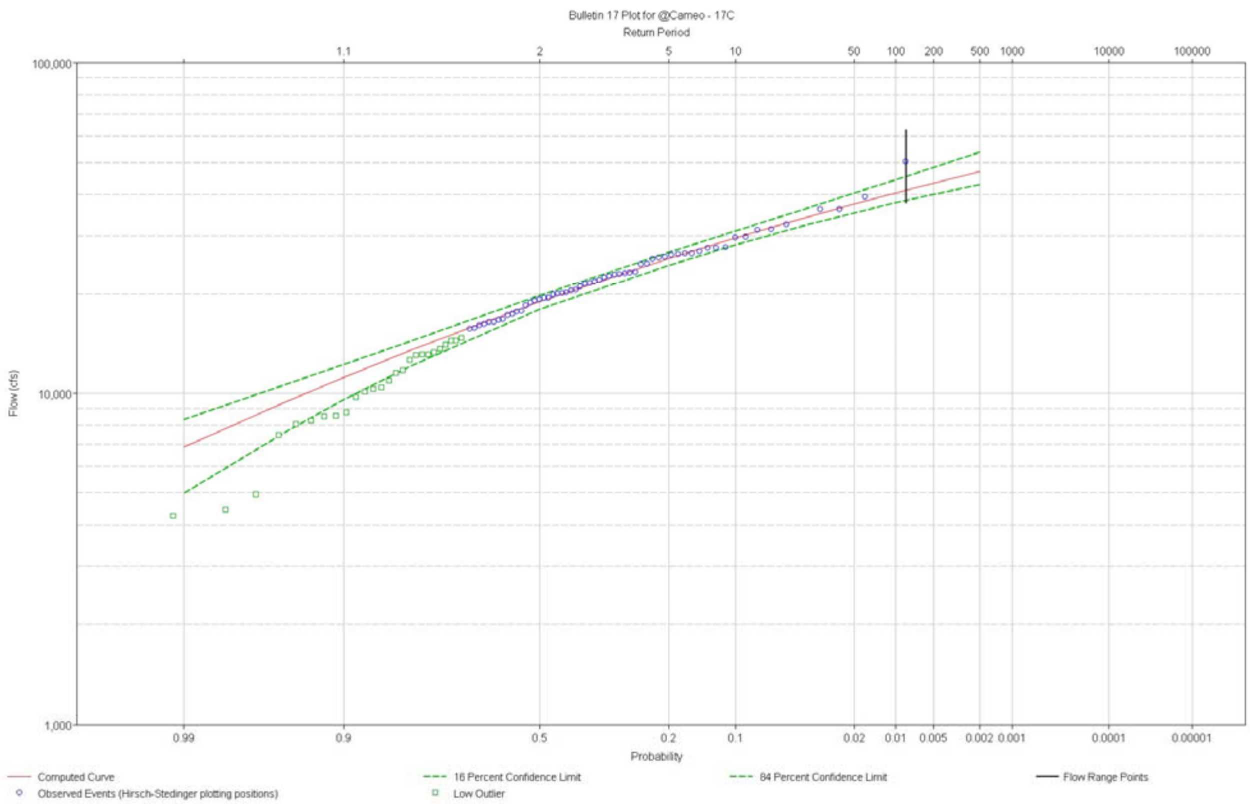


Figure 3-13 – Bulletin 17C Calculated Frequency Curve for Colorado River near Cameo

Table 3-17 - Peak Flows Colorado River near Cameo

Drainage Area (mi^2)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
7,986	29,600	37,400	40,400	46,800

3.13 09106000 COLORADO RIVER NEAR PALISADE

The systematic record included 32 years of peak flow data between the years 1902 and 1933. This matches the same number of records used in the J.F. Sato analysis in 1989. All records from this gage have a USGS quality code of 6 - Discharge affected by Regulation or Diversion. Except for the records from 1932 and 1933, all other records have a USGS quality code of 2 - Discharge is an Estimate. The records with the code were assigned a +/- 25% uncertainty in each of the listed flows. As the Palisade gage is within the projection limits of the Fruita Gage, the 1884 historic flood was projected to this gage. This new flow (81,339 cfs) was then assigned a +/- 25% uncertainty. This gage was operating for the 1921 flood so the systematic value for this event was used as opposed to projecting flows from the Fruita gage. For the gap in data between 1885 and 1901, the perception threshold was set to 51,000 cfs which is equal to the flow during 1917, the second highest in the systematic record, which generally defines the highest point in the rest of the dataset.

The highest systematic flow at the Palisade gage was 52,400 cfs recorded in 1921. The gage record is entirely before any of the reservoirs within the basin were constructed. The initial 17C analysis resulted in one low outlier being censored based on the Multiple Grubbs-Beck Test. In this scenario, the 0.2% annual-chance-exceedance peak flow was 76,500 cfs. This projected flow is higher than projected flows from any nearby gages and the existing FIS documents.

To test sensitivity, the LOT was raised to 22,000 cfs which resulted in seven low outliers being censored from the data set. Under this scenario, the 0.2% annual-chance-exceedance peak flow increased further to 78,700 cfs. It is believed that the uncertainty limits are having a more extreme impact on the graph than systematic records alone would have as an initial run without the uncertainty placed the 0.2% annual-chance-exceedance peak flow at around 70,900 cfs. Due to the opposite response in raising the LOT and the inverted fit of the calculated curve to the observed data, the values developed from the initial analysis with one outlier was used. No change to the FFA was made to account for the high projected flow values.

Since all the recorded data is from pre-reservoir construction within the basin and all the flows being estimated, it is not recommended to use this gage for any regulatory or design work. Instead, data from 09095500 Colorado River near Cameo or 09106150 Colorado River Below Grand Valley Diversion Near Palisade should be used for all future analysis. For reference, the resulting estimated flood frequency curve for the Colorado River Near Palisade gage is shown in Figure 3-14 with the peak flows shown in Table 3-18.

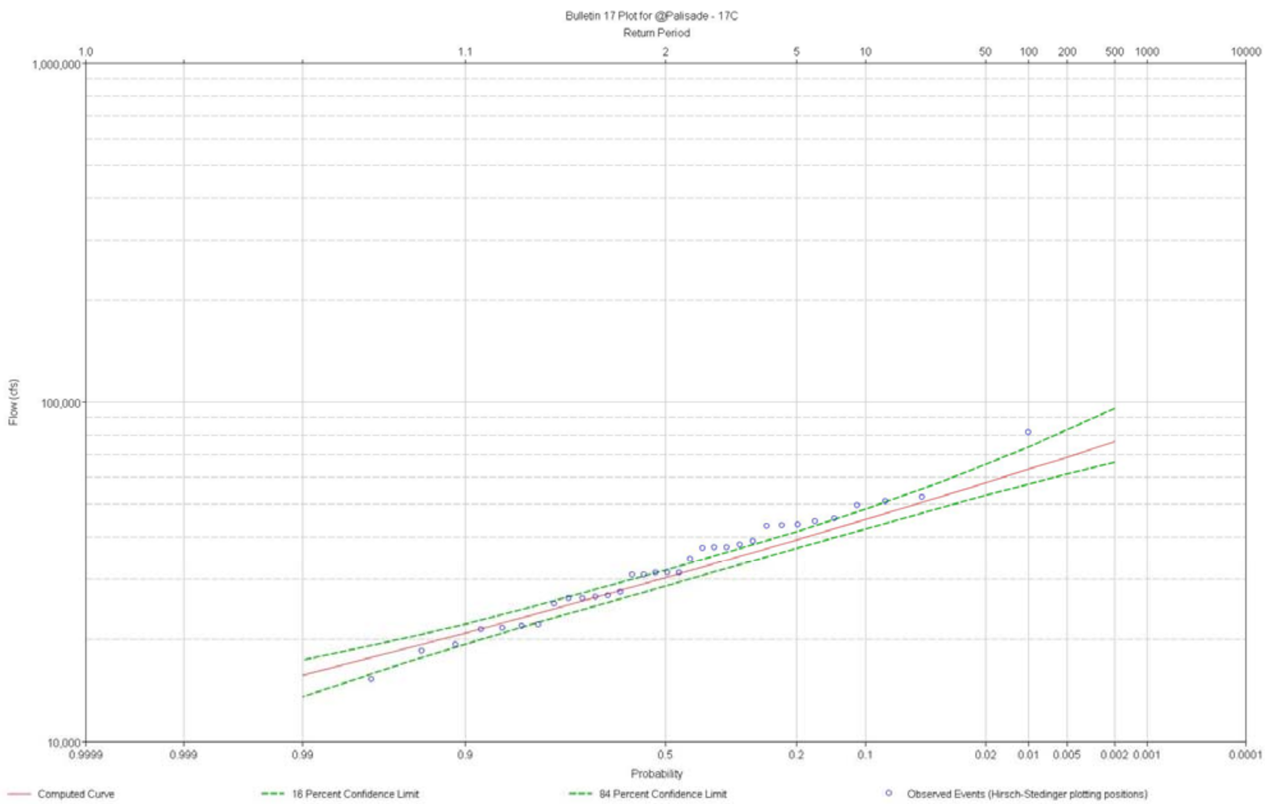


Figure 3-14 – Bulletin 17C Calculated Frequency Curve for Colorado River near Palisade

Table 3-18 - Peak Flows Colorado River near Palisade

Drainage Area (mi^2)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
8,738	45,000	57,800	63,300	76,400

3.14 09106150 COLO RIVER BELOW GRAND VALLEY DIVERSION NEAR PALISADE

The systematic record included 26 years of peak flow data between the years 1991 and 2016. Data from this gage did not exist for the previous analysis by J.F. Sato in 1989. All records from this gage have a USGS quality code of 5 - Discharge affected to unknown degree by Regulation or Diversion. Additionally, the records for 1995,1996, and 2001 have a USGS quality code of 1 - Discharge is a Maximum Daily Average. 1995 is the 3rd highest flow on record so additional investigation was performed into the trend between the maximum daily average and the recorded peak flow for other adjacent years in the record. Annual peak flow values were compared to the annual daily averages of the days those peaks occurred on for the years 1991 through 1999 to determine if a trend was present. The values are shown in Table 3-19.

Table 3-19 - Grand Valley Diversion Peak Comparison

Date of Peak	15 Minute Peak (cfs)	Daily Average Peak (cfs)	% Difference
6/15/1991	14,100	12,500	-11%
5/28/1992	8,070	7,560	-6%
5/29/1993	27,400	25,900	-5%
6/2/1994	11,600	8,930	-23%
6/17/1995	---	29,600	---
5/20/1996	21,500	20,300	-6%
6/6/1997	28,400	26,500	-7%
5/22/1998	14,800	14,200	-4%
6/9/1999	13,300	12,500	-6%
		Average:	**-6%**

Values for 1994 and 1995 were censored from the analysis as 1994 appears to be an outlier and 1995 is the year we are trying to estimate. Excluding 1994, the average of the remaining years results in a 6% difference between the 15-minute peak and the daily average peak. For the analysis, the peak value for 1995 is replaced with 29,600 cfs to match the recorded daily average peak. The high value was increased by 6% to 31,376 cfs.

The highest systematic flow at the Grand Valley Diversion gage was 32,700 cfs recorded in 2011. The gage was not in place to capture the 1984 flood flows which have consistently been the highest on record at the upstream gages. In addition, the gage was also not operational during the historic 1884 and 1921 floods. Since this gage is assumed to be out of the major influence of the upstream reservoirs all three of these floods have been applied using WRIR 99-4190 methodology (Vaill, 2000) and given a 25% uncertainty value.

To account for the 1984 flow, the flow taken at the Cameo gage for 1984 (39,300 cfs) was projected downstream to the location of the Grand Valley Diversion Gage. This new flow (42,065 cfs) was then added as a historical record in the data set and a +/- 25% uncertainty was added to the record. The threshold between 1984 and 1991 for the EMA analysis was set to 28,364 cfs. This number was obtained by taking the next highest peak at the Cameo gage between 1984 and 1991 and projecting it downstream to the location of the Grand Valley Diversion gage.

For the 1884 and 1921 flows, the flows taken at the Fruita Gage (125,000 cfs and 81,100 cfs for 1884 and 1921 respectively) were projected upstream to the location of the Grand Valley Diversion Gage. These new flows (81,785 cfs, and 53,062 cfs) were then added as historical records to the data set and given a +/- 25% uncertainty. The threshold for the years with no data between 1884 and 1984 for the EMA analysis was set to 42,000 cfs which is approximately equal to the 1984 projected peak flow.

With all these data adjustments, the analysis did not filter out any low outliers. The LOT was examined to try to get a better fitting curve, but when the LOT was raised, the computed values were increasing for the more extreme events and the curve was turning more concave up. The short data record at this gage does seem to have a noticeable impact on the results as there is not a good spread of data between frequent events and extreme events. For this analysis, no change to the LOT was made and the curve was used as is. Without any adjustment, there is reasonable agreement between the projected values, the previous FIS results and the upstream and downstream gages. The resulting estimated flood frequency curve for the Colorado River Below Grand Valley Diversion Near Palisade gage is shown in Figure 3-15, including the uncertainty limits for the 1884 and 1921 floods as well as the data adjustment to the 1995 flow, and the peak flows from the FFA are shown in Table 3-20.

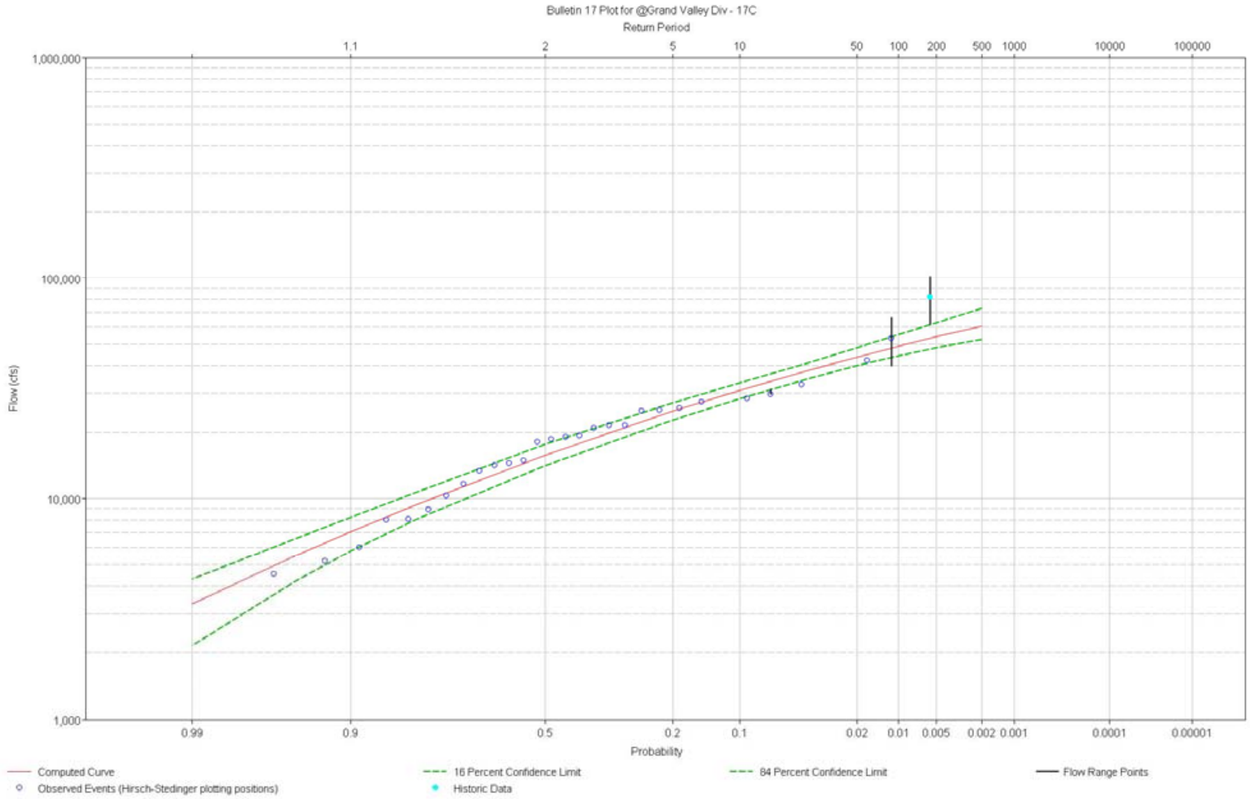


Figure 3-15 – Bulletin 17C Calculated Frequency Curve for Colorado River Below Grand Valley Div.

Table 3-20 - Peak Flows Colorado River Below Grand Valley Diversion

Drainage Area (mi²)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
8,813	30,900	43,800	49,000	60,600

3.15 09153000 COLORADO RIVER NEAR FRUITA

The systematic record included 16 years of peak flow data between the years 1908 and 1923 with one historical peak discharge in 1884. This matches the same number of records used in the J.F. Sato analysis in 1989. All records except the 1884 record have a USGS quality code of 5 - Discharge affected to unknown degree by Regulation or Diversion. The 1884 record has a USGS quality code of 7 - Discharge is an Historic Peak. The 1884, 1908, 1909, and 1910 records have a USGS quality code of 2 - Discharge is an Estimate. A 25% uncertainty value was applied to these records.

The Fruita gage is the only gage within the basin to have recorded data for the 1884 flood. The magnitude of this flood was reported to be approximately 125,000 cfs at this location. The highest systematic flow at the Fruita gage was 81,100 cfs recorded in 1921. In addition to being in the gage data, the magnitudes of both the 1884 event and the 1921 event matched those listed in the “Floods in Colorado” report published by the USGS in 1948. Due to the 1884 extreme event, and the very short record at the gage, the magnitude of the less-frequent events in the FFA are higher than the estimates from the nearby gages. No low outliers were censored from the data set using the Multiple Grubbs-Beck Test and no adjustments to the LOT were performed due to the small amount of data. For the missing data between 1885 and 1907 an observation threshold of 79,100 cfs was used which was the 2nd highest systematic record at the gage. Due to the short data record, all the recorded data being from pre-reservoir construction within the basin, and the projections being significantly higher than those from the surrounding gages, it is not recommended to use this gage for any regulatory or design work. For reference, the resulting estimated flood frequency curve for the Colorado River Near Fruita gage is shown in Figure 3-16, including the data points with their uncertainty bounds, and the peak flows from the FFA are shown in Table 3-21.

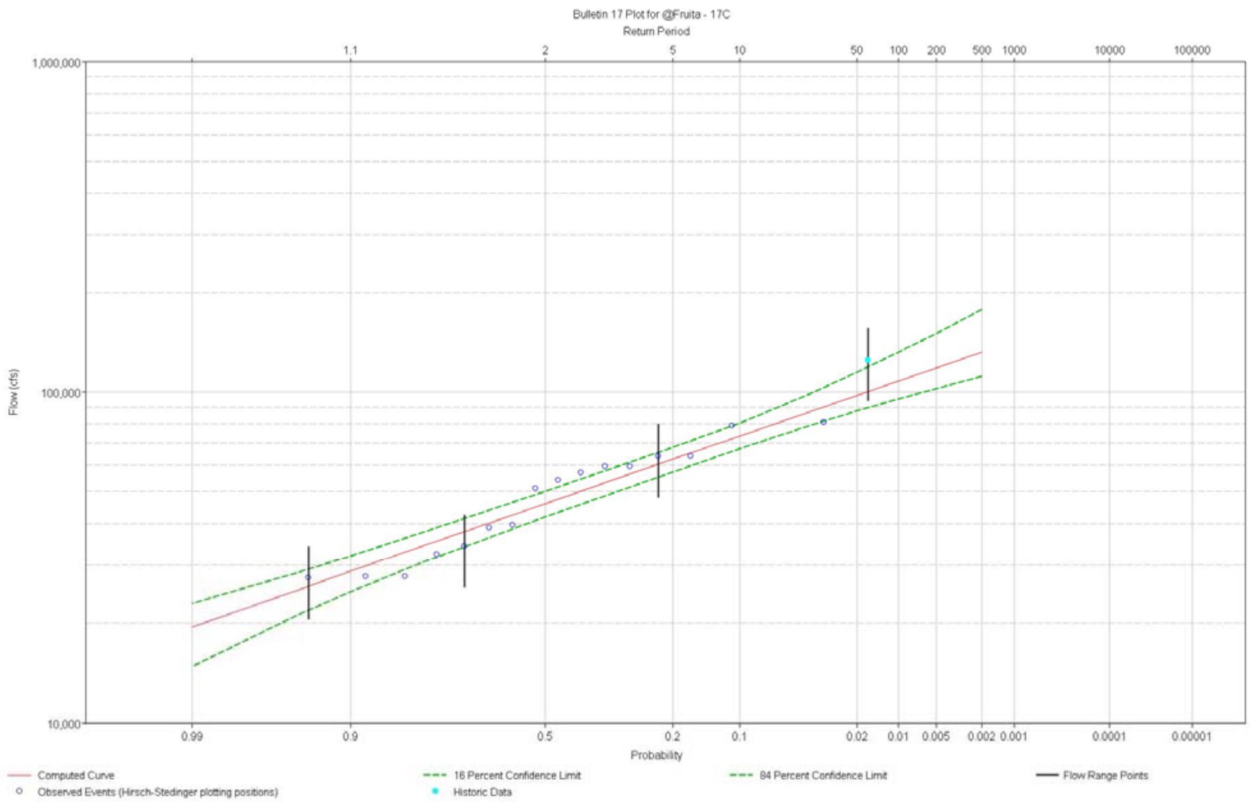


Figure 3-16 – Bulletin 17C Calculated Frequency Curve for Colorado River near Fruita

Table 3-21 - Peak Flows Colorado River near Fruita

Drainage Area (mi^2)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
17,100	73,700	97,800	108,000	132,000

3.16 09163500 COLORADO RIVER NEAR COLORADO-UTAH STATE LINE

The systematic record included 66 years of peak flow data between the years 1951 and 2016. This supersedes the 35 records used in the previous hydrologic analysis performed by J.F. Sato in 1989. All records from this gage have a USGS quality code of 5 - Discharge affected to unknown degree by Regulation or Diversion. The highest systematic flow at the Colorado-Utah State Line gage was 69,800 cfs recorded in 2011. The gage record is missing both the

1884 and 1921 flood events seen by the upstream gages. A preliminary FFA was developed to determine the impact of these two storm events. The flows from these two floods were projected downstream to the location of the Colorado-Utah State Line gage using WRIR 99-4190 methodology (Vaill, 2000). These new flows (128,753 cfs [1884] and 83,535 cfs [1921]) were then added as historical records to the data set. For the missing flows a threshold of 62,100 cfs was selected as it was the 2nd highest systematic peak in the record. As the 1884 record at Fruita had a code of 2 and the 1921 record was also treated as an estimate, both values were assigned a +/- 25% uncertainty. By making this change, the 0.2% annual-chance-exceedance peak flow increased from 86,500 cfs to 104,000 cfs. Similar to the Grand Valley Diversion gage in section 3.13, these flows were included in the analysis due to their historical nature and relevance in the context of possible historic/paleo floods which the lower part of the basin could experience and were assigned a 25% uncertainty. As mentioned in Section 2.2.6, this area is assumed to be beyond the influence of the reservoirs so the entire record length was used in the analysis.

Four low outliers were censored from the data set using the Multiple Grubbs-Beck Test. The resulting estimated flood frequency curve for the Colorado River near Colorado-Utah State Line gage is shown in Figure 3-17, including the uncertainty limits for the historic floods, and the peak flows from the FFA are shown in Table 3-22. It was noted that some of the historic points plot above the flood frequency curve for the more infrequent events. This may be due to the impacts of the upstream diversions and reservoirs as both points are prior to the construction of this regulation. A weighted skew coefficient for this and other similar gages may be warranted for future studies, however, no weighted skew was assigned for this analysis.

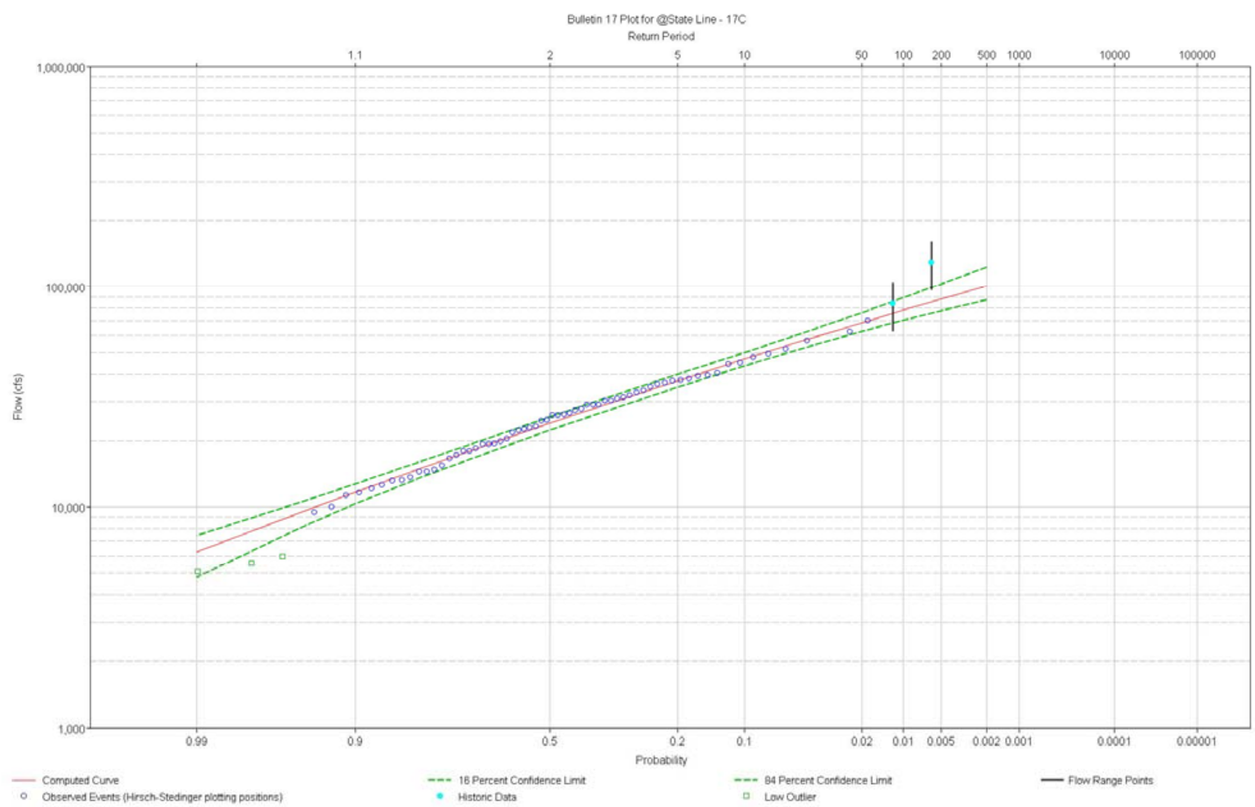


Figure 3-17 – Bulletin 17C Calculated Frequency Curve for Colorado River near CO-UT State Line

Table 3-22 - Peak Flows Colorado River near CO-UT State Line

Drainage Area (mi^2)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
17,849	46,900	68,600	78,100	101,000

3.17 09180500 COLORADO RIVER NEAR CISCO, UTAH

This gage was analyzed to provide one additional data point at the end of the record to provide consistent flood frequency results for the studied segment of the Colorado River and the gages below the study area. The systematic record included 99 years of peak flow data between the years 1914 and 2016 with one historic peak in 1884. This gage was not used in any previous study within Colorado. All records from this gage have a USGS quality code of 6 - Discharge affected by Regulation or Diversion. The 1884 flow also has USGS quality codes of 2 – Discharge is an Estimate and 7 – Discharge is an Historic Peak. The highest flow at the Cisco Utah gage was 125,000 cfs recorded as the historical peak in 1884. This is the exact same flow as recorded at the Fruita gage even though nearly an additional 30% of tributary drainage area, notably the Dolores River, was added at this gage compared to the Fruita gage. Because of this, the 125,000 cfs value is projected downstream to the location of the Cisco gage, following the WRIR 99-4190 methodology (Vaill, 2000) and assumed that the 0.64 exponent for the Northwest region is still applicable. This was done to remain consistent with the rest of the analysis. This new value was 155,700 cfs for the Colorado River near Cisco, which theoretically better reflects the additional snowmelt contribution from the Dolores River and other tributary areas. The projected 1884 flood, including its error bounds, is outside of the 84% confidence limits. From communication with Dr. Greenbaum, there is paleoflood evidence that the 1884 flow at the Moab site was closer to 125,000 cfs than the projected 155,700 cfs value. However, for this analysis, it was determined that using the 155,700 cfs was more conservative while still being justifiable.

The 1921 flood record at Fruita was also projected downstream to the Cisco gage as there was no record of it in the systematic data of the Cisco gage. This new flow was calculated to be 101,000 cfs. In addition, both flows were given a 25% uncertainty to remain consistent with the rest of the analysis. The highest systematic flow was 76,800 cfs in 1917 and the highest recent systematic flow was 70,300 cfs in 1984 which was used as the high value for all the missing data points in the EMA analysis.

49 low outliers were censored from the data set using the Multiple Grubbs-Beck Test. The resulting estimated flood frequency curve for the Colorado River Near Cisco, Utah gage is shown in Figure 3-18, including the uncertainty limits for the historic flows and the peak flow results from the FFA are shown in Table 3-23.

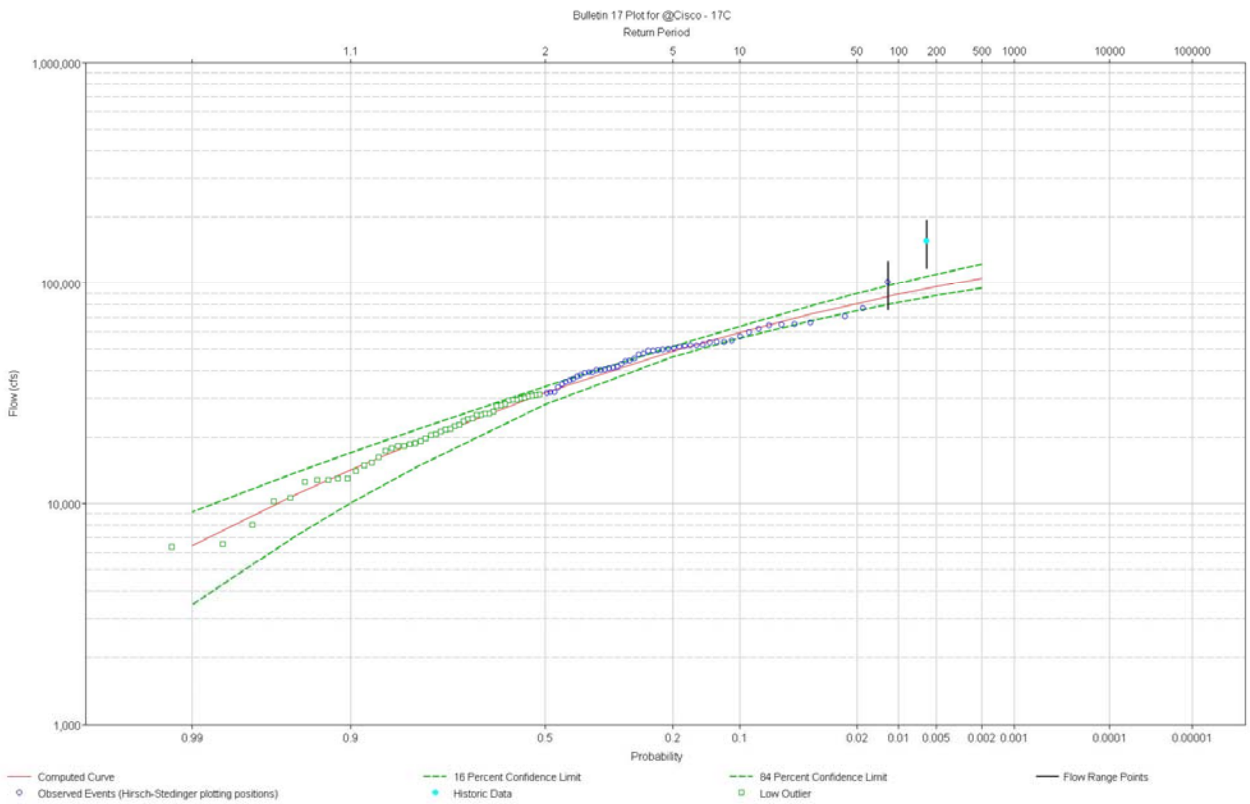


Figure 3-18 – Bulletin 17C Calculated Frequency Curve for Colorado River near Cisco, Utah

Table 3-23 - Peak Flows Colorado River Near Cisco, Utah

Drainage Area (mi^2)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
24,100	59,800	80,900	89,000	106,000

4.0 Flood Frequency Analysis Summary

In general, the results from the FFA show continuity from gage to gage with flows increasing downstream. The computed 10%, 2%, 1%, and 0.2% annual-chance-exceedance peak flows all do not cross either the upstream or downstream computed flows. A graph demonstrating this is shown as Figure 4-1. The upward trend for the extreme flows on the log-log graph should be noted as this appears to indicate the loss of regulation at these higher flow events.

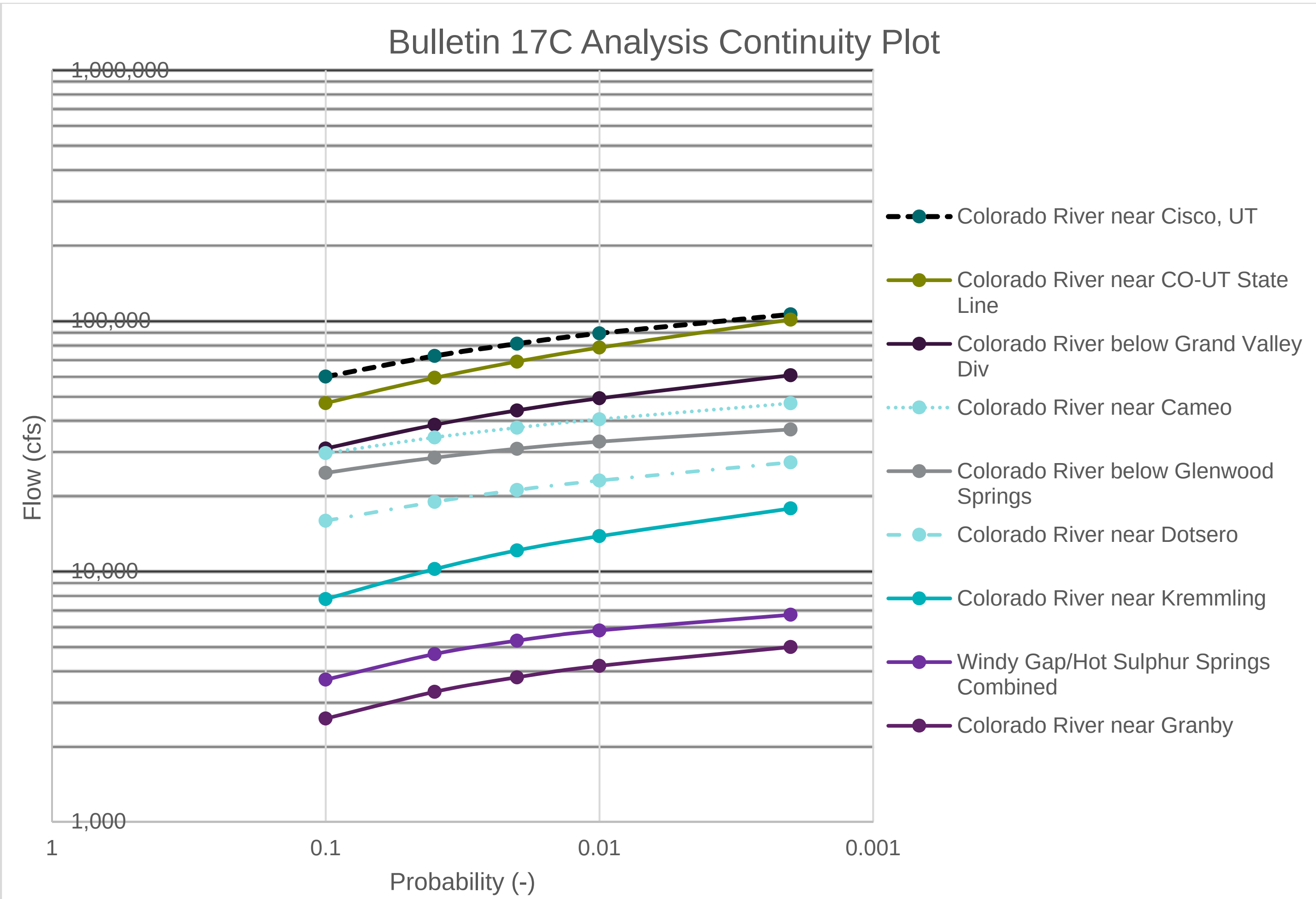


Figure 4-1 – Bulletin 17C Continuity Plot

4.1.1 FIS Flow Change Determination

Flows for this study were projected from each gage to the same flow change locations found in the respective FIS documents using the WRIR 99-4190 methodology (Vaill, 2000). When projected to the nearest flow change location listed in the effective FIS, the new projected flows have an overall decrease when compared to the previously published effective FIS flows. The gage selected for use at each flow change location was determined by examining the quality of data at the gage, the distance away from the flow change point, and the overall continuity in the flood frequency curves from upstream to downstream.

4.1.2 Combined Results and Comparison to Bulletin 17B

The final combined results from the FFA analyses are shown in Table 4-1. All analyzed gages are shown as well as the WRIR 99-4190 projections to the existing FIS flow change locations (Vaill, 2000). Gages not recommended for use as described in Section 3.0 are highlighted in gray while the others are in white. Flow change locations from the previous FIS documents are highlighted in light blue with the resulting projections to these locations highlighted in green. The percentage difference between the published FIS flow values and the new projections is listed in the Percent Difference columns for all the FIS flows.

A Bulletin 17B analysis following standard procedures listed in the guidance document was also performed in parallel to the Bulletin 17C analyses and the results are included in Table 4-1. This analysis used the Single Grubbs-Beck Test rather than the Multiple Grubbs-Beck Test. A percentage difference between the 17C analysis and the 17B analysis is included for all gages analyzed by the FFA. This was done to highlight the differences between the 17B and 17C analysis, especially with the Multiple Grubbs-Beck Test. The Bulletin 17C approach had a pronounced impact on narrowing the confidence limits and producing projected curves which have a much better fit to the data points.

Also included in Table 4-1, is the final skew and mean squared error from the Bulletin 17C analysis.

Table 4-1 Flood Frequency Analysis Summary

Gage	Gage Number	Data Set (# of Records)	Drainage Area (mi^2)	FIS Analysis				Bulletin 17B Analysis				Bulletin 17C Analysis				Percent Difference				Skew	MSE
				10%	*2%*	*1%*	*0.20%*	*10%*	*2%*	*1%*	*0.20%*	*10%*	*2%*	*1%*	*0.20%*	*10%*	*2%*	*1%*	*0.20%*		
Colorado River below Lake Granby	9019000	Entire Record (32)	312	-	-	-	-	532	1,360	1,950	4,200	530	1,360	1,940	4,170	0%	0%	-1%	-1%	0.52	0.569
Colorado River near Granby	9019500	LOT ** 1600 cfs (33)	323	-	-	-	-	2,770	9,150	14,100	34,100	2,580	3,770	4,190	4,980	-7%	-59%	-70%	-85%	-0.89	0.132
Windy Gap/Hot Sulphur Springs Combined	Combo	Combination (64)	825	-	-	-	-	3,590	6,420	7,860	11,800	3,690	5,280	5,800	6,700	3%	-18%	-26%	-43%	-1.04	0.179
Colorado River near Kremmling	9058000	Recent Flows (54)	2,379	-	-	-	-	7,430	13,000	15,900	24,200	7,740	12,100	13,800	17,800	4%	-7%	-13%	-26%	-0.55	0.135
Colorado River near Kremmling	9058000	Recent Flows (54)	3,400	-	-	-	-	9,510	16,600	20,300	31,000	9,900	15,500	17,700	22,800	-	-	-	-		
FIS - Upstream of Eagle River	-	FIS Flows	3,400	14,649	19,685	21,650	25,933	-	-	-	-	-	-	-	-	-32%	-21%	-18%	-12%		
FIS - Downstream of Eagle River	-	FIS Flows	4,344	18,950	24,900	27,140	31,830	-	-	-	-	-	-	-	-	-17%	-16%	-16%	-15%		
Colorado River near Dotsero	9070500	Recent Flows (49)	4,344	-	-	-	-	15,700	21,100	23,100	27,800	15,800	21,000	22,800	27,000	-	-	-	-		
Colorado River near Dotsero	9070500	Recent Flows (49)	4,390	-	-	-	-	15,800	21,200	23,300	28,000	15,900	21,100	23,000	27,200	1%	0%	-1%	-3%	-0.50	0.141
Colorado River at Glenwood Springs	9072500	Entire Record (67)	4,558	-	-	-	-	24,800	31,300	33,700	38,600	24,800	31,600	34,100	39,300	0%	1%	1%	2%	-0.47	0.109
Colorado River near Dotsero	9070500	Recent Flows (49)	4,560	-	-	-	-	16,200	21,700	23,900	28,700	16,300	21,600	23,600	27,900	-	-	-	-		
FIS - Upstream of Roaring Fork River	-	FIS Flows	4,560	21,500	29,000	32,500	41,000	-	-	-	-	-	-	-	-	-24%	-26%	-28%	-34%		
Below Glenwood - Roaring Fork FFA	-	Entire Record (50)	4,560	-	-	-	-	16,400	21,600	23,400	27,300	16,400	21,500	23,400	27,200	0%	0%	0%	0%	-0.58	0.146
Colorado River below Glenwood Springs	9085100	Entire Record (50)	4,560	-	-	-	-	18,900	27,100	29,200	32,100	20,700	25,800	27,600	30,800	-	-	-	-		
Colorado River below Glenwood Springs	9085100	Entire Record (50)	6,014	-	-	-	-	22,600	32,300	34,800	38,300	24,700	30,800	32,900	36,800	9%	-5%	-5%	-4%	-0.72	0.159
Colorado River below Glenwood Springs	9085100	Entire Record (50)	6,020	-	-	-	-	22,600	32,300	34,800	38,300	24,700	30,800	32,900	36,800	-	-	-	-		
FIS - Just Downstream of Roaring Fork River *	-	FIS Flows	6,020	22,000	33,000	40,000	57,000	-	-	-	-	-	-	-	-	12%	-7%	-18%	-35%		
Colorado River below Glenwood Springs	9085100	Entire Record (50)	6,300	-	-	-	-	23,300	33,300	35,900	39,500	25,400	31,700	33,900	37,900	-	-	-	-		
FIS - At New Castle *		FIS Flows	6,300	22,900	34,800	41,000	56,800	-	-	-	-	-	-	-	-	11%	-9%	-17%	-33%		
Colorado River below Glenwood Springs	9085100	Entire Record (50)	6,590	-	-	-	-	24,000	34,200	36,900	40,600	26,200	32,700	34,900	39,000	-	-	-	-		
FIS - Downstream of Divide Creek	-	FIS Flows	6,590	28,300	37,700	41,800	51,300	-	-	-	-	-	-	-	-	-7%	-13%	-17%	-24%		
FIS - At Rifle	-	FIS Flows	6,930	23,900	37,900	45,000	65,000	-	-	-	-	-	-	-	-	13%	-10%	-18%	-34%		
Colorado River near Cameo	9095500	Entire Record (83)	6,930	-	-	-	-	27,200	34,400	36,900	41,600	27,000	34,200	36,900	42,700	-	-	-	-		
Colorado River near De Beque	9093700	Entire Record (31)	7,370	-	-	-	-	30,900	43,000	48,200	60,100	27,200	35,900	39,400	47,300	-12%	-17%	-18%	-21%	-0.26	0.183
FIS - At Confluence with Parachute Creek	-	FIS Flows	7,370	30,200	40,000	44,200	54,100	-	-	-	-	-	-	-	-	-7%	-11%	-13%	-18%		
Colorado River near Cameo	9095500	Entire Record (83)	7,370	-	-	-	-	28,300	35,800	38,400	43,200	28,100	35,500	38,400	44,500	-	-	-	-		
Colorado River near Cameo	9095500	Entire Record (83)	7,986	-	-	-	-	29,800	37,700	40,400	45,500	29,600	37,400	40,400	46,800	-1%	-1%	0%	3%	-0.37	0.084
Colorado River near Palisade	9106000	Entire Record (32)	8,738	-	-	-	-	46,300	64,900	72,700	90,500	45,000	57,800	63,300	76,400	-3%	-11%	-13%	-16%	0.15	0.481
Colorado River near Cameo	9095500	Entire Record (83)	8,800	-	-	-	-	31,700	40,100	43,000	48,400	31,500	39,800	43,000	49,800	-	-	-	-		
Upstream of Confluence with Gunnison River	-	FIS Flows	8,800	32,900	44,400	49,300	61,000	-	-	-	-	-	-	-	-	-6%	-1%	-1%	-1%		
Colorado River below Grand Valley Div	9106150	Entire Record (27)	8,800	-	-	-	-	38,100	65,000	78,000	111,900	30,900	43,800	49,000	60,500	-	-	-	-		
Colorado River below Grand Valley Div	9106150	Entire Record (27)	8,813	-	-	-	-	38,100	65,100	78,100	112,000	30,900	43,800	49,000	60,600	-19%	-33%	-37%	-46%	-0.41	0.227
Downstream of Confluence with Gunnison River	-	FIS Flows	17,000	50,600	73,100	83,700	111,400	-	-	-	-	-	-	-	-	-10%	-9%	-10%	-12%		
Colorado River near CO-UT State Line	9163500	Entire Record (66)	17,000	-	-	-	-	40,500	69,400	78,100	91,400	45,500	66,500	75,700	97,900	-	-	-	-		
Colorado River near Fruita	9153000	Entire Record (17)	17,100	-	-	-	-	87,300	128,000	148,000	198,000	73,700	97,800	108,000	132,000	-16%	-24%	-27%	-33%	-0.01	0.367
Colorado River near CO-UT State Line	9163500	Entire Record (66)	17,849	-	-	-	-	41,800	71,600	80,600	94,300	46,900	68,600	78,100	101,000	12%	-4%	-3%	7%	-0.16	0.089
Colorado River near CO-UT State Line	9163500	Entire Record (66)	24,100	-	-	-	-	50,700	86,800	97,700	114,000	56,800	83,100	94,600	122,000	-	-	-	-		
FIS - near Cisco, Utah	-	FIS Flows	24,100	59,000	78,500	86,000	100,000	-	-	-	-	-	-	-	-	-4%	6%	10%	22%		-
Colorado River near Cisco, UT	9180500	Entire Record (99)	24,100	-	-	-	-	61,800	86,600	96,500	118,000	59,800	80,900	89,000	106,000	-3%	-7%	-8%	-10%	-0.56	0.085

Gage FFA
WIR-99 Gage FFA Projection
Existing FIS Effective Flows
Gage Recommended for Omission
Gage Data Calculation FFA Analysis

* Data from preliminary Garfield County FIS and may have changed after creation of this table.
** LOT - Low Outlier Threshold set to

4.1.3 Conclusion

Detailed results for the selected gages and the recommended flows for the FIS flow change locations are included in Table 4-2. Language for future FIS documents is included in Appendices D through G. This table also includes the projections for the 4% and 1% Plus annual-chance-exceedance events from the flood frequency analysis. The 1% Plus annual-chance-exceedance event is calculated by examining the confidence limits of the 1% storm. The intent is to provide the data user some information on the error bounds of the storm. A 1% storm is not a set point due to data uncertainty. The upper 84-percent confidence limit is traditionally used for stream gage records to determine what is the maximum flow that one could attribute to a 1%-annual-chance event.

As previously discussed, the influence of the upstream reservoirs and diversions within the Colorado River Basin have a pronounced impact on creating multiple PILFs, especially at the gages in the upper part of the basin. They also impact infrequent flood flows as the outlet structures of these reservoirs are still smaller than the historic channels previously available to convey flow, and some peak attenuation occurs as a result.

With the assumptions made in this analysis, the overall flows in the basin increase from upstream to downstream and censor low flows as well as the pre-reservoir flows which are no longer relevant to the current conditions within the basin. This analysis, in general, lowers the previously published 1%-annual-chance-exceedance FIS flows by an average of 14%. In addition, many of the flow inconsistencies at the Roaring Fork/Colorado Confluence and others have been resolved. The final FFA results are shown in Table 4-2. HEC-SSP data is provided in Appendix H. A plot of the flows versus drainage area for all reported return periods, except for the 1% Plus, is shown in Figure 4-2. A plot of discharge per drainage area is shown in Figure 4-3.

Table 4-2 Final Flood Frequency Analysis Summary

Gage	Gage Number	Data Set (# of Records)	Source	Drainage Area (mi^2)	Bulletin 17C Analysis						Effective FIS		1% % Change	0.2% % Change
					10%	*4%*	*2%*	*1%*	*1% Plus*	*0.2%*	*1%*	*0.20%*		
Colorado River near Granby	9019500	LOT * 1600 cfs (33)	FFA Analysis	323	2,580	3,300	3,770	4,190	8,280	4,980	-	-	-	-
Windy Gap/Hot Sulphur Springs Combined	Combo	Combination (64)	FFA Analysis	825	3,690	4,670	5,280	5,800	6,920	6,700	-	-	-	-
Colorado River near Kremmling	9058000	Recent Flows (54)	FFA Analysis	2,379	7,740	10,200	12,100	13,800	17,200	17,800	-	-	-	-
Upstream of Eagle River	-	-	WIR-99 (Kremmling)	3,400	9,900	13,000	15,500	17,700	22,000	22,800	21,650	25,933	-18%	-12%
Downstream of Eagle River	-	-	WIR-99 (Dotsero)	4,344	15,800	18,800	21,000	22,800	26,900	27,000	27,140	31,830	-16%	-15%
Colorado River near Dotsero	9070500	Recent Flows (49)	FFA Analysis	4,390	15,900	18,900	21,100	23,000	27,100	27,200	-	-	-	-
Upstream of Roaring Fork River	-	-	Below Glenwood - Roaring Fork FFA	4,560	16,400	19,400	21,500	23,400	27,300	27,200	32,500	41,000	-28%	-34%
Colorado River below Glenwood Springs	9085100	Entire Record (50)	FFA Analysis	6,014	24,700	28,400	30,800	32,900	35,900	36,800	-	-	-	-
Just Downstream of Roaring Fork River	-	-	WIR-99 (Below Glenwood)	6,020	24,700	28,400	30,800	32,900	35,900	36,800	40,000	57,000	-18%	-35%
At New Castle	-	-	WIR-99 (Below Glenwood)	6,300	25,400	29,300	31,700	33,900	37,000	37,900	41,000	56,800	-17%	-33%
Downstream of Divide Creek	-	-	WIR-99 (Below Glenwood)	6,590	26,200	30,100	32,700	34,900	38,100	39,000	41,800	51,300	-17%	-24%
At Rifle	-	-	WIR-99 (Cameo)	6,930	27,000	31,200	34,200	36,900	40,500	42,700	45,000	65,000	-18%	-34%
At Confluence with Parachute Creek	-	-	WIR-99 (Cameo)	7,370	28,100	32,500	35,500	38,400	42,100	44,500	44,200	54,100	-13%	-18%
Colorado River near Cameo	9095500	Entire Record (83)	FFA Analysis	7,986	29,600	34,200	37,400	40,400	44,300	46,800	-	-	-	-
Upstream of Confluence with Gunnison River	-	-	WIR-99 (Grand Valley)	8,800	30,900	38,400	43,800	49,000	55,300	60,500	49,300	61,000	-1%	-1%
Colorado River below Grand Valley Div	9106150	Entire Record (27)	FFA Analysis	8,813	30,900	38,400	43,800	49,000	55,400	60,600	-	-	-	-
Downstream of Confluence with Gunnison River	-	-	WIR-99 (State Line)	17,000	45,500	57,400	66,500	75,700	86,500	97,900	83,700	111,400	-10%	-12%
Colorado River near CO-UT State Line	9163500	Entire Record (66)	FFA Analysis	17,849	46,900	59,200	68,600	78,100	89,200	101,000	-	-	-	-
Colorado River near Cisco, UT	9180500	Entire Record (99)	FFA Analysis	24,100	59,800	72,300	80,900	89,000	100,000	106,000	86,000	100,000	3%	6%

** LOT - Low Outlier Threshold set to*

† WIR-99 – Analysis of the Magnitude and Frequency of Floods in Colorado Water Resources Investigations Report 99-4190 (2000) – Equation 3

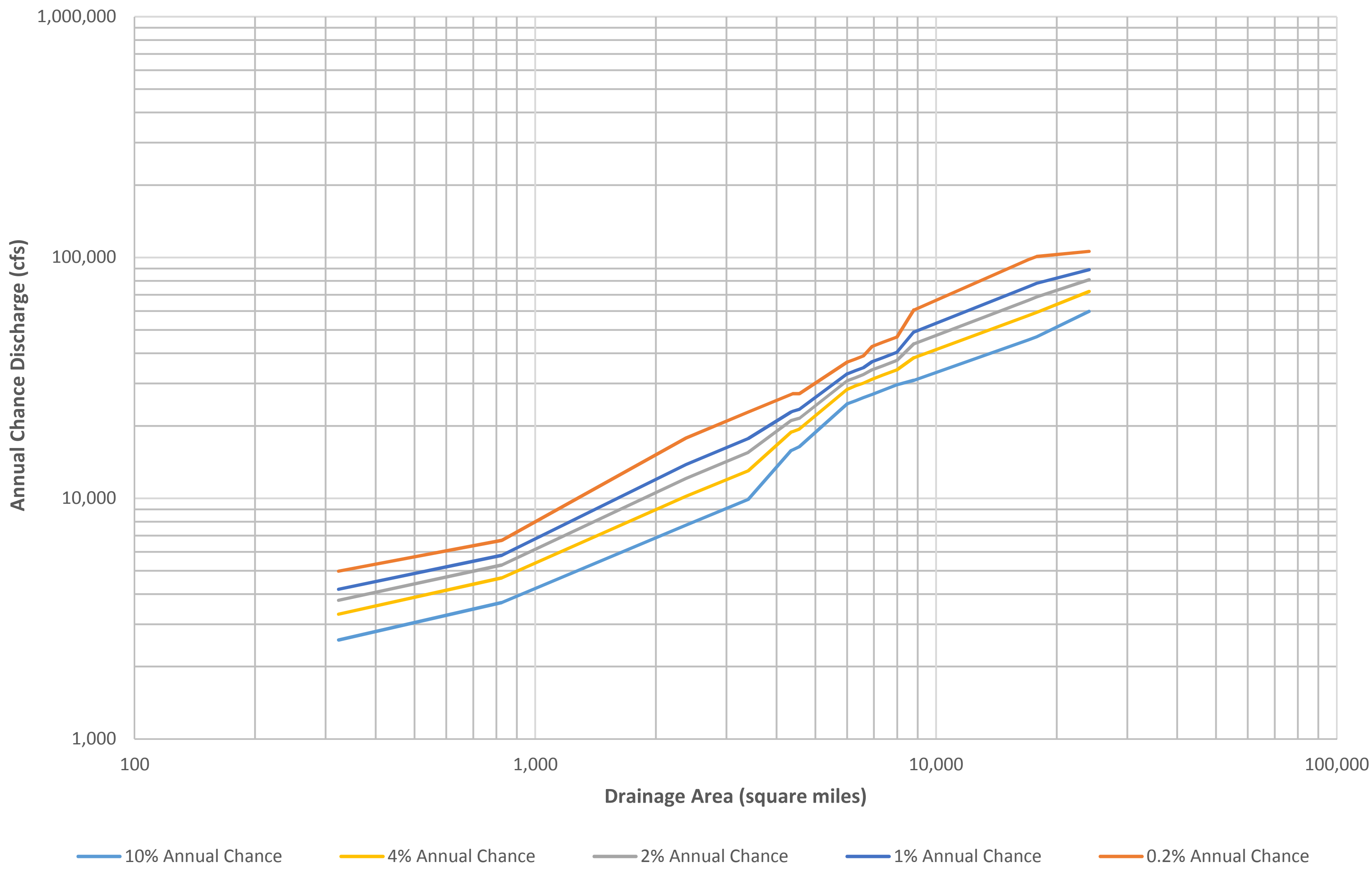


Figure 4-2 - Discharge Versus Drainage Area

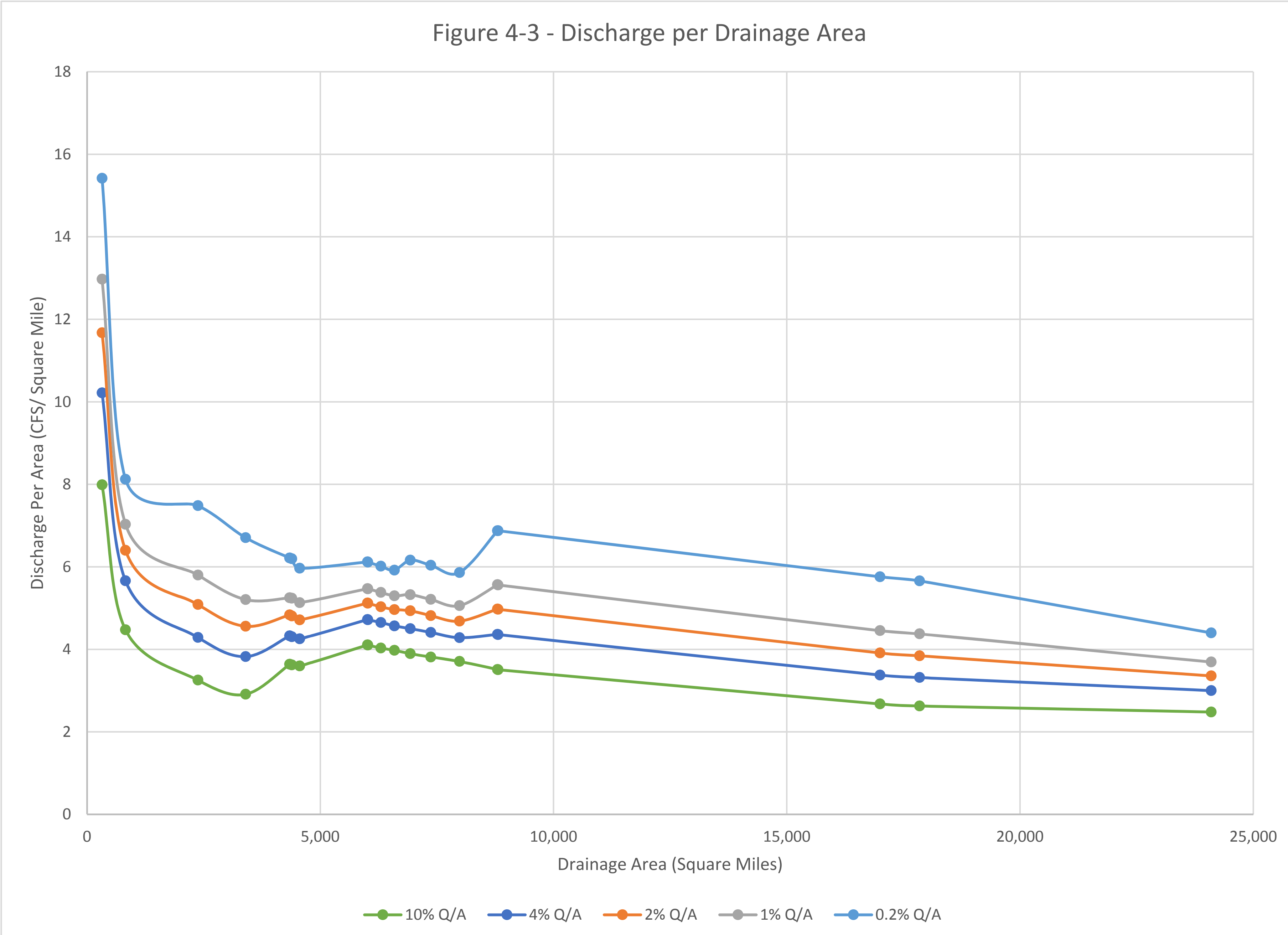


Figure 4-3 - Discharge per Drainage Area
Discharge Per Area (CFS/ Square Mile)
18
16
14
12
10
8
6
4
2
0
0
5,000
10,000
15,000
20,000
25,000
Drainage Area (Square Miles)
10% Q/A
4% Q/A
2% Q/A
1% Q/A
0.2% Q/A

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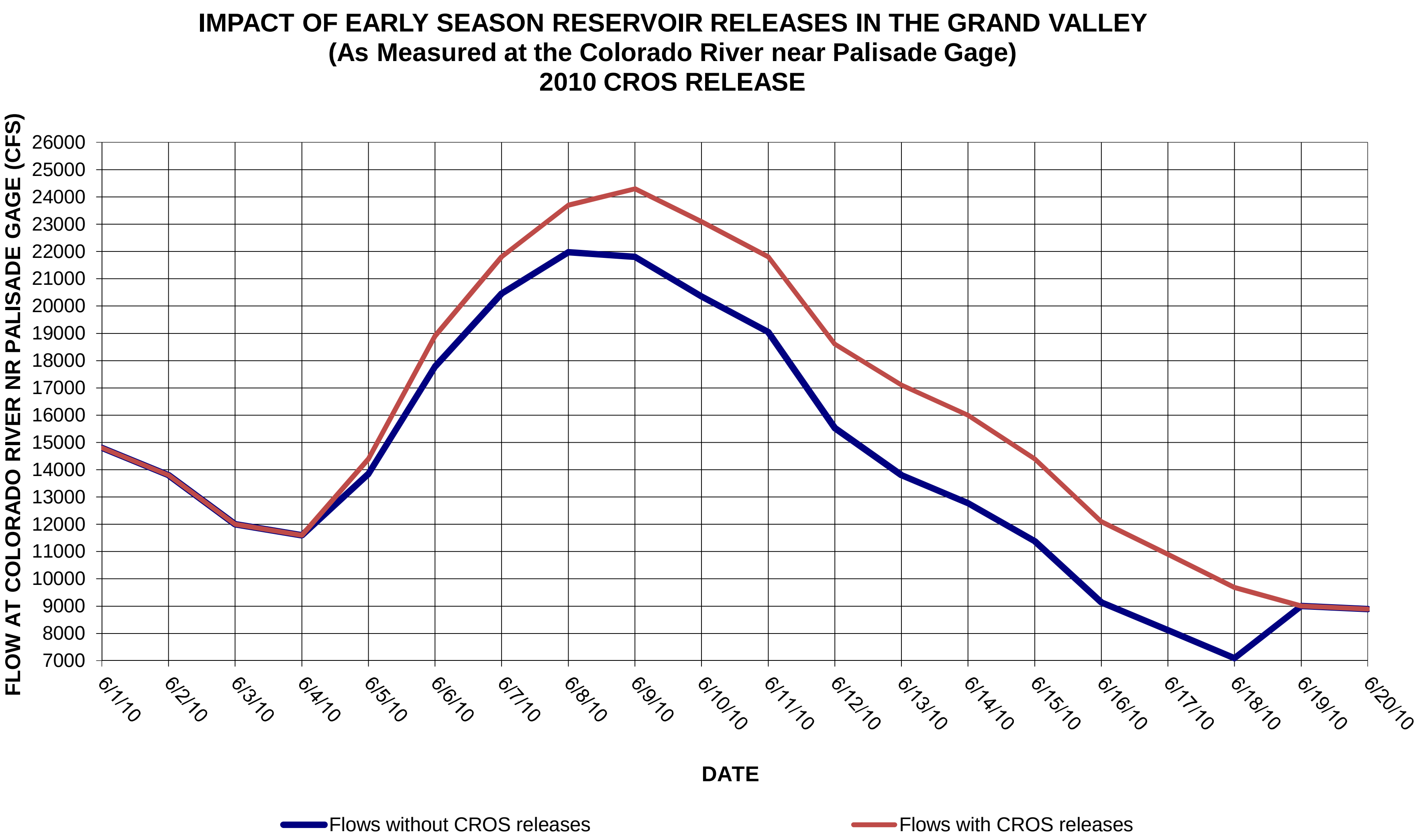
APPENDIX A

CROS Release Information



IMPACT OF EARLY SEASON RESERVOIR RELEASES IN THE GRAND VALLEY
(As Measured at the Colorado River near Palisade Gage)
2010 CROS RELEASE
FLOW AT COLORADO RIVER NR PALISADE GAGE (CFS)
26000
25000
24000
23000
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6/1/10
6/2/10
6/3/10
6/4/10
6/5/10
6/6/10
6/7/10
6/8/10
6/9/10
6/10/10
6/11/10
6/12/10
6/13/10
6/14/10
6/15/10
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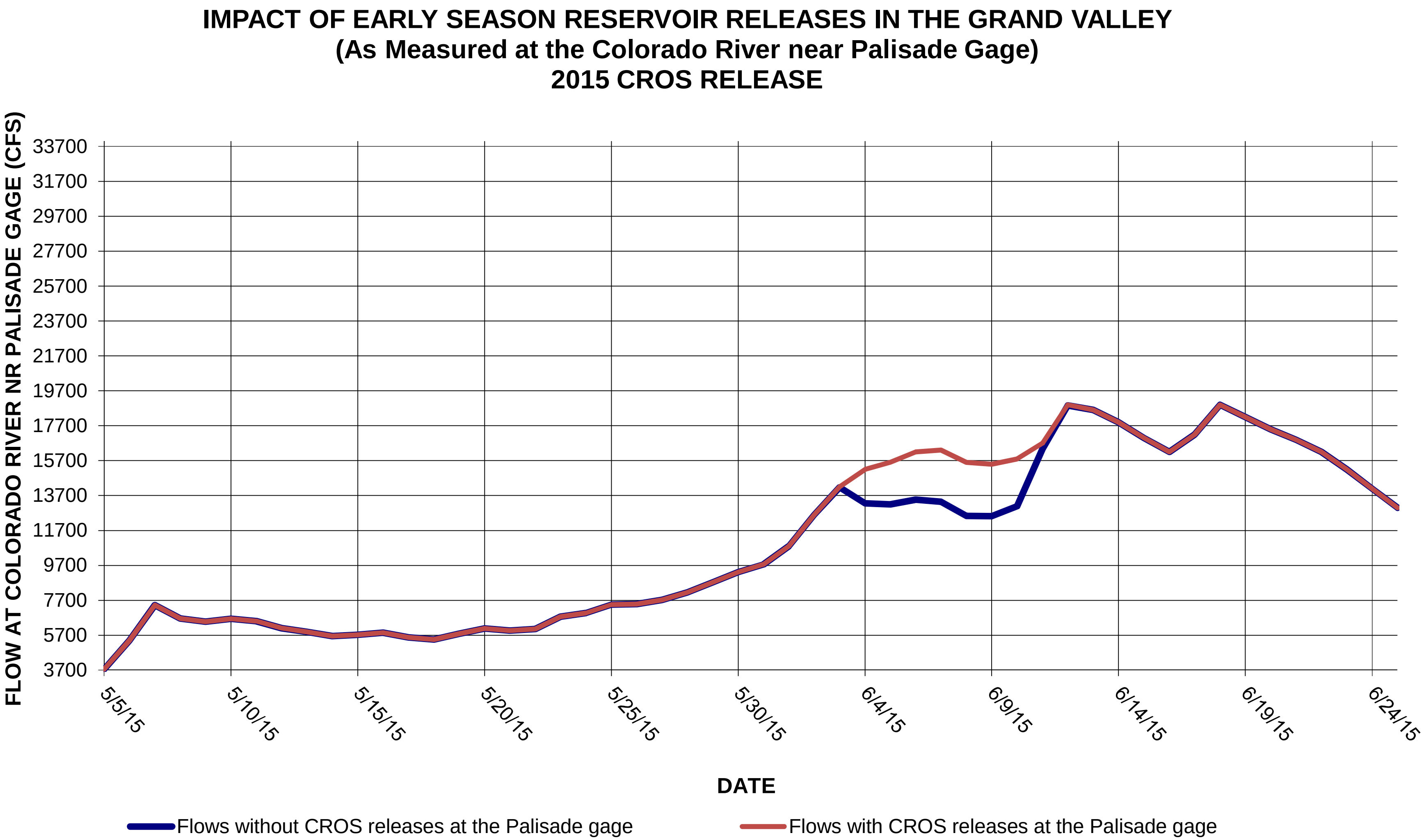
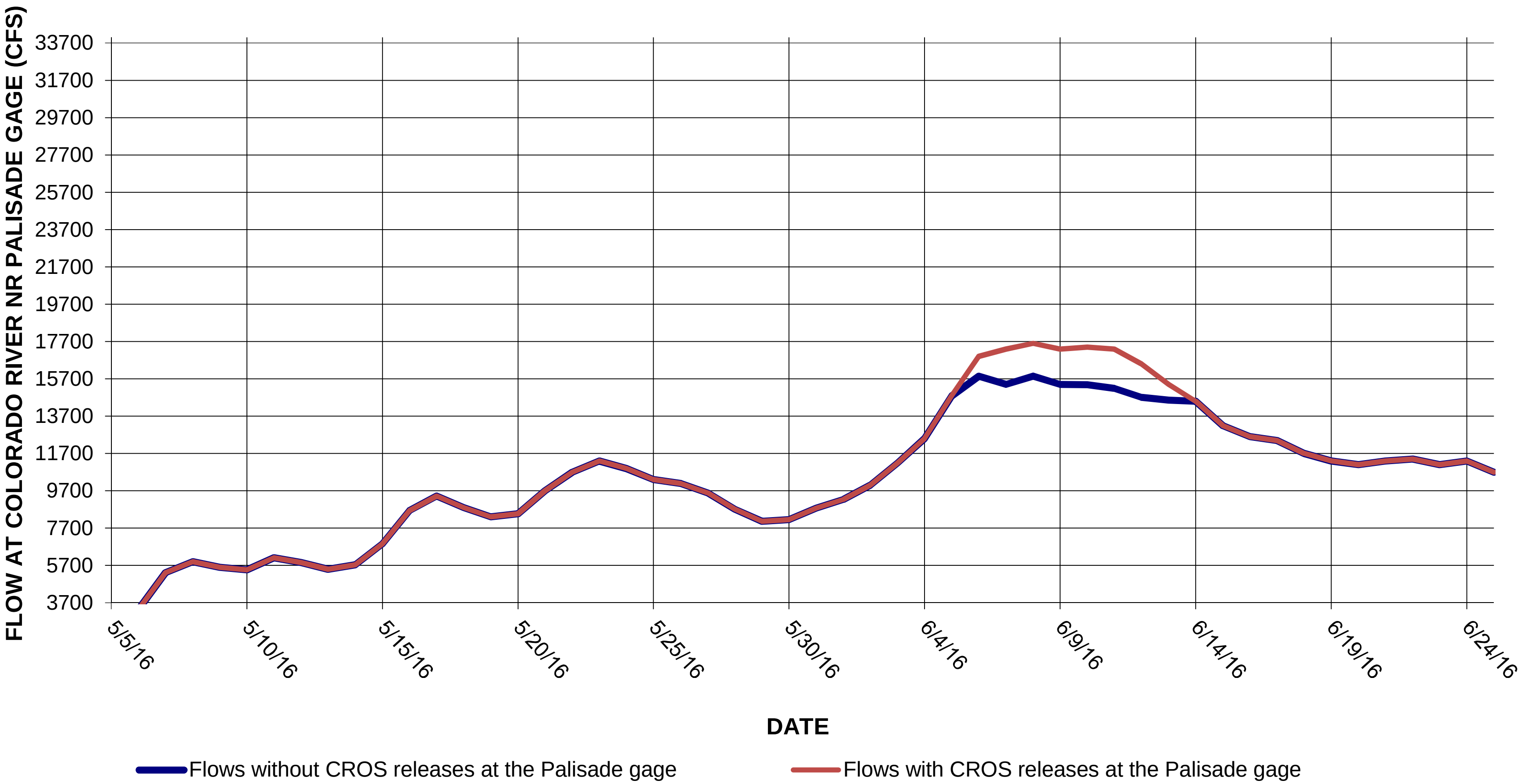
6/19/10
6/20/10
DATE
Flows without CROS releases
Flows with CROS releases


IMPACT OF EARLY SEASON RESERVOIR RELEASES IN THE GRAND VALLEY
(As Measured at the Colorado River near Palisade Gage)
2015 CROS RELEASE
FLOW AT COLORADO RIVER NR PALISADE GAGE (CFS)
33700
31700
29700
27700
25700
23700
21700
19700
17700
15700
13700
11700
9700
7700
5700
3700
5/5/15
5/10/15
5/15/15
5/20/15
5/25/15
5/30/15
6/4/15
6/9/15
6/14/15
6/19/15
6/24/15
DATE
Flows without CROS releases at the Palisade gage
Flows with CROS releases at the Palisade gage

IMPACT OF EARLY SEASON RESERVOIR RELEASES IN THE GRAND VALLEY
(As Measured at the Colorado River near Palisade Gage)
2016 CROS RELEASE



Colorado River near Granby Paleoflood Draft Report

Summary of Paleoflood Reconstruction Data for the Colorado River near Granby, Colorado, with a Comparison to Maximum Flooding in Northwestern Colorado

Robert D. Jarrett, Ph.D. **DRAFT - October 11, 2017**

Introduction

AMEC-Foster Wheeler is conducting a flood-frequency study for selected streamflow-gaging stations on the Colorado River from just downstream from Lake Granby to the Colorado-Utah State line for the Colorado Water Conservation Board. There are two streamflow-gaging stations on the Upper Colorado River in northwestern Colorado selected as part of their flood-frequency study where paleoflood data was requested (figure 1). The Colorado River below Lake Granby (09019000) has a period of record from 1951 to 1982 and was located on the right bank about 0.3 mi downstream from Granby Dam (latitude 40°08'39", longitude 105°52'00"). The drainage area at the gage was 312 mi^2 and was located at an elevation of about 8,050 ft. The Colorado River near Granby (09019500) has period of record from 1907-1911, 1933-1953, and 1961-present and is located in on the right bank about 0.3 mi upstream from bridge on U.S. Highway 34 about 3.2 miles upstream from Granby (Latitude 40°07′15″, longitude 105°54′00″). This gage has a drainage area is 323 mi^2 and is located at an elevation of about 7,960 ft.

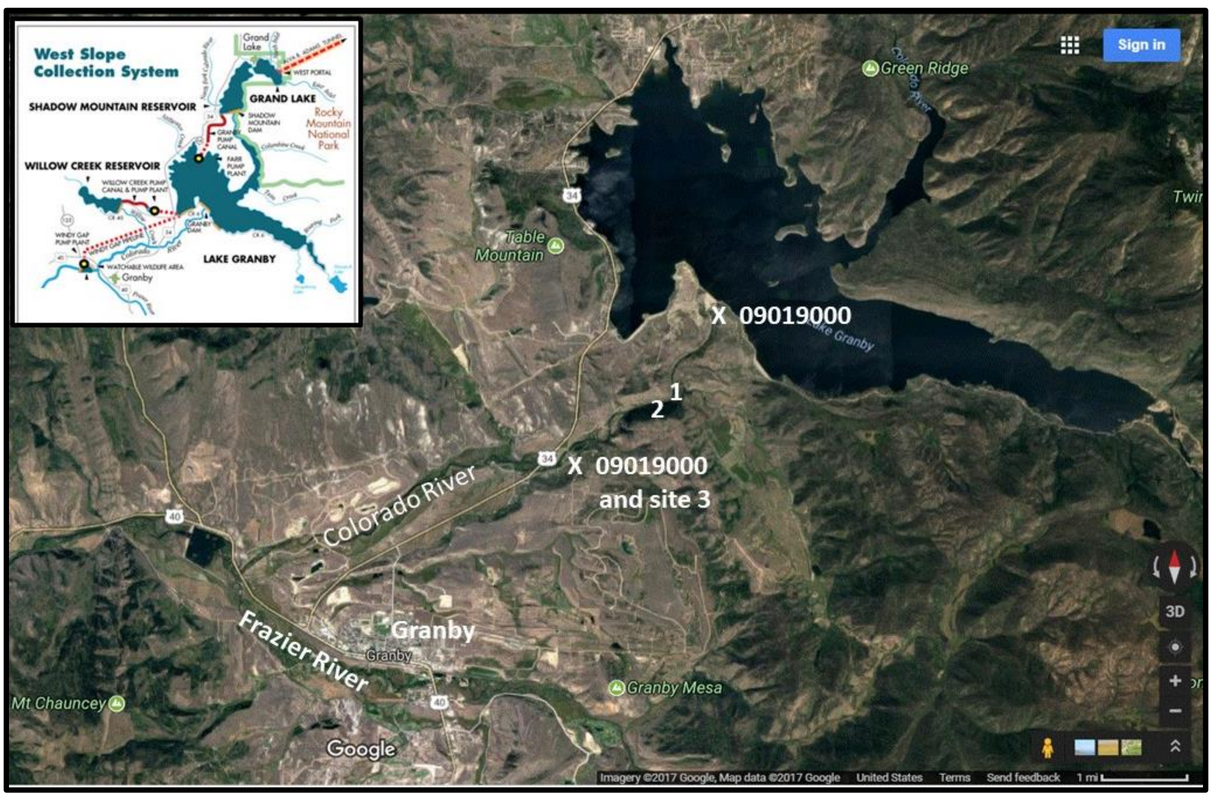


Figure 1. Map of Colorado River between Lake Granby and Granby, Colorado (source: Imagery from Google Map Data, 2017); inset map shows the general location of the study area, which is

located just west of the Continental Divide and Rocky Mountain National Park, and the Colorado-Big Thompson Project (inset map source: http://www.northernwater.org/). USGS streamflow-gaging stations “below Lake Granby” (station number 09019000 – discontinued) and “near Granby” (09019500) are located downstream from Lake Granby. The locations of the three paleoflood reconstruction sites also are shown.

Numerous water-supply reservoirs have been constructed along the Colorado River and several of its tributaries in Colorado. The Colorado-Big Thompson Project, which was constructed between 1938 and 1957, is one of the first of many large-scale storage projects and diversions of water from the Colorado River Colorado River basin (http://www.northernwater.org/). Three reservoirs are located upstream from Granby (figure 1, inset). Grand Lake was formed in a glaciated valley that is dammed by a terminal moraine of glacial till from the Pinedale Glaciation (age is less than about 12,000 years ago). Grand Lake is Colorado's largest and deepest natural lake, which located in the headwaters of the Colorado River (figure 1, inset), and has a capacity of 68,600 ac-ft. Shadow Mountain Reservoir, which is located between Grand Lake and Lake Granby (figure 1, inset), has maximum capacity 17,354 acre-feet and was completed in 1946. Lake Granby was created in 1950 by the construction of Granby Dam (figure 1) and has a storage capacity of 539,758 ac-ft. Water collected and stored in Lake Granby and Shadow Mountain Reservoir are transferred into Grand Lake and then under the Continental Divide to the Big Thompson River for use in northeastern Colorado. None of the reservoirs in the Colorado River basin in Colorado have designated flood-control storage, though due to their combined storage capacity they have had a dramatic effect on peak flows (figure 2). Thus, the AMEC-Foster Wheeler flood-frequency analysis for gages located in the Upper Colorado River basin is being evaluated using annual peak discharges since closure of those dams (selected as data from 1960 to present).

AMEC-Foster-Wheeler requested a paleoflood study for the two streamflow-gaging stations on the Colorado River between Lake Granby and Granby, Colorado. The purpose of the paleoflood study is to obtain paleoflood data to provide constraints of maximum flooding because the unknown effects of storage capacity of the three reservoirs on peak flows on the two gaging stations. Knowledge of large floods that may not be contained within streamflow-gaging station records can be improve the reliability of flood-frequency analyses and to help assess flood hazards for the Colorado River from Lake Granby to Granby, Colorado.

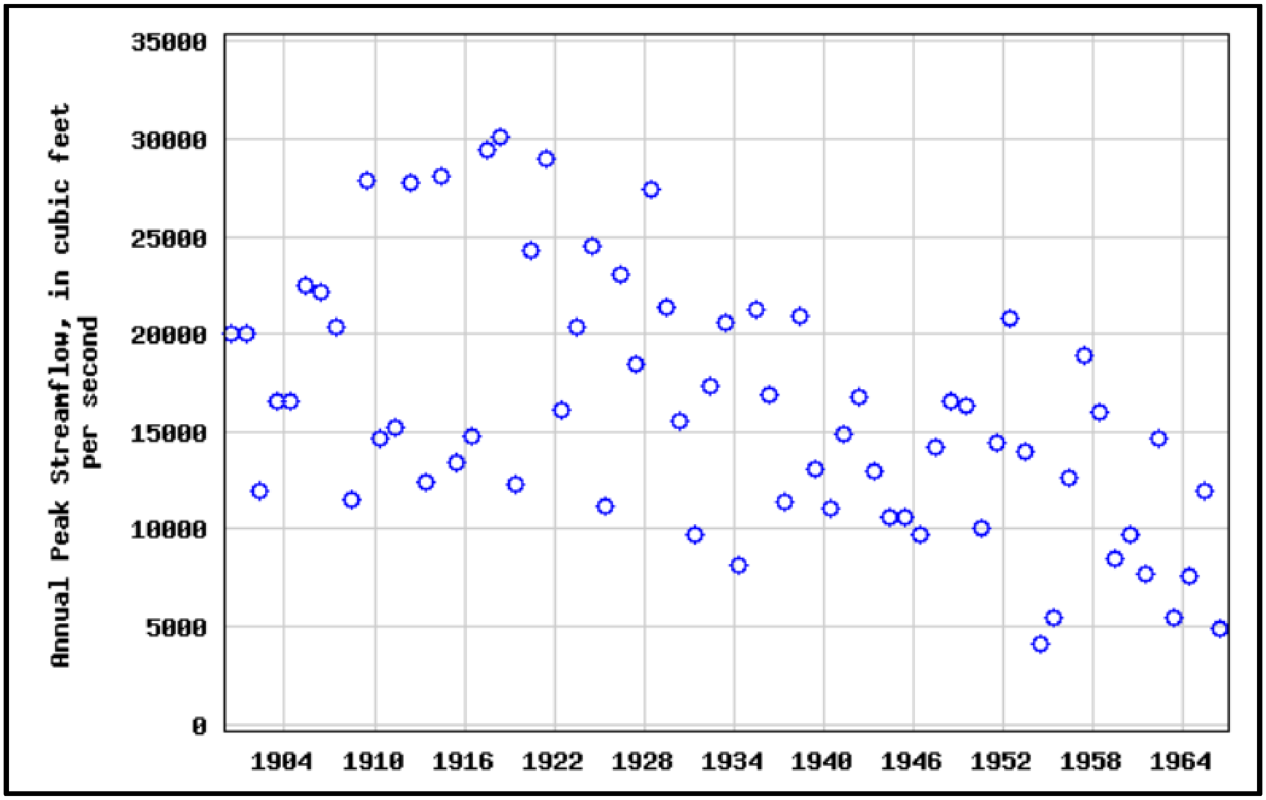
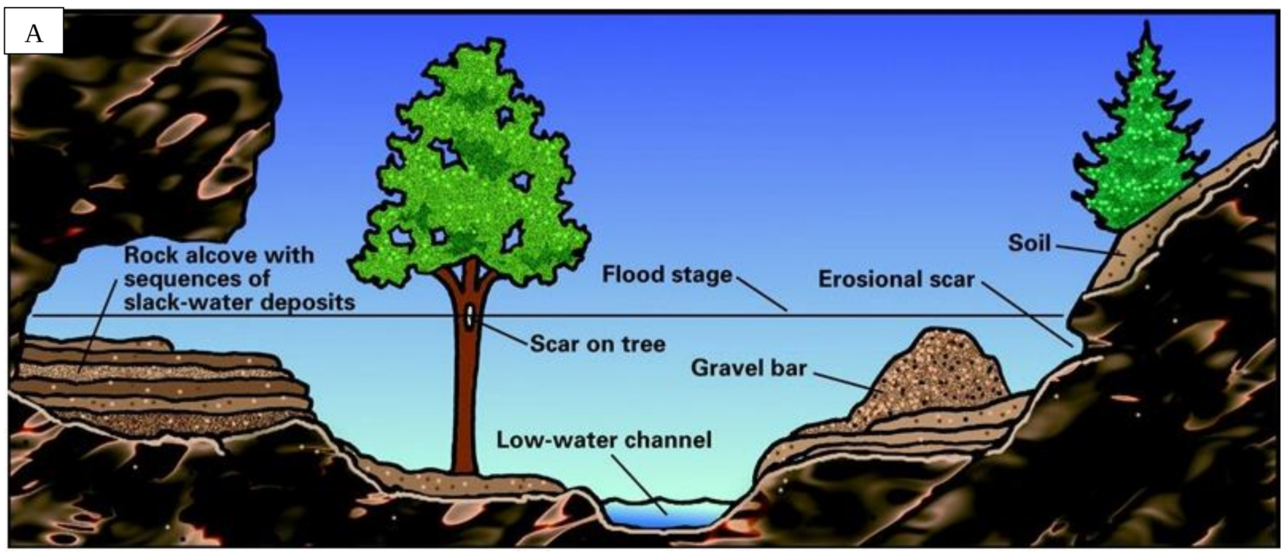


Figure 2. Annual peak flows for the Colorado River at Glenwood Springs, Colorado (09072500 – station discontinued in 1966). The drainage area at the gage was 4,558 mi^2 and was located at an elevation of 5,721 ft just upstream from the Roaring Fork River. Construction of water-supply reservoirs and flow diversions have resulted in a dramatic decrease of peak flows with time. Source: http://waterdata.usgs.gov/nwis.

Paleoflood and Post-1960 Peak Discharge Reconstructions

When peak discharges are needed for streams during flood conditions, and those streams are not accessible due to dangerous conditions or the streams are not being gaged, post-flood, indirect methods can be used (Benson and Dalrymple, 1967). Paleoflood hydrology is the science of reconstructing the magnitude, age, and frequency of large floods using geological evidence and a variety of interdisciplinary techniques (Baker, 1987; Jarrett and Costa, 1988; Jarrett, 1990; Jarrett and Tomlinson, 2000; Jarrett and England, 2002; House and others, 2002; England and others, 2010). Paleoflood studies provide important information that can be used in flood-hazard assessments, flood-frequency analysis, floodplain management, dam-safety assessments, and other water-resources investigations. The important factor for paleoflood studies is that the largest flood in a specified time scale is the primary flood documented, although in many paleoflood studies multiple large floods have been reconstructed (Baker, 1987; House and others, 2002; England and others, 2010). Although most paleoflood studies involve very rare floods typically used for dam-safety assessments (Costa and Jarrett, 1988; Jarrett and Tomlinson, 2000; Jarrett, 2000; House and others, 2002), the methodology is applicable to historic or modern floods at gaged and ungaged sites.

When stream velocity, depth, and slope decrease, flowing water often is no longer competent to transport all sediments. Floods leave distinctive sedimentary deposits, botanical evidence, erosional features on channel margins, and modifications of geomorphic surfaces by floodwaters in channels and on floodplains; these features are termed paleostage indicators (PSIs) and are shown in figure 3. In paleoflood studies in lower gradient rivers in the desert southwest of the United States, the most commonly used PSIs are slack-water deposits (SWD) of silt and sand rapidly deposited from suspension in sediment-laden waters where velocity decreases during the time that inundation occurs (figure 3b). Other types of PSIs used in paleoflood studies, particularly in mountain streams, include deposits of flood bars of sand, gravel, cobble, and boulders. The geomorphic evidence of floods in mountain basins (McCain and others, 1979; Jarrett and Costa, 1986, 1988; Waythomas and Jarrett, 1994; Grimm and others, 1995; Pruess and others, 1998; Jarrett and Tomlinson, 2000; Jarrett and England, 2002) is unequivocal (figure 3c). Flood and paleoflood evidence in higher gradient streams is relatively easy to recognize and long lasting (many thousands of years) because of the quantity, morphology, and structure and size of sediments deposited by floods.



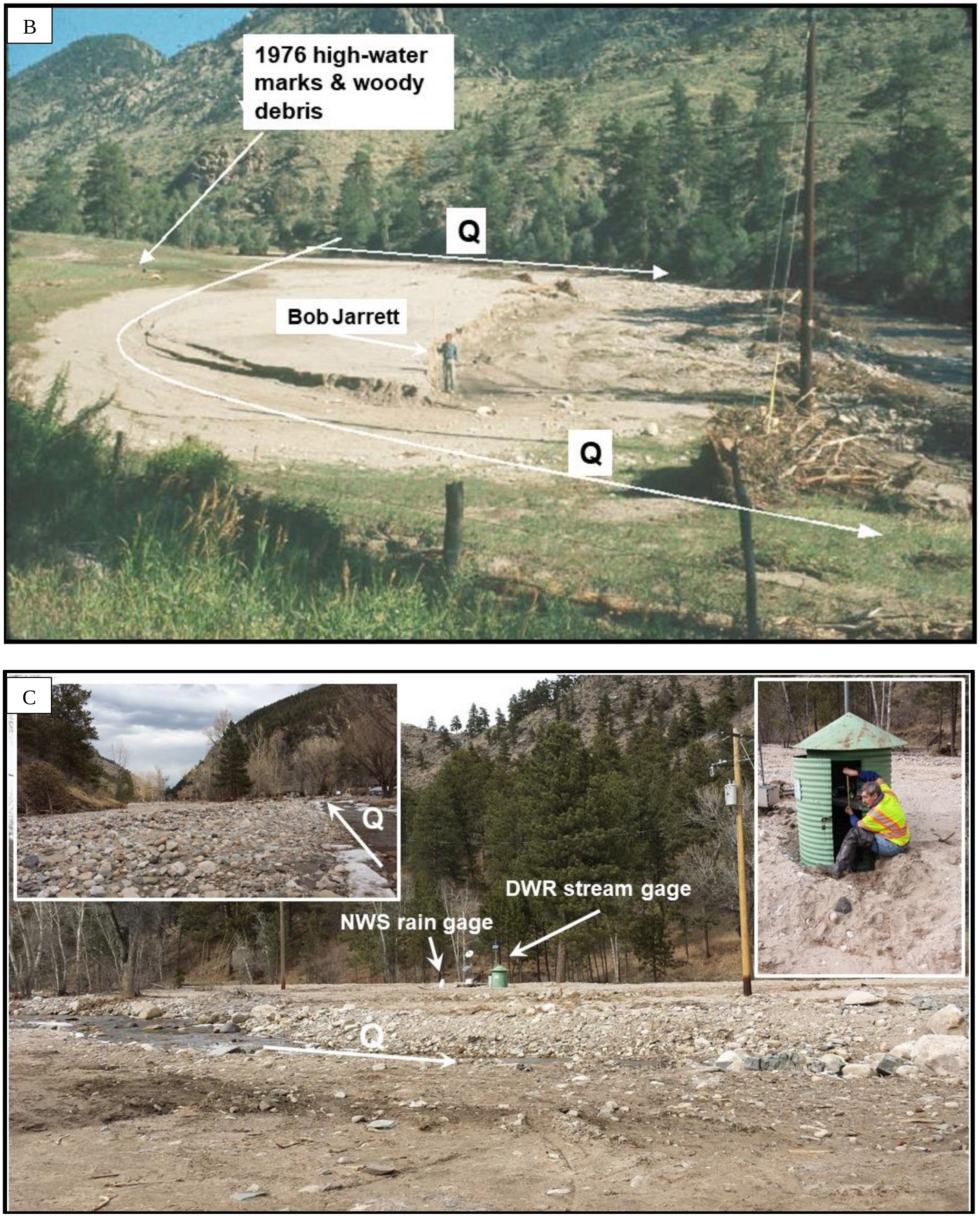


Figure 3. a) Diagrammatic section across a stream channel showing a peak flood stage and various paleoflood features used as paleostage indicators (PSIs) such as slack-water deposits (SWDs), gravel, cobble, and boulder flood bars (FBs), tree scars, and erosional scars (Source:

modified from Jarrett and England, 2002). b) July 1976 sandy gravel deposits on the right bank of the North Fork Big Thompson River near Drake, Colorado. c) September 2013 boulder deposits on the left bank of the North Fork Big Thompson River at Drake, Colorado (at Colorado Division of Water Resources streamflow-gaging station). Of interest is the lack of physical damage to the DWR gage and the National Weather Service precipitation gage, although sediments surround both gages; thus, indicating the sediments were deposited concurrent with the rising stage of the flood.

A main source of uncertainty in paleoflood reconstructions is maximum stage inferred from PSIs. Jarrett and England (2002) conducted a systematic assessment of the relation between PSIs and the peak stage of recent floods (HWMs) responsible for their emplacement (the average flood recurrence interval was 75 years with a range from about a 2 years to about 10,000 years). They made surveys of flood-deposited sediments (fresh PSIs) and flood HWMs from large floods for 192 stream sites that had a wide range of hydraulic and sedimentologic conditions, which were primarily located in thirteen States in the western United States. Analysis of the data indicated that the elevation of the top of the flood sediments (new PSIs), which ranged from silt to large boulders was on average about 0.1 ft higher than the HWMs (figure 4), particularly those deposited along channel margins. In channels with gradients greater than about 0.03 ft/ft, the top of flood deposits (new PSIs) can be up to 3 ft above HWMs along channel margins due to the extreme energy of the flow. Thus, paleoflood reconstructions using PSIs of various ages particularly those located along channel margins in bedrock channels or relatively stable, alluvial channels can provide reliable peak discharges.

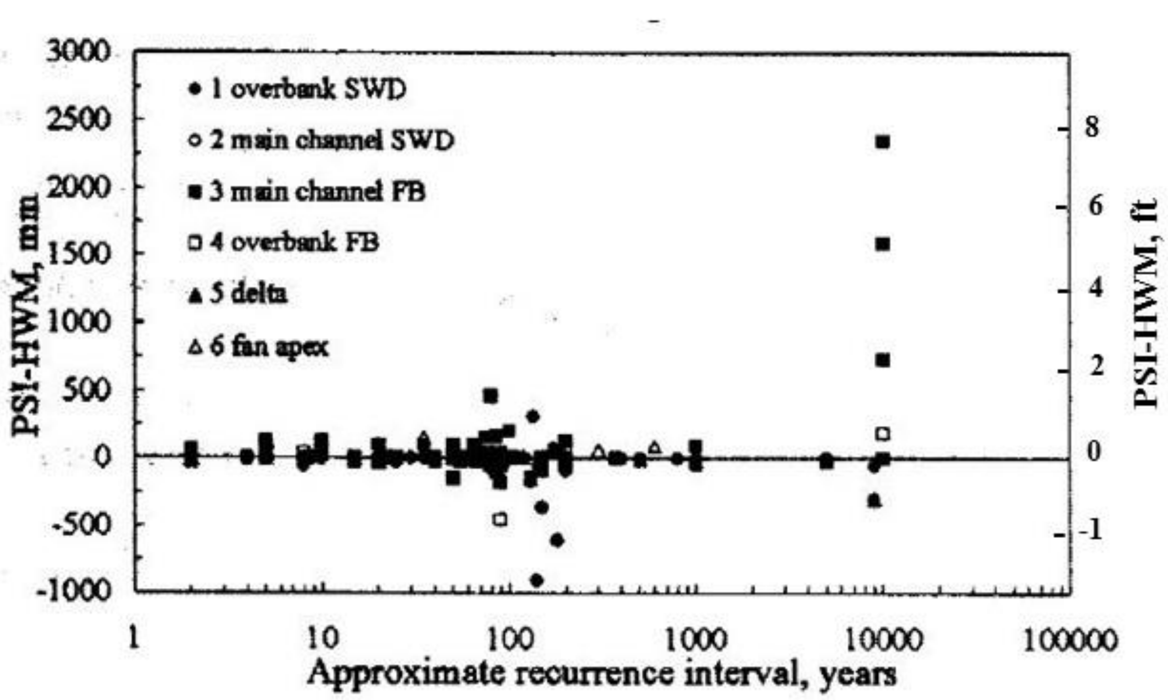
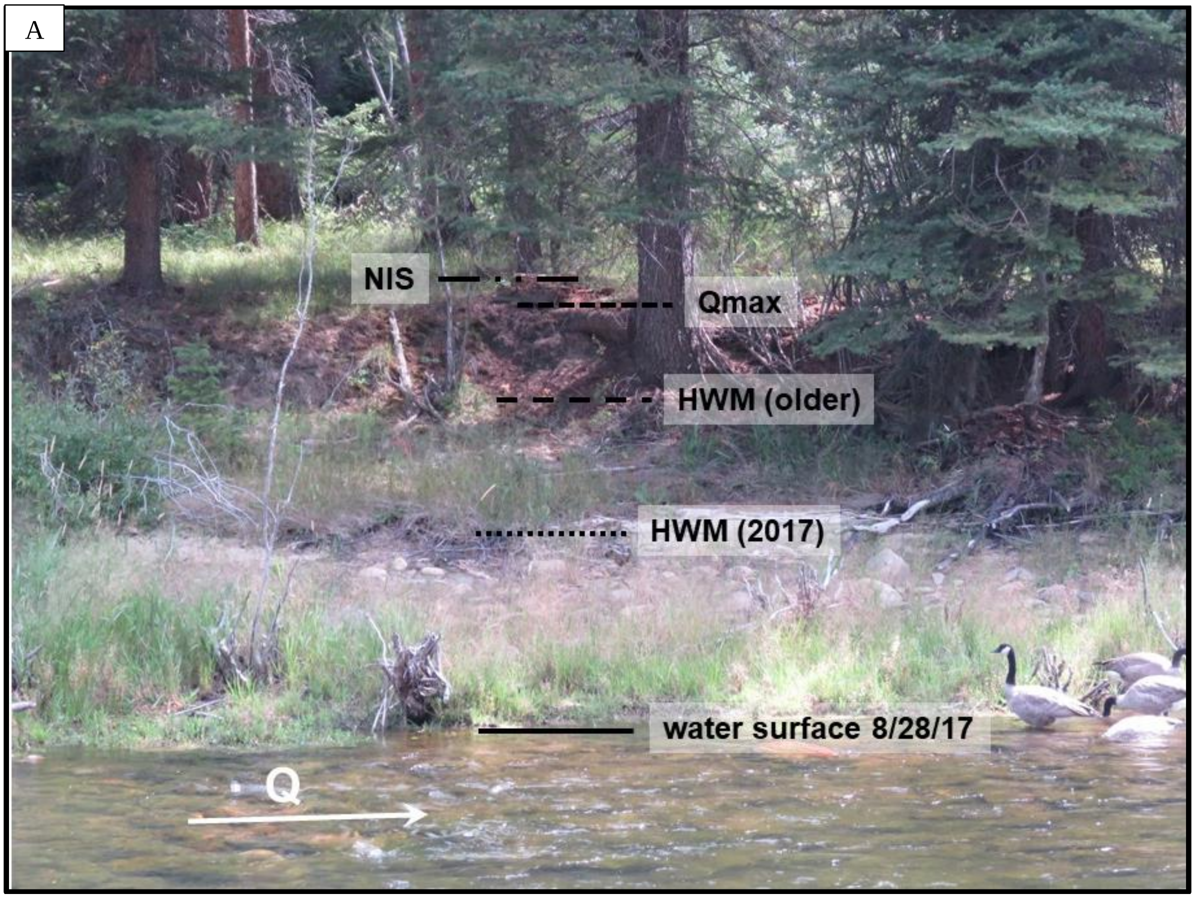


Figure 4. Graph of difference between the elevation of new PSIs and HWMs (0 difference mean the top of PSIs equals the HWMs) stratified by deposit type and approximate recurrence interval of studied floods (Source: modified from Jarrett and England, 2002). All types of PSI indicators seldom are found in one reach of channel.

The types of sites where flood deposits commonly are found and studied include: (1) locations of rapid energy dissipation, where transported sediments would be deposited, such as tributary junctions, reaches of decreased channel gradient, channel-width expansions, or reaches of increased flow depth; (2) locations along the sides of valleys in wide, expanding reaches where sediments would likely be deposited as new PSIs; (3) ponded areas upstream from channel contractions, and; (4) the inside of bends or overbank areas on the outside of bends. Fluvial sediments typically are rounded and smooth with distinct geomorphic structure (e.g., flood bars), whereas colluvial sediments (from hillslopes) typically are angular with little rounding. Identifying past flood surfaces requires examination of multiple deposits throughout a reach to determine depositional processes. For example, there can be some angular clasts that have recently fallen in the channel and deposited in flood bars that are comprised primarily flood transported, rounded clasts (gravel, cobble, and boulders).

An important factor in paleoflood studies is that the largest flood (Qmax) in a time scale is the primary flood documented; in many stream environments with fine-grained deposits (e.g., figure 3a), evidence of dozens of past floods can be preserved. Subsequent, larger floods may deposit sediments on top of PSIs and/or erode previous flood evidence, and then leave evidence of the new, larger flood. In paleoflood investigations, lack of physical evidence of the occurrence of flooding is as important as discovering tangible on-site evidence of such floods. Lack of flood evidence, termed non-inundation surfaces (NISs) or non-exceedance bounds (Jarrett and Tomlinson, 2000; England and others, 2010, respectively), provide important information about the discharge bound at a site that help support the evidence of maximum flooding along streams. These NISs have no fluvial erosional or depositional evidence and are determined to be stable surfaces with the age estimated such as by absolute radiocarbon dating (House and others, 2002; England and others, 2010) or relating dating methods if resources for absolute dating are unavailable (Jarrett and Tomlinson, 2000). Maximum paleoflood and the NIS surface for the Colorado River near Granby are shown in figure 5a.


A
NIS
Qmax
HWM (older)
HWM (2017)
water surface 8/28/17
Q


B
HWM (older)
Q


C
HWM (2017)
Q

Figure 5. Photographs along the Colorado River near Granby: a) typical high-water marks (HWMs), PSIs from the maximum flood and NIS surface (various black lines) for the Colorado River near Granby at site 2 with direction of streamflow; b) HWMs of an older flood at site 1 (needles, leaves, and twigs); c) 2017 HWM evidence of fine woody debris deposited around boulders at site 1; c) 2017 HWM of grass and fine woody debris in willows and older HWM of grass and small woody debris at site 3. Sites 1 and 3 have thick willow vegetation on streambanks making photographs showing PSIs and NISs difficult.

High-Water Mark Evidence of Contemporary Flooding

Contemporary floods are defined as those occurring in about the past 150 years (Jarrett and Tomlinson, 2000). HWMs typically consist of organic material such as grass, leaf and needle litter, twigs, branches, and small pine cones that float on the water surface and are emplaced at the highest level of the flood water in the channel or on adjacent overbank areas. HWMs can be preserved for decades in higher gradient channels in semi-arid and arid climates (Koenig and others, 2016). Relative weathering of remaining organic material allows for distinguishing between HWMs of different ages. HWMs for different aged, peak discharges were differentiated by level above the streambed and amount relative weathering characteristics of bark (amount of remaining bark and coloration), and regrowth of vegetation on HWMs and flood deposits. HWMs emplaced in 2017 from spring snowmelt consist mostly grass and needles along stream banks and in willow vegetation were easily recognized (figure 5). HWMs from the largest post-reservoir flood (after 1960) also were identified based on much greater weathering of small branches in the deposits.

Critical-Depth Method for Estimating Peak Discharges of Paleofloods and Floods

Indirect methods used to reconstruct peak discharge are based on hydraulic equations that relate the discharge to the water depth, channel slope, flow resistance, and the channel geometry (Benson and Dalrymple, 1967; Jarrett, 1985; Webb and Jarrett, 2002). Step-back-water analysis is one of the most common methods used to estimate discharge in rivers (House and others, 2002). Estimating paleoflood discharge using PSIs (which can be regarded as old HWMs) is similar to estimating peak discharge using recent HWMs (Webb and Jarrett, 2002). However, paleoflood reconstructions generally have larger uncertainties than recent peak-discharge estimates due to more uncertainty of PSIs use for maximum flood level. Peak-discharge estimates for the largest post-reservoir flood (after 1960) also were made for recent (2017) and older flood from high-water marks of organic material (needles, grass, small twigs) remaining on streambanks along the Colorado River at the three paleoflood reconstruction sites (figure 5).

Paleoflood discharge is reconstructed from estimates of flood width and depth corresponding to the elevation of the top of flood-deposited sediments (PSIs), NISs, and HWMs obtained during on-site visits to streams on August 28 and 29, 2017. Channel slope needs to be equal to or greater than 0.01 ft/ft to ensure critical flow (Trieste and Jarrett, 1987; Grant, 1997; Jarrett and England, 2002). Flood depth is estimated by using the PSIs, NISs, and HWMs located along the channel or on the floodplain above the channel-bed elevation (an arbitrary vertical datum was used in this study, which is often the case).

The critical-depth method commonly is used to estimate peak discharges from floods in streams with slopes of about 0.01 ft/ft (1 foot per 100 feet) or higher (Trieste and Jarrett, 1987; Jarrett and Tomlinson, 2000; Webb and Jarrett, 2002; Yochum and Moore, 2013); streamflow often is at or very near critical flow for long reaches of channels (Jarrett, 1984, 1990; Trieste and Jarrett, 1987; Jarrett and England, 2002). Peak discharge for a flood is computed using the continuity equation

$$Q = A \times V,$$

where Q is the peak discharge in cubic feet per second (cfs), A is the cross-sectional area between the PSIs, NISs, and HWMs on stream banks and the ground elevation in square feet (ft^2), and V is the average streamflow velocity in the cross section in feet per second (ft/s). For the critical-depth method,

$$V = V_c = (g \times D)^{0.5},$$

where V_c is the critical velocity, g is the acceleration due to gravity of 32.2 ft/s^2, and D is the mean depth of flow in the cross section in ft. To reduce the uncertainty of the peak discharge, multiple cross-section estimates at sites are obtained and results are averaged.

The method has been validated to provide peak-discharge estimates for floods with uncertainties of ±15 percent as shown in figure 6 (Jarrett and England, 2002) and is supported by theoretical analysis (Grant, 1997). Several advantages of this method include: 1) it is extremely cost effective compared with standard indirect flood measurement techniques; 2) hydraulic measurements can be done by one person, and; 3) hydraulic calculations do not require estimates of channel roughness (Manning's n-values rapidly vary with depth of flow in higher gradient rivers, Jarrett, 1985), rather discharge is a function of channel geometry for critical flow. Thus, when streamflow is critical, it is independent of upstream or downstream effects.

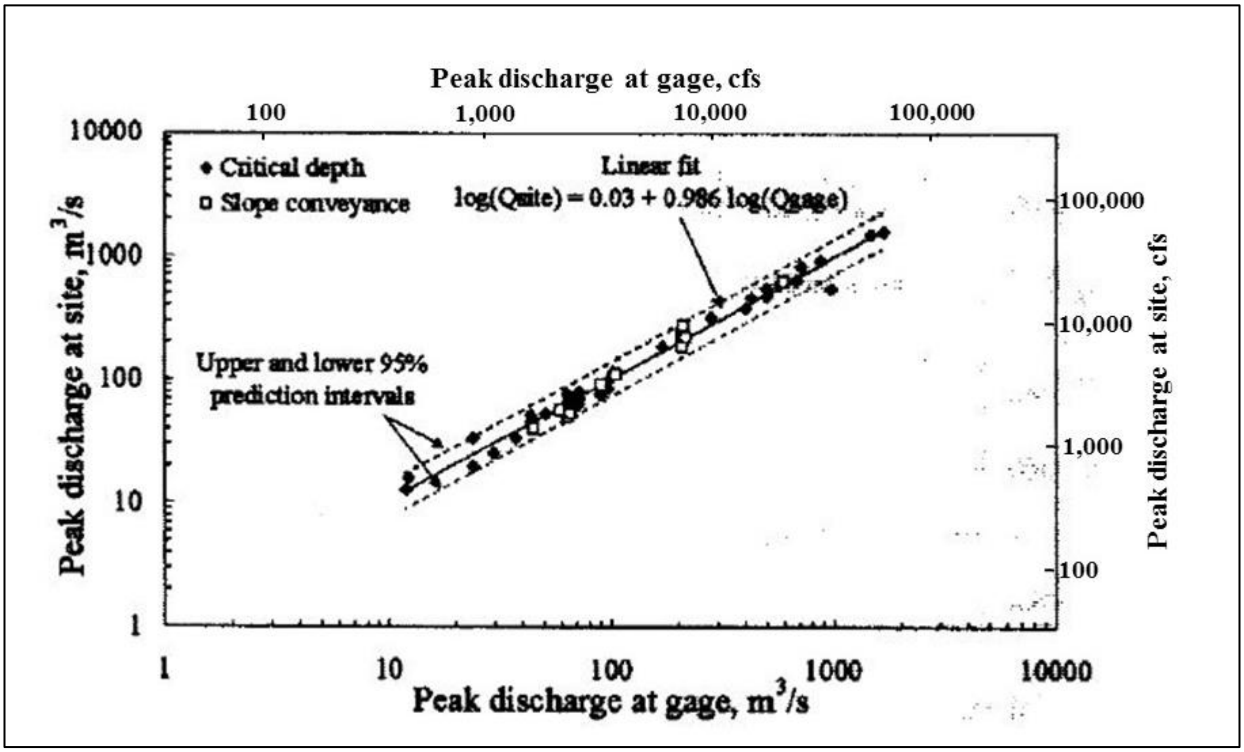


Figure 6. Relation of peak discharge measured by current meter at streamflow-gaging stations and peak discharge computed with the critical-depth and slope-conveyance methods (Source: modified from Jarrett and England, 2002). The critical-depth method was validated and provide peak-discharge estimates of about ±15 percent in stable channels; however, for paleoflood reconstructions, the uncertainty is about ±25 percent.

Results of Paleoflood and Flood Reconstructions

Proper site selection for a paleoflood (and post-1960 peak discharges) reconstructions require visiting channels to identify reaches of relatively stable channel geometry, straight and uniform (width, depth, and velocity) channels, and good definition of PSIs, NISs, and HWMs. No major tributaries enter between the three sites and the two streamflow-gaging stations (figure 1).

Drainage areas range from 319 mi^2 for sites 1 and 2 and 323 mi^2 for site 3 (Source: https://water.usgs.gov/osw/streamstats/). USGS StreamStats is a Web application that incorporates a Geographic Information System to provide users with various analytical tools that are useful for a variety of water-resources planning and management purposes, and for engineering-design purposes. The Colorado River is composed of well-rounded, boulders (1-2.5 ft in diameter), thus the channel likely is stable during high flows. The channel has irregular spaced, longitudinal flood bars, well sorted sediments, and imbricated boulders (preferential orientation of cobble and boulders). For relative straight and uniform channels, erosion usually is minimal due to conveyor-belt like transport of smaller sediments. Since upstream reservoir construction, decreased peak flows have resulted in very dense willow growth along much of the Colorado River that formerly conveyed larger peak flows (figures 7a and 9a). Channel cross sections and HWMs were surveyed where channel slope was 0.01 ft/ft or greater for the three sites along the Colorado River near Granby (figure 1). Photographs, channel geometry, and paleoflood estimates of the three selected reaches are shown in figures 7-9.

B

Colorado River blw Lake Granby (09019000) paleoflood data

Site 1 is upstream from county road bridge and downstream from 09019000 gage (and transferable to Colorado River near Granby, 09019500)
Lat 40 7 59, Long 105 52 32, Elev 8,077 ft
Date: August 28, 2017 Time of survey 1:45 pm (discharge at Colorado River near Granby (09019500) = 100 cfs
Drainage area = 319 sq mi (from USGS StreamStats, 9/4/2017)

Cross-section data

Station ft	**Depth** ft	**Comments**	Qmax depth ft	QHWM older ft	QHWM recent ft	
0	0	NIS				
5	0.5	Sta 0-45 ft	0			
10	1	dense willows & brush	0.5	0		Assume
15	2.5		2	1	0	Sta 0-45 ft
20	2.9		2.4	1.4	0.4	is ineffective flow
25	3		2.5	1.5	0.5	for post-dam
30	3.3		2.8	1.8	0.8	discharges
35	3.7		3.2	2.2	1.2	due to very
40	3.7		3.2	2.2	1.2	dense willows
45	4	HWM, recent (fine debris)	3.5	2.5	1.5	
50	4.2		3.7	2.7	1.7	
55	4.5	WS 8/28	4	3	2	
60	6.5		6	5	4	
65	6	S ~ 0.01 ft/ft	5.5	4.5	3.5	
70	6	1-2.5 ft diameter boulders	5.5	4.5	3.5	
75	5.5	on streambed	5	4	3	
80	5.3		4.8	3.8	2.8	
85	5.1	riffle downstream	4.6	3.6	2.6	
90	4.8	controls low flows	4.3	3.3	2.3	
95	4.7		4.2	3.2	2.2	
100	4.6		4.1	3.1	2.1	
105	4.5	WS 8/28	4	3	2	
110	2.5	HWM, recent (fine debris)	2	1	0	
115	1.5	HWM, small branches (older)	1	0	Ave = 2.4 ft	
120	0.5	Qmax	0	Ave = 2.6 ft		
125	0	NIS Ave =	3.3 ft			
Ave depth =	3.5 ft					

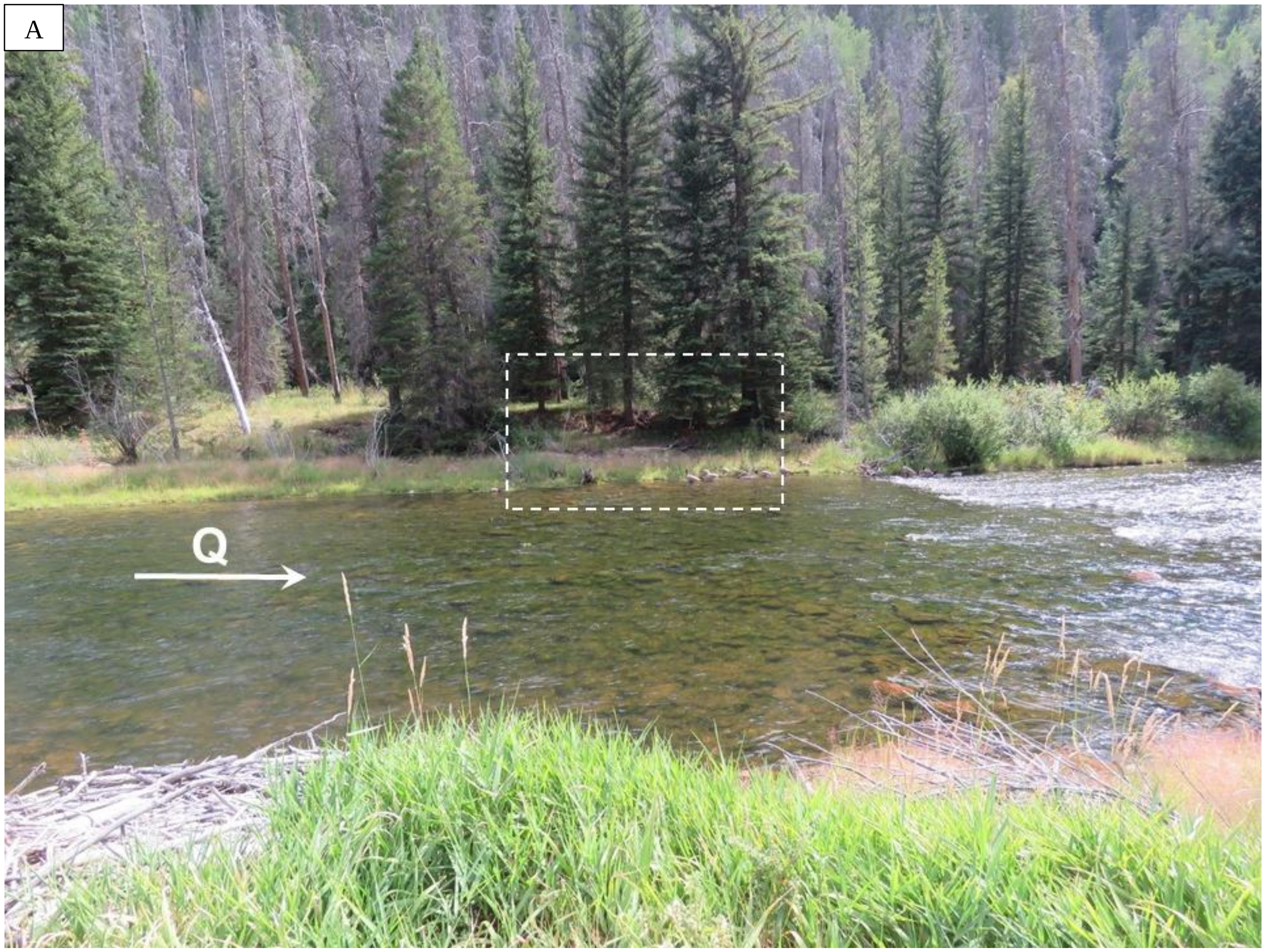
Qnis NIS(mean depth) = 3.5 ft
Qnis = 125 ft x 3.5 ft x (Vc =(3.5 ft x 32.2 ft/s^2)^0.5= 10.6 ft/s)= 4,640 cfs

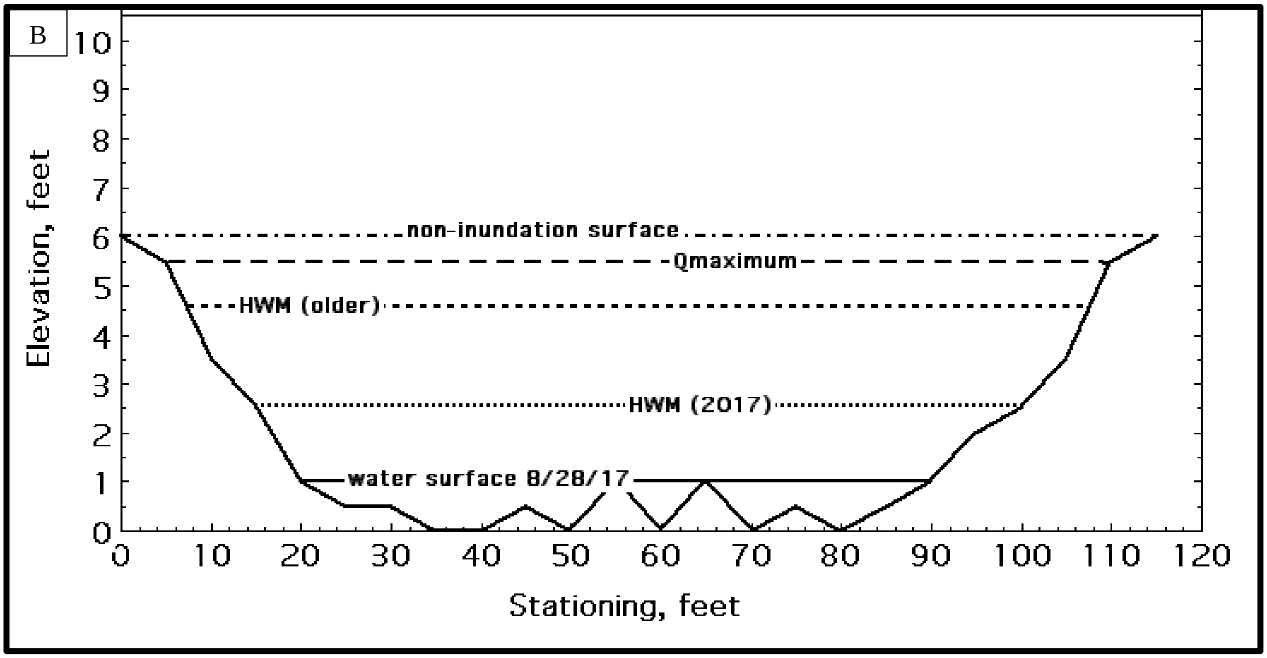
Qmax Qmax (mean depth) = 3.3 ft; width = 120-5 = 115 ft
Qmax = 115 ft x 3.3 ft x (Vc =(3.3 ft x 32.2 ft/s^2)^0.5= 10.3 ft/s)= 3,910 cfs

Qhwm(older) HWM (older) mean depth = 2.6 ft; width = 115-10= 105 ft
Qhwm older = 105 ft x 2.6 ft x (Vc =(2.6 ft x 32.2 ft/s^2)^0.5= 9.1 ft/s)= 2,480 cfs

Qhwm(recent) HWM (recent) mean depth = 2.4 ft; effective width = 110-45 = 65 ft
Qhwm recent = 65 ft x 2.4 ft x (Vc =(2.4 ft x 32.2 ft/s^2)^0.5= 8.8 ft/s)= 1,410 cfs

Figure 7. Colorado River at site 1: a) upstream view of reach from the Grand County Road 627 bridge (which spans the Colorado River), and; b) channel geometry and critical-depth computations for various PSIs, the NIS, and HWMs. The small peak flows in Doe Creek, a 6.14 mi^2 left-bank tributary deposited a small flood bar in the Colorado River. Colorado River flows are unable to transport the larger sediments downstream.


A
Q


B
Elevation, feet
10
9
8
7
6
5
4
3
2
1
0
non-inundation surface
Qmaximum
HWM (older)
HWM (2017)
water surface 8/28/17
0
10
20
30
40
50
60
70
80
90
100
110
120
Stationing, feet

C

Colorado River blw Lake Granby (09019000) paleoflood data

Site 2 is along County road downstream from gage 09019000 (results are transferable to Colorado River near Granby, 09019500)
Lat 40 7 49, Long 105 52 46, Elev 8,011 ft
Date: August 28, 2017 Time of survey 3 pm (discharge at Colorado River near Granby (09019500) = 100 cfs
Drainage area = 319 sq mi (from USGS StreamStats, 9/3/2017)

Cross-section data

Station ft	**Depth** ft	**Comments**	Qmax depth ft	QHWM older depth ft	QHWM recent depth ft
0	0	NIS			
5	0.5	Qmax (undisturbed ground by large tree)	0.0		
10	2.5	HWM, small branches	2.0	0	
15	3.5		3.0	1	0.0
20	5	WS 8/28	4.5	2.5	1.5
25	5.5		5.0	3	2.0
30	5.5	1-2.5 ft diameter boulders	5.0	3	2.0
35	6	on streambed	5.5	3.5	2.5
40	6		5.5	3.5	2.5
45	5.5	S~1%	5.0	3	2.0
50	6		5.5	3.5	2.5
55	5.5	riffle downstream	5.0	3	2.0
60	6	controls low flows	5.5	3.5	2.5
65	5		4.5	2.5	1.5
70	6		5.5	3.5	2.5
75	5.5		5.0	3	2.0
80	6		5.5	3.5	2.5
85	5.5		5.0	3	2.0
90	5	WS 8/28	4.5	2.5	1.5
95	4		3.5	1.5	0.5
100	3.5	HWM, small branches (recent)	3.0	1	0.0
105	2.5	HWM, small branches (older)	2.0	0	Ave = 1.8 ft
110	0.5		0.0	Ave = 2.5 ft	
115	0	NIS from LB (top of road ~5 ft higher)	Ave = 4.1 ft		
	Ave = 4.2 ft				

Qnis NIS(mean depth) = 4.2 ft
Qnis = 115 ft x 4.2 ft x (Vc =(4.2 ft x 32.2 ft/s^2)^0.5= 11.6 ft/s)= 5,600 cfs

Qmax Qmax (mean depth) = 4.1 ft; width = 110-5 = 105 ft
Qmax = 105 ft x 4.1 ft x (Vc =(4.1 ft x 32.2 ft/s^2)^0.5= 11.5 ft/s)= 4,950 cfs

Qhwm(older) HWM (older) mean depth = 2.2 ft; width = 105-10= 95 ft
Qhwm older = 95 ft x 2.5 ft x (Vc =(2.5 ft x 32.2 ft/s^2)^0.5= 9.0 ft/s)= 2,140 cfs

Qhwm(recent) HWM (recent) mean depth = 1.8 ft; width = 100-15 = 85 ft
Qhwm recent = 85 ft x 1.8 ft x (Vc =(1.8 ft x 32.2 ft/s^2)^0.5= 7.6 ft/s)= 1,160 cfs

Figure 8. Colorado River at site 2: a) view from right bank of reach (dashed rectangle is area shown in figure 5a); b) graph of cross section 2 with levels of NIS, PSIs, HWMs, and water surface on August 28, 2017, and; c) channel geometry and critical-depth computations for various PSIs, the NIS, and HWMs.


A
Gage (09019500)
Q

B

C

Colorado River near Lake Granby (09019500) paleoflood data

Site 3 is ~25 ft downstream USGS gage(09019500)

Lat 40 7 15, Long 105 54 00 (from gage description), GPS Elev 7,995 ft

Date: August 28, 2017 Time of survey 3 pm (discharge at Colorado River near Granby (09019500) = 100 cfs

Drainage area = 319 sq mi (from USGS StreamStats, 9/3/2017)

Cross-section data

Station ft	**Depth** ft	**Comments**	Qmax depth ft	QHWM(older) depth ft	QHWM(recent) depth ft	
0	0	NIS				
5	1		0			
10	1.5		0.5	0		
15	2.5		1.5	1	0	Assume
20	2.7		1.7	1.2	0.2	Sta 0-85 ft is ineffective
25	3.1		2.1	1.6	0.6	flow for post-dam
30	3.1	Sta 0-85 ft, very dense willows/brush	2.1	1.6	0.6	discharges
35	3.7	(likely post-dam closure)	2.7	2.2	1.2	due to
40	3.9	S~ 0.01 ft/ft	2.9	2.4	1.4	dense willows
45	4.1		3.1	2.6	1.6	
50	4.1	1-2.5 ft diameter boulders	3.1	2.6	1.6	
55	4.2	on streambed	3.2	2.7	1.7	
60	4.2		3.2	2.7	1.7	
65	4.3		3.3	2.8	1.8	
70	4.3		3.3	2.8	1.8	
75	4.3		3.3	2.8	1.8	
80	4.4		3.4	2.9	1.9	
85	4.4		3.4	2.9	1.9	
90	4.5	WS 8 6.7 GH = 1.89	3.5	3	2	
95	5		4	3.5	2.5	
100	5.2		4.2	3.7	2.7	
105	5.5	riffle dowsnstream from cross section	4.5	4	3	
110	6.5	controls low flows	5.5	5	4	
115	6.5		5.5	5	4	
120	4.5	WS 8/28	3.5	3	2	
125	2.5	HWM (recent), small twigs and grass	1.5	1	0	
130	1.5	HWM (older), more weathered, small branches	0.5	0	Ave = 2.5 ft	
135	1	Qmax	0	Ave = 2.5 ft		
140	0	NIS	Ave = 2.8 ft			
Ave =	3.5 ft					

Qnis NIS(mean depth) = 3.5 ft
Qnis = 140 ft x 3.5 ft x (Vc =(3.5 ft x 32.2 ft/s^2)^0.5= 10.6 ft/s)= 5,190 cfs

Qmax Qmax (mean depth) = 2.8 ft; width = 135-5 = 130 ft
Qmax = 130 ft x 2.8 ft x (Vc =(2.8 ft x 32.2 ft/s^2)^0.5= 9.5 ft/s)= 3,460 cfs

Qhwm(older) HWM (older) mean depth = 3.0 ft; width = 130-10 = 120 ft
Qhwm older = 120 ft x 2.5 ft x (Vc =(2.5 ft x 32.2 ft/s^2)^0.5= 9.0 ft/s)= 2,700 cfs

Qhwm(recent) HWM (recent) mean depth = 2.5 ft; effective width = 125-85= 40 ft
Qhwm recent = 40 ft x 2.5 ft x (Vc =(2.5 ft x 32.2 ft/s^2)^0.5= 9.0 ft/s)= 900 cfs

Figure 9. Colorado River at site 3: a) downstream view from Grand County Road 623 bridge b); photograph of USGS streamflow-gaging station Colorado River near Granby (09019500), which is located on the right bank about 350 ft downstream from County Road 623, and; c) channel geometry and critical-depth computations for various PSIs, the NIS, and HWMs.

Discussion

This section provides a discussion of the paleoflood results and a comparison with maximum contemporary floods and paleoflood floods in northwestern Colorado. A summary of peak discharges reconstructed at sites 1 to 3 associated with PSIs, the NIS, and HWMs are listed in figure 10. Using the average peak discharge from multiple sites (cross sections) helps reduce any error associated with preservation of PSIs and possible changes in the elevation of the channel bed (Jarrett and England, 2002). Because the drainage areas for the three sites only ranges from 319 mi^2 for sites 1 and 2 and 323 mi^2, which differ by about 1 percent, the results can be averaged for corresponding peak discharges without adjusting for a drainage-area ratio (figure 10). The results of the three peak discharge values for the PSIs, the NIS, and HWMs are less than about 25 percent, thus, indicating good reliability and account for various hydraulic conditions, potential channel change, and representativeness of PSI, NIS, and HWMs of actual flood height. In basins subject to substantial out-of-bank flooding from rainfall, preservation of sediments (amount and size of clasts) deposited as flood bars, mid-channel bars, or as overbank deposits is unequivocal (figure 3), however, there is a lack of such deposits in the study reaches in the Colorado River upstream from Granby. Maximum clast size (boulders in excess of 2 ft in diameter) on the channel bed in the study reaches, exceeds the maximum clast size in the small, isolated flood bars, which is indicative of the lack of flow competence of peak flows typical of snowmelt runoff (Jarrett and Tomlinson, 2000; Jarrett and England, 2002). The lack of flood deposit features as well as the height of channel bank scour were the primary erosional and deposition features used to define the maximum paleoflood (Qmax). The NIS was defined as a higher ground surface that has no erosional or depositional flood features and is 0.5 to 1 ft higher than Qmax for the three paleoflood sites on the Colorado River near Granby. Conservatively, the NIS was assigned an age of greater than 100 years using the relative-dating methods of Jarrett and Tomlinson (2000). Similarly, Qmax was assigned an age of about 100 years, though both the NIS and Qmax could be older (e.g., reflect a longer time frame). HWMs from 2017 are very well defined at the three sites. Older flood HWMs (post-reservoir closure, ~1960) also are well preserved at each site.

Qnis(ave) = in 100+ years	(4,640 + 5,600 + 5,190 cfs)/3 =	**5,100 cfs**	+/-10%
Qmax(ave) = in ~100 years	(3,910 + 4,950 + 3,460 cfs)/3 =	**4,100 cfs**	+/-21%
Qhwm(older) = post-1960	(2,480 + 2,140 + 2,700 cfs)/3 =	**2,400 cfs**	+/-12%
Qhwm(2017) = post-1960	(1,410 + 1,160 + 900 cfs)/3 =	**1,200 cfs**	+/-25%

Figure 10. Summary of the maximum paleoflood (Qmax), discharge associated with the NISs, and HWMs for the three sites on the Colorado River upstream from Granby. Average reconstructed discharge values are rounded to two significant figures to reflect their level of uncertainty. The estimated uncertainty of the discharges also is listed. Additional confidence in paleoflood estimates is exhibited when multiple sites are used and all the results are similar.

The very well-developed, imbricate clast structure of boulder bed material in the Colorado River in the study area are indicative of snowmelt flooding. Imbricate deposits occur during water-dominated flow (versus from flash floods and debris flows) and are more pronounced when stream velocity and discharge decrease slowly (Costa and Jarrett, 1981; Waythomas and Jarrett, 1994; Pierson, 2004). For flash floods from intensive rainfall and debris flows where deposition is rapid, there is little development of clast imbrication.

Once the average discharges for Qmax, NIS, the HWMs had been computed (figure 10), a retrieval of selected peak discharges for the Colorado River near from Granby (09019500) was made to compare the paleoflood with streamflow-gaging station data (https://nwis.waterdata.usgs.gov/co/nwis/sw). Results are within ±10 percent of gage values and add credibility to the results, which are surprisingly good (and coincidental for the same discharge for Qmax and the 1909 flood of record at the gaging station).

Paleoflood	Reconstructions cfs	Gage cfs	Date	Percent Difference
Qnis(ave) = in 100+ years	5,100	n/a	n/a	n/a
Qmax(ave) = in ~100 years	4,100	4,100	6/20/1909	0
Qhwm(older) = post-1960	2,400	2,520	6/22/1996	-5
Qhwm(2017) = post-1960	1,200	1,320	6/22-23/2017	10

Figure 11. Comparison of paleoflood data and peak-flow data for the Colorado River near Granby (09019500).

An envelope curve was developed of maximum flooding at 198 streamflow-gaging stations (3,512 station years of record) with records dating to the early 1900s, floods at 20 miscellaneous sites, and paleoflood data in northwestern Colorado by Jarrett and Tomlinson (2000) shown in figure 12. For rivers draining higher mountain areas in northwestern Colorado (greater than about 7,000 ft), peak flows are dominated by snowmelt runoff. For comparison, the envelope curves for streams below about 7,500 ft in eastern Colorado and for the United States (Costa, 1987) also are shown on figure 12, which demonstrate the lower-magnitude flooding in northwestern Colorado. Of notable interest is that the envelope curve of maximum flooding in about the last 10,000 years is less than 25 percent larger than the envelope curve of contemporary flooding in northwestern Colorado. Because 25 percent is the typical uncertainty for estimating extreme flood discharges it is difficult to ascribe the difference to more than flood measurement error. Maximum flooding in eastern Colorado is about 3 times larger than for similarly sized streams in northwestern Colorado. Maximum flooding in eastern Colorado streams is slightly smaller than maximum flooding in the United States. The maximum paleoflood and discharge associated with the NIS for the Colorado River (figure 10) were added to figure 12. Although the Upper Colorado River basin has large annual snowpack and snowmelt runoff, Qmax and Qnis for the Colorado River near Granby plot below the envelope curve of contemporary and longer term, maximum flooding for northwestern Colorado, which is most likely due attenuation of peak flows through Grand Lake.

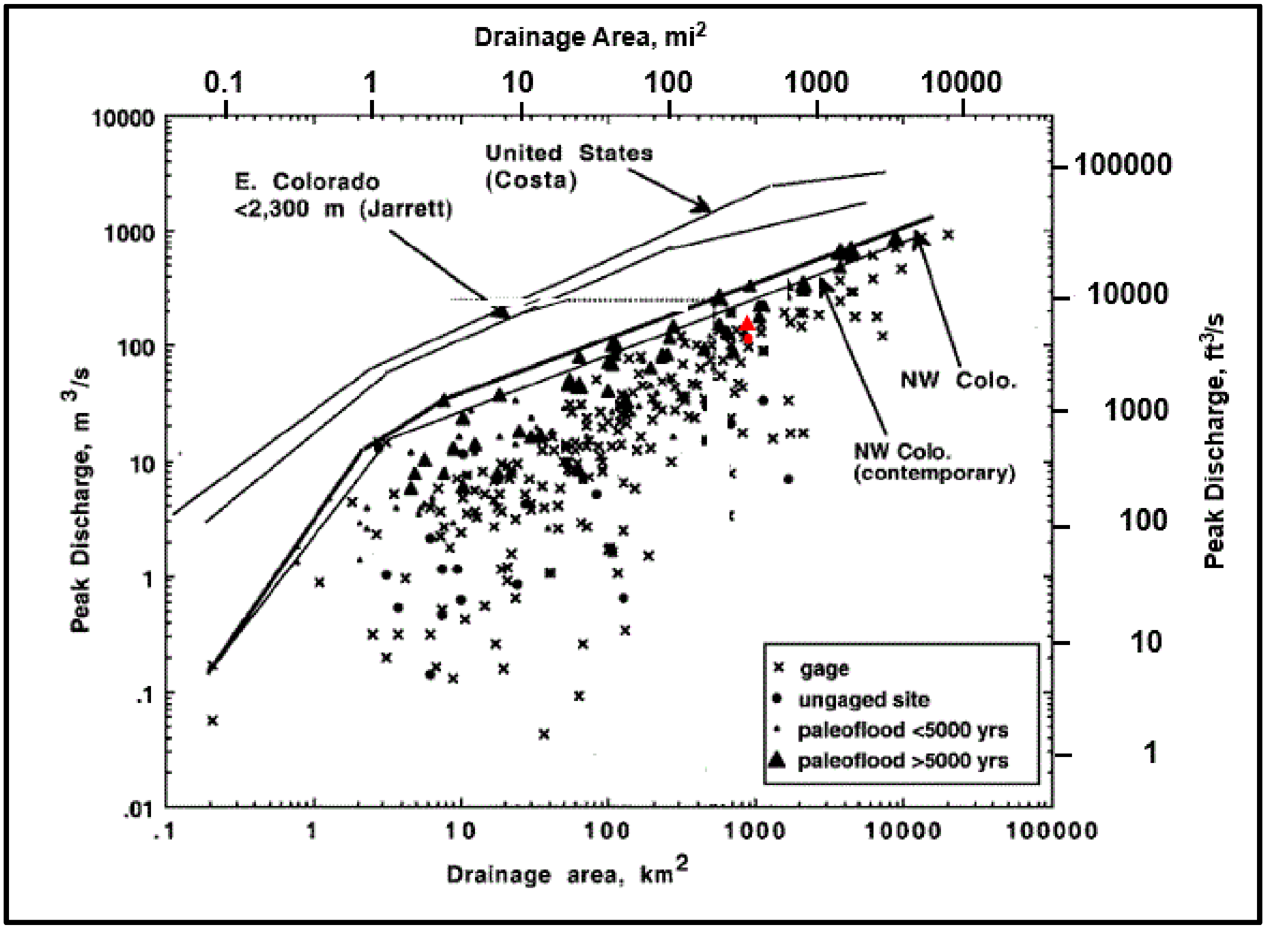


Figure 12. Relation between contemporary peak discharges (about the past 150 years) and paleoflood discharges (the largest in about 10,000 years) and drainage area with envelope curves for northwestern Colorado. The maximum paleoflood (red dot) and discharge associated with the NIS (red triangle) for the Colorado River near Granby. Envelope curves of maximum flooding for eastern Colorado (Jarrett, 1990) and for the United States (Costa, 1987) are shown for comparison (Source: modified from Jarrett and Tomlinson, 2000).

Another approach to assess the relative magnitude of a flood and determine if rainfall flooding substantially contributes to flooding is to compare unit discharges for various floods; unit discharge is the peak discharge divided by the drainage area. Unit discharge decreases rapidly from about 500 to 100 cfs/mi^2 for basins at elevations about 5,000 ft to 10,500 ft, respectively, for small basins in northwestern Colorado (figure 13), which reflect much smaller convective storms and less intense rainfall at higher elevations. The unit discharges for Qmax and Qnis were 12.7 cfs/mi^2 and 15.8 cfs/mi^2, respectively, are also shown on figure 13, which are somewhat smaller than unit discharges for medium sized mountain streams (say greater than 150 mi^2) above 7,500 ft in northwestern Colorado. For Comparison, unit discharges for natural watersheds have exceeded 4,000 cfs/mi^2 in the foothills of Colorado, such as during the July 31, 1976, Big Thompson Canyon flash flood (the envelope curve for eastern Colorado is shown on figure 13), which resulted from about 7 in of rain in about an hour and 14 in of rain in several hours (McCain and others, 1979; Jarrett and Tomlinson, 2000).

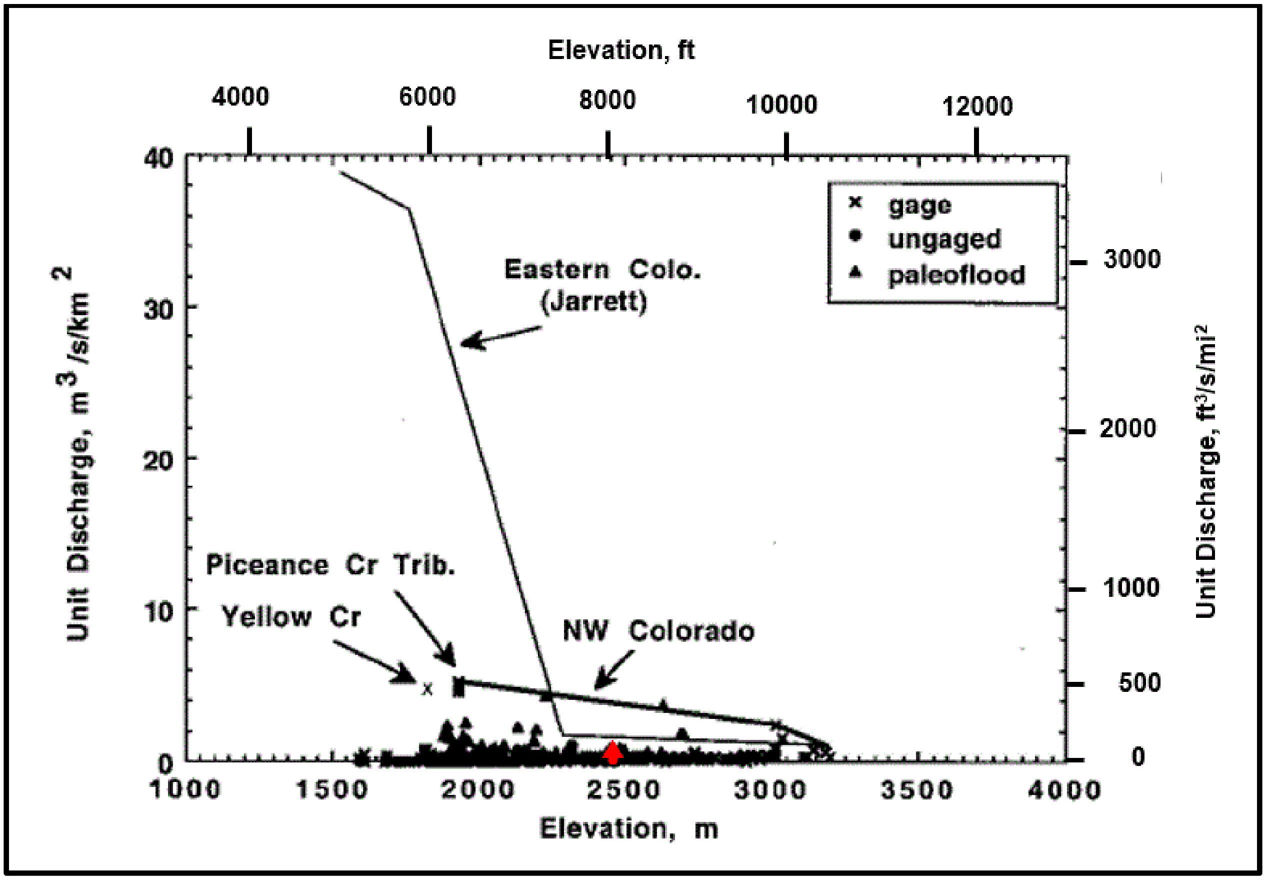


Figure 13. Relation between maximum unit discharge and elevation with envelope curve for northwestern Colorado and eastern Colorado (Source: Jarrett and Tomlinson, 2000). For basins with elevations below about 7,000 ft, increasing values of unit discharge are from localized convective storms over small areas (5-20 mi^2) that entrain substantial amounts of fine sediments that bulk the flow (e.g., hyper-concentrated flows) such as in Piceance Creek tributary and Yellow Creek. The unit discharge values for Qmax of 12.7 cfs/mi^2 (red dot) and Qnis of 15.8 cfs/mi^2 (red triangle) are added to the graph.

A final approach to assess potential maximum flooding in the Upper Colorado River basin is to evaluate maximum rainfall data. A relation between maximum 24-hour rainfall (there is very limited data for shorter durations) and elevation for the study area in northwestern Colorado is shown in figure 14. These data were compiled from documented rainstorms from about 1900 through 1997 (McKee and Doesken, 1997). Although there has been extensive documentation of extreme rainstorms in Colorado, there have been few intense flood producing rainstorms documented in northwestern Colorado (triangles in figure 14). The maximum rainfall is less than about 4 inches in 24 hours in northwestern Colorado. The maximum 24-hour amount for northwestern Colorado of 3.2 in was recorded in Meeker, which is at an elevation of about 6,240 ft. Of particular interest in western Colorado, maximum 24-hour precipitation amounts fell as snow and are presented as snow-water equivalent (figure 14). Additionally, maximum monthly values for northwestern Colorado only slightly exceed record maximum 24-hour amounts for southwestern Colorado (figure 14), which provides dramatic evidence of large relative difference in flood-producing rainfall from northwestern to southwestern Colorado. The maximum 24-hour rainfall data in southwestern Colorado also are shown on figure 14 for comparison to help define maximum rainfall west of the Continental Divide in Colorado. The maximum rainfall amount for southwestern Colorado is about 6 in in about 90 minutes for 1976 Sweetwater Creek storm and about 6 in in 24 hours for the 1972 Dove Creek storm (McKee and Doesken, 1997). Maximum rainfall in western Colorado is substantially less than in eastern Colorado, which is subject to some of the most extreme rainfall flooding in the United States (Costa and Jarrett, 2008). For example, the maximum observed rainfall was about 24 in in less than 6 hours in a May 1935 rainstorm in eastern Colorado (Jarrett, 1990; Costa and Jarrett, 2008).

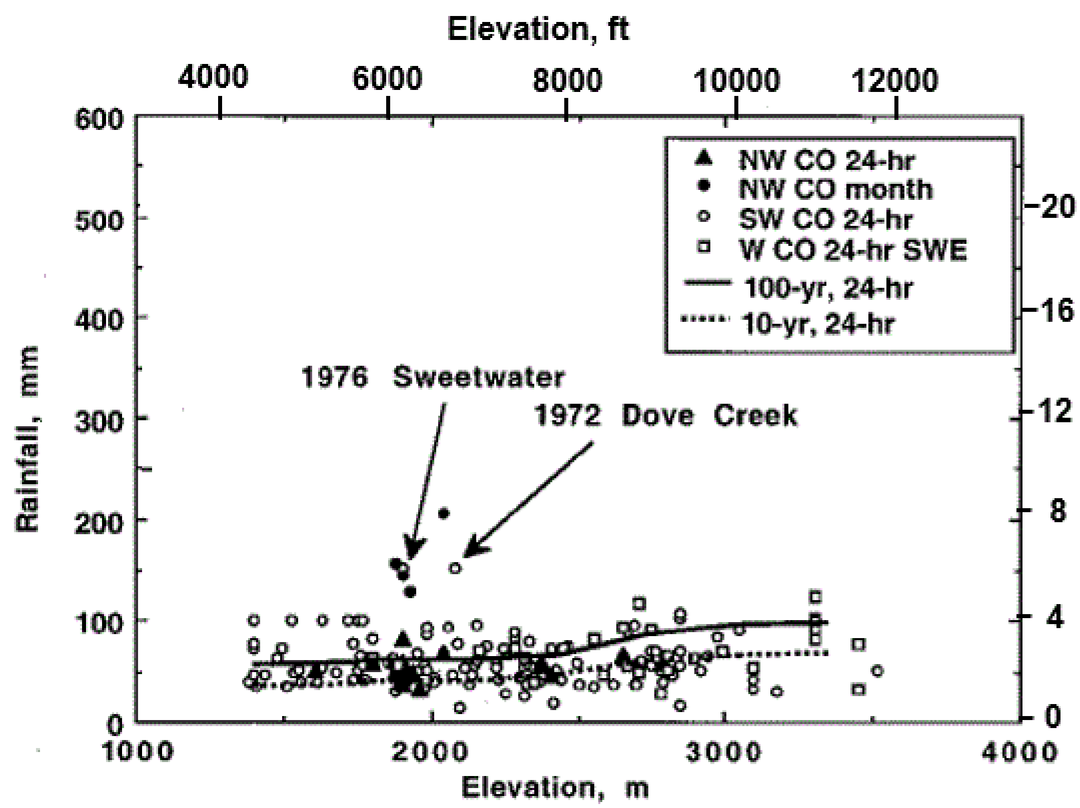


Figure 13. Maximum 24-hour and maximum monthly precipitation for northwestern (NW) Colorado and maximum 24-hour precipitation for southwestern (SW) Colorado (Source:

modified from Jarrett and Tomlinson, 2000). Two of the largest southwestern Colorado rainstorms (Sweetwater Creek and Dove Creek) are noted. It is important to note that numerous large snowstorms reported as snow-water equivalent (SWE) account for some of the largest 24-hour precipitation amounts in all of western (W) Colorado. The 10-year and 100-year, 24-hour duration rainfall amounts are shown to place contemporary rainfall data into a frequency context (Source: modified from Jarrett and Tomlinson, 2000).

The paleoflood data from this study and analyses of other flood, paleoflood, and extreme precipitation data in northwestern Colorado provide definitive evidence for relatively low magnitude peak flows in the Upper Colorado River basin above 7,500 ft. The preponderance of evidence supports the flood and paleoflood data listed in figure 10.

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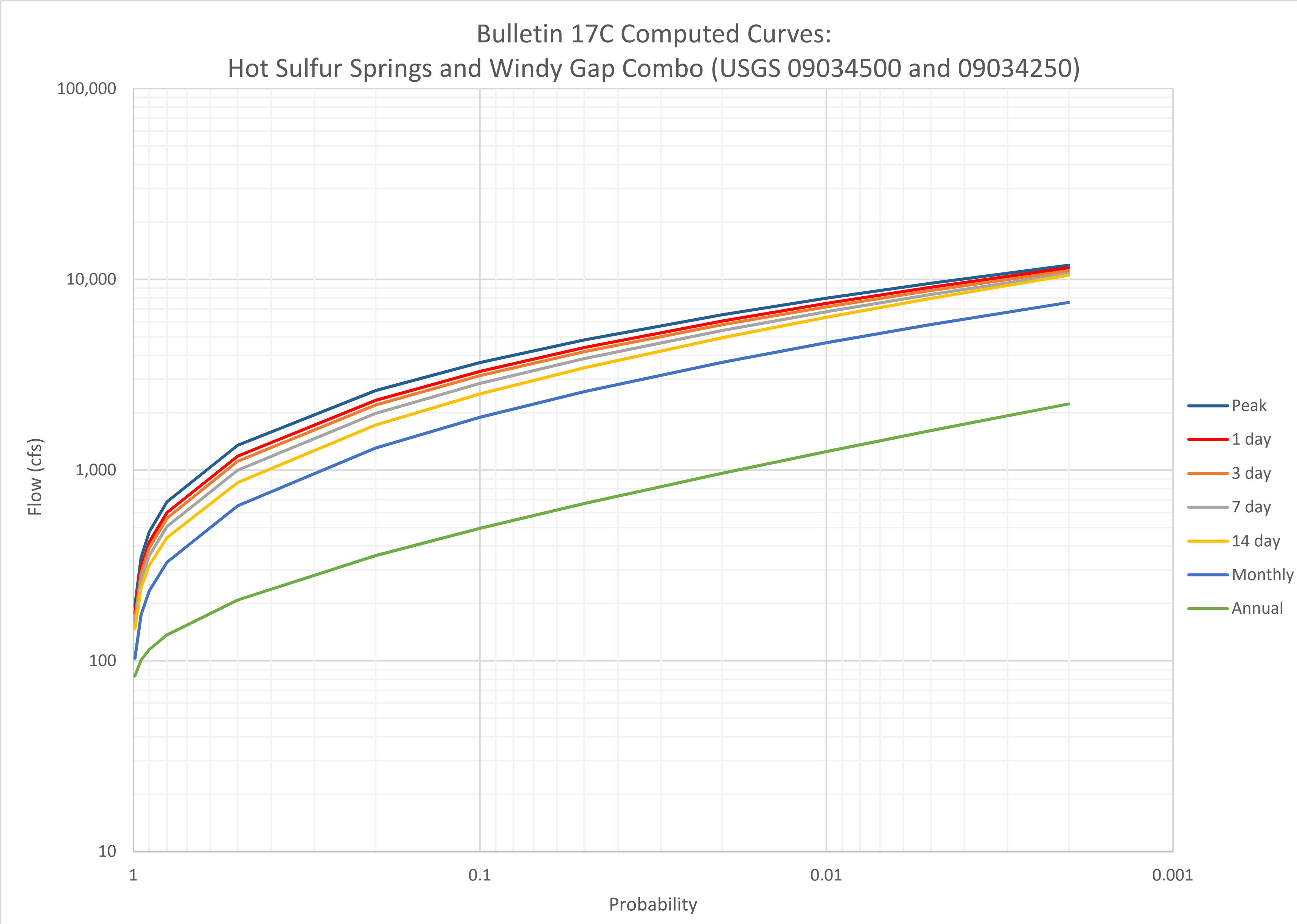
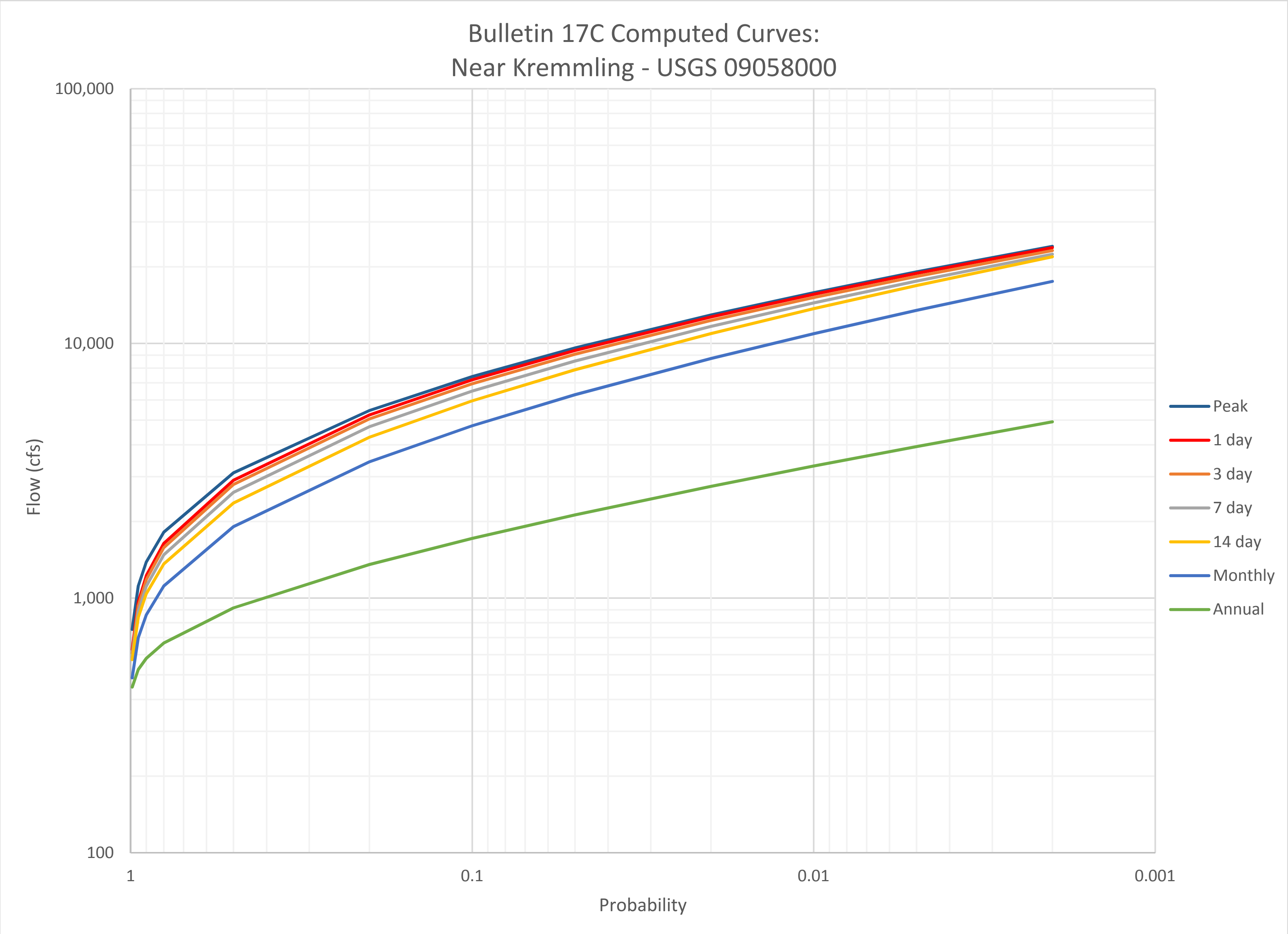
Stream Gage Continuity Plots


Bulletin 17C Computed Curves:
Hot Sulfur Springs and Windy Gap Combo (USGS 09034500 and 09034250)
100,000
10,000
1,000
100
10
Flow (cfs)
1
0.1
0.01
0.001
Probability
Peak
1 day
3 day
7 day
14 day
Monthly
Annual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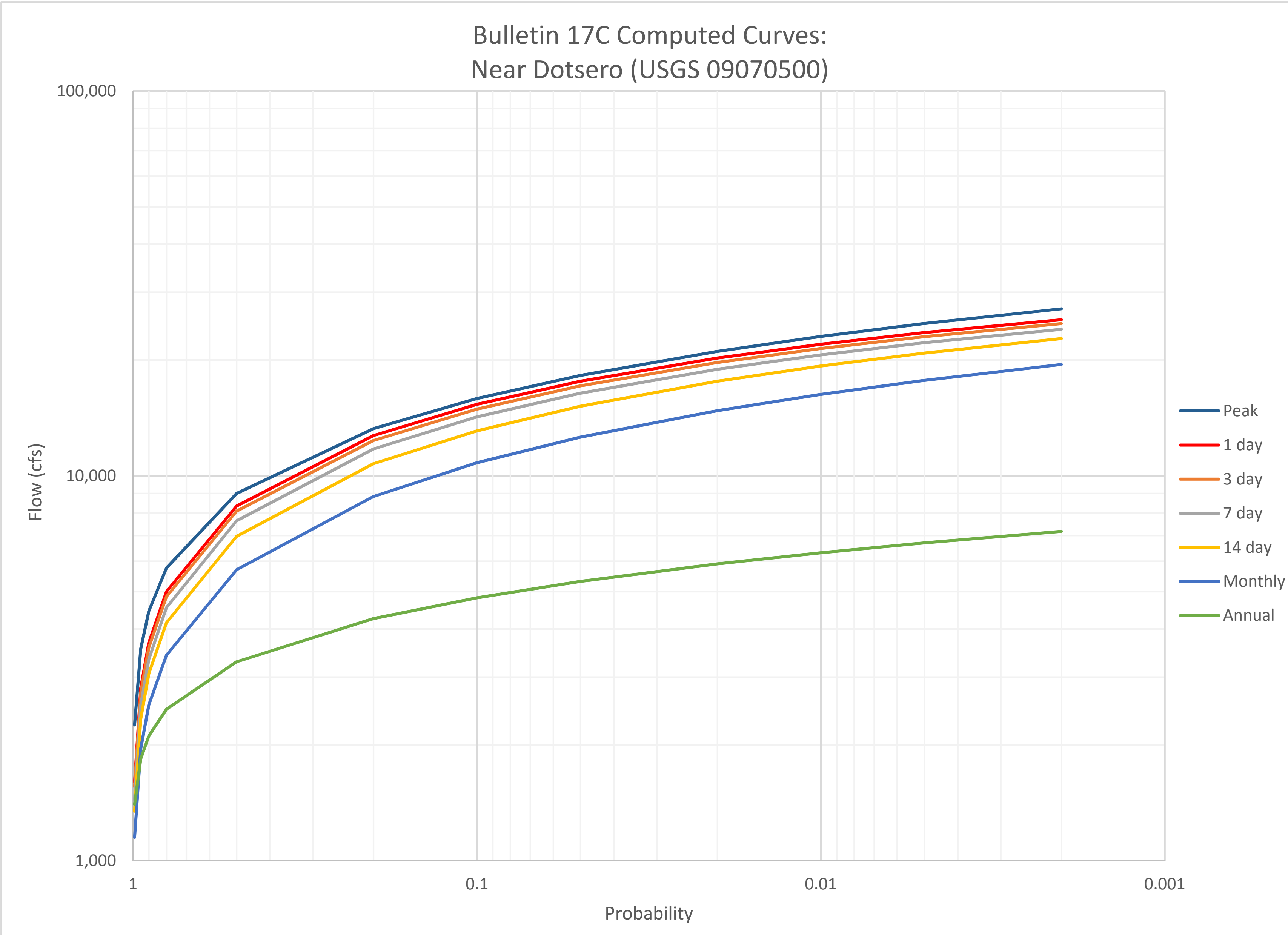
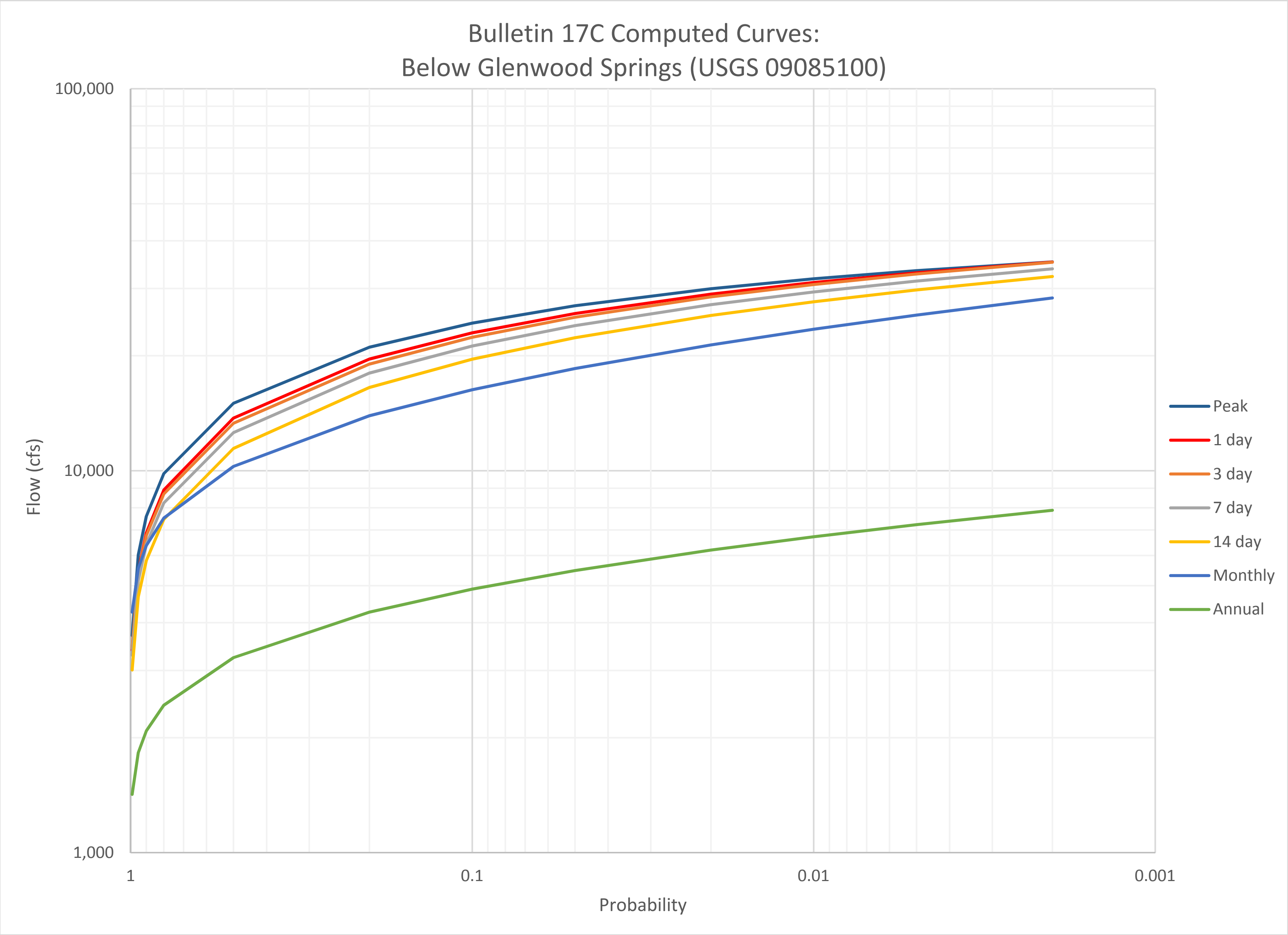
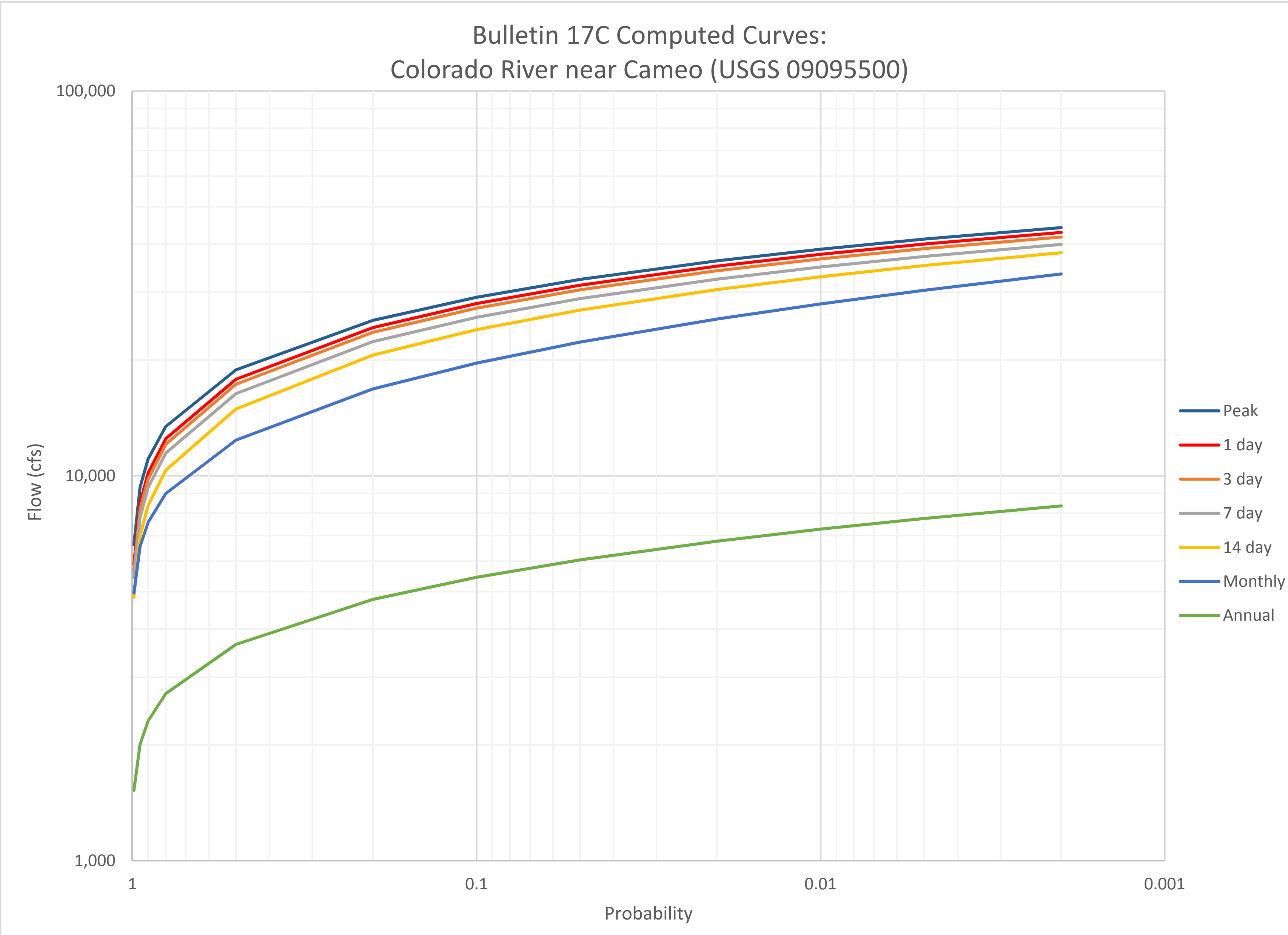
Near Kremmling - USGS 09058000
100,000
10,000
1,000
100
Flow (cfs)
1
0.1
0.01
0.001
Probability
Peak
1 day
3 day
7 day
14 day
Monthly
Annual

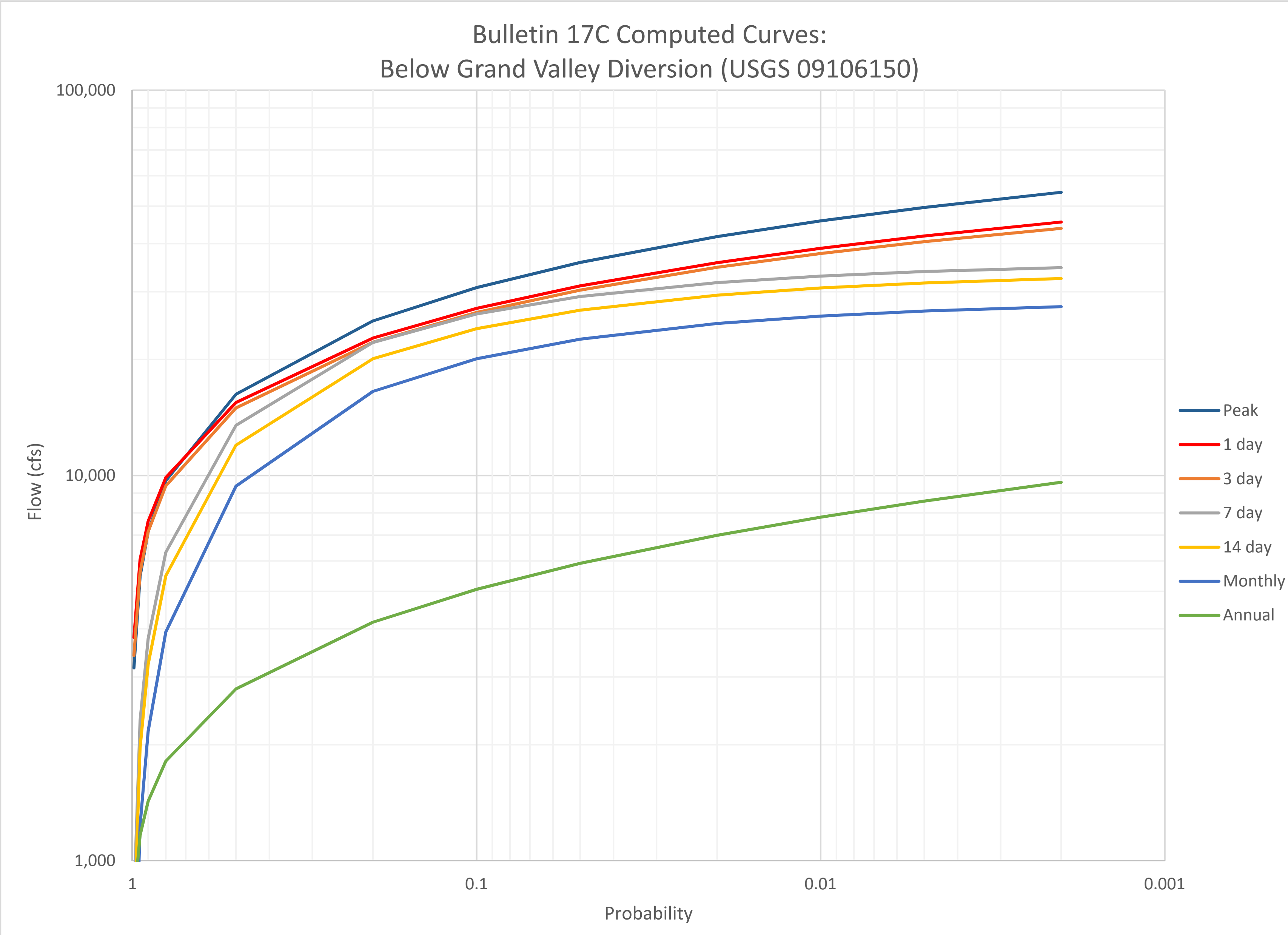


Bulletin 17C Computed Curves:
Near Dotsero (USGS 09070500)
100,000
10,000
1,000
Flow (cfs)
1
0.1
0.01
0.001
Probability
Peak
1 day
3 day
7 day
14 day
Monthly
Annual

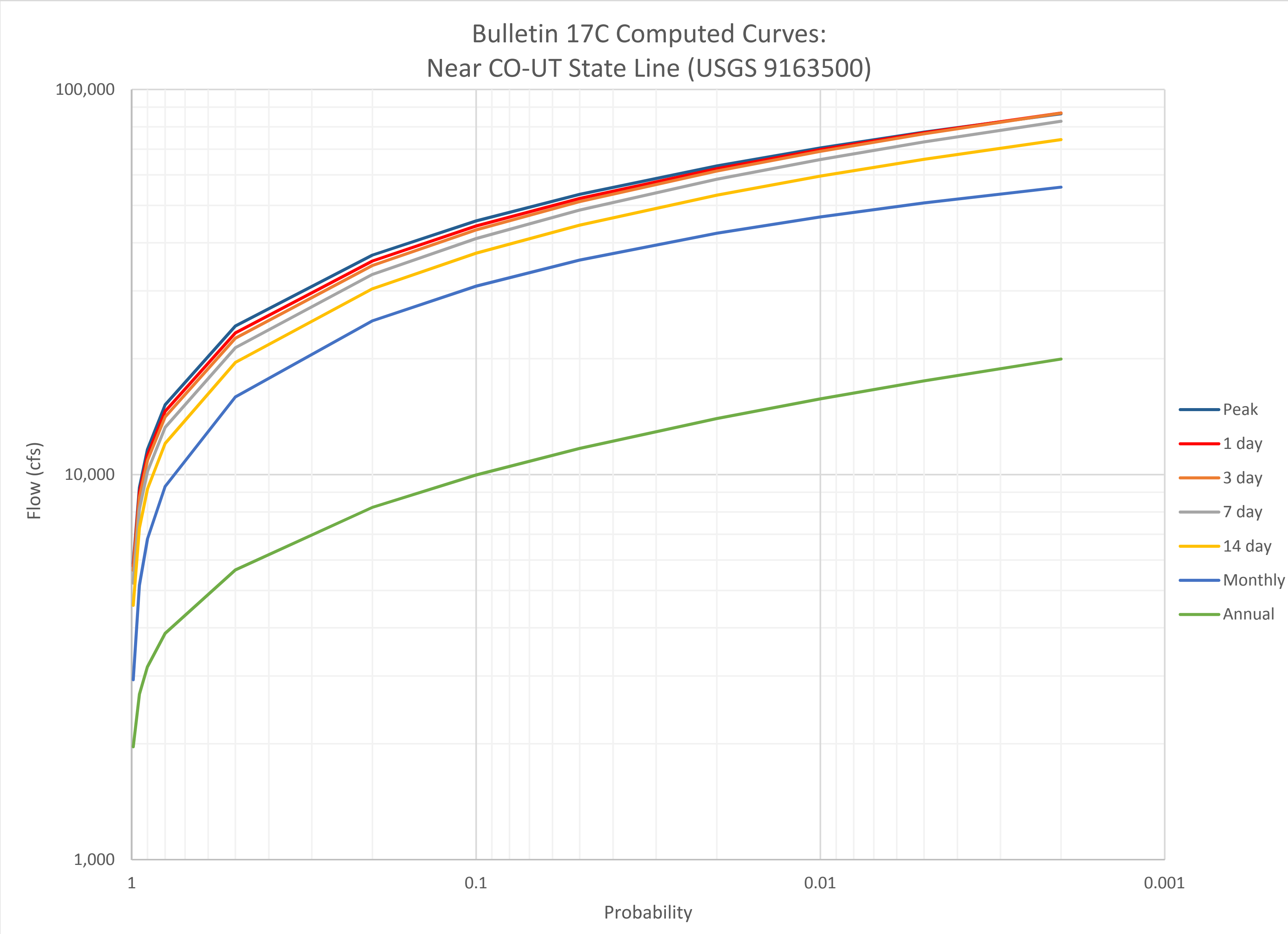


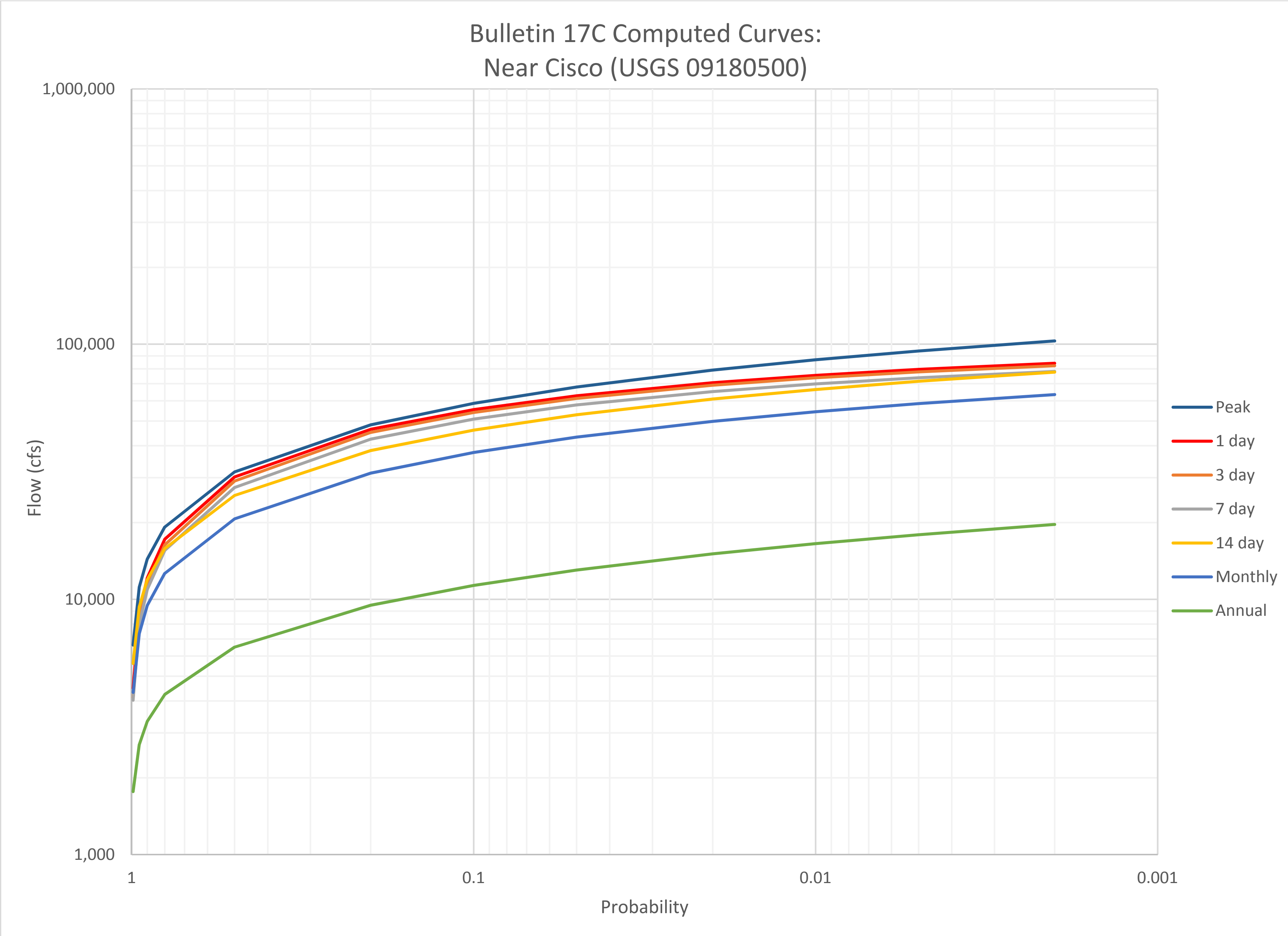
Bulletin 17C Computed Curves:
Below Glenwood Springs (USGS 09085100)
100,000
10,000
1,000
Flow (cfs)
1
0.1
0.01
0.001
Probability
Peak
1 day
3 day
7 day
14 day
Monthly
Annual


Bulletin 17C Computed Curves:
Colorado River near Cameo (USGS 09095500)
100,000
10,000
1,000
Flow (cfs)
1
0.1
0.01
0.001
Probability
Peak
1 day
3 day
7 day
14 day
Monthly
Annual



Bulletin 17C Computed Curves:
Below Grand Valley Diversion (USGS 09106150)
100,000
10,000
1,000
Flow (cfs)
1
0.1
0.01
0.001
Probability
Peak
1 day
3 day
7 day
14 day
Monthly
Annual


Bulletin 17C Computed Curves:
Near CO-UT State Line (USGS 9163500)
100,000
10,000
1,000
Flow (cfs)
1
0.1
0.01
0.001
Probability
Peak
1 day
3 day
7 day
14 day
Monthly
Annual



Bulletin 17C Computed Curves:
Near Cisco (USGS 09180500)
1,000,000
100,000
10,000
1,000
Flow (cfs)
1
0.1
0.01
0.001
Probability
Peak
1 day
3 day
7 day
14 day
Monthly
Annual

APPENDIX D

Grand County FIS Replacement Language and Tables

Secion developed from the 2016 FEMA FIS Template. Most language is boilerplate language from the template. Sections that have been edited to reflect the 2017 Colorado River Hydrology Study from Granby to the State Line are highlighted.

SECTION 5.0 – ENGINEERING METHODS

For the flooding sources in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded at least once on the average during any 10-, 25-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 25-, 50-, 100-, and 500-year floods, have a 10-, 4-, 2-, 1-, and 0.2% annual chance, respectively, of being equaled or exceeded during any year.

Although the recurrence interval represents the long-term, average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 100-year flood (1-percent chance of annual exceedance) during the term of a 30-year mortgage is approximately 26 percent (about 3 in 10); for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

In addition to these flood events, the “1-percent-plus”, or “1%+”, annual chance flood elevation has been modeled and included on the flood profile for certain flooding sources in this FIS Report. While not used for regulatory or insurance purposes, this flood event has been calculated to help illustrate the variability range that exists between the regulatory 1% annual chance flood elevation and a 1% annual chance elevation that has taken into account an additional amount of uncertainty in the flood discharges (thus, the 1% “plus”).

5.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak elevation-frequency relationships for floods of the selected recurrence intervals for each flooding source studied. Hydrologic analyses are typically performed at the watershed level. Depending on factors such as watershed size and shape, land use and urbanization, and natural or man-made storage, various models or methodologies may be applied.

Hydrologic analysis for the Colorado River was carried out by Amec Foster Wheeler under contract with the CWCB (Reference 1). Flood frequency curves for the 10%, 4%, 2%, 1%, 1% Plus, and 0.2% annual chance flood events were developed based on records from USGS stream-gaging stations and a Bulletin 17C flood frequency analysis.

A summary of the hydrologic methods applied to develop the discharges used in the hydraulic analyses for each stream is provided in Table 3. Greater detail (including assumptions, analysis, and results) is available in the archived project documentation.

A summary of the discharges is provided in Table 1. Frequency Discharge-Drainage Area Curves used to develop the hydrologic models may also be shown in Figure for selected flooding sources. Stream gage information is provided in Table 2.

Table 1: Summary of Discharges

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)					
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	1% Plus Annual Chance	0.2% Annual Chance
Colorado River	Near Kremmling	2,379	7,740	10,200	12,100	13,800	17,200	17,800
Colorado River	At Hot Sulphur Springs	825	3,690	4,670	5,280	5,800	6,920	6,700
Colorado River	Near Granby	323	2,580	3,300	3,770	4,190	8,280	4,980

*

Figure 7: Frequency Discharge-Drainage Area Curves

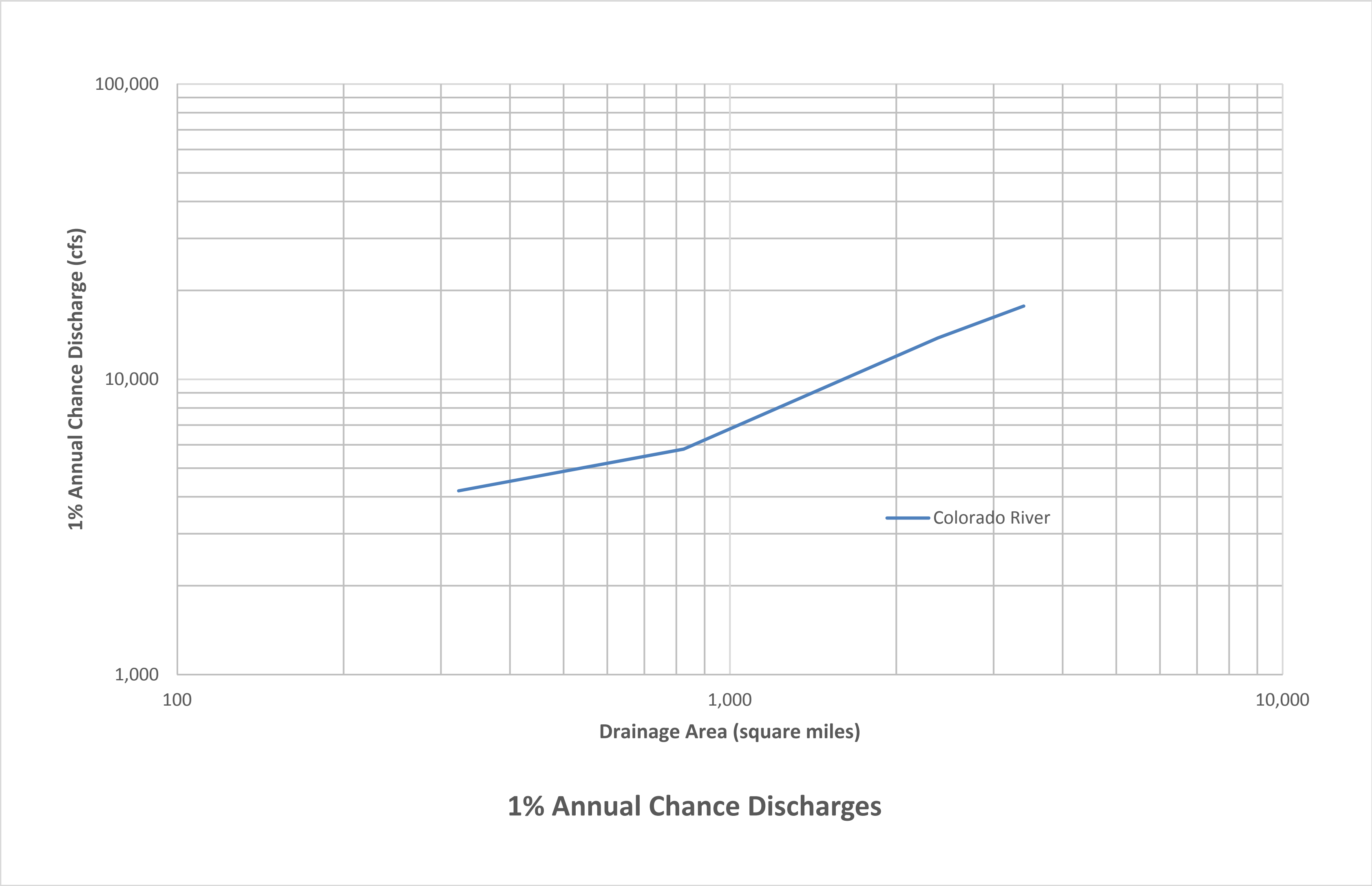


Table 2: Stream Gage Information used to Determine Discharges

Flooding Source	Gage Identifier	Agency that Maintains Gage	Site Name	Drainage Area (Square Miles)	Period of Record	
					From	To
Colorado River	09019500	USGS	Colorado River near Granby, CO	323	6/17/1908	06/22/2016
Colorado River	09034250	USGS	Colorado River at Windy Gap	788	07/03/1982	6/23/2016
Colorado River	09034500	USGS	Colorado River at Hot Sulphur Springs	825	06/08/1905	06/01/1994
Colorado River	09058000	USGS	Colorado River near Kremmling	2,379	06/04/1905	06/09/2016

5.2 Hydraulic Analyses

Table 3: Summary of Hydrologic and Hydraulic Analyses

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Colorado River	Colorado / Utah State Line	Granby, CO	Bulletin 17C / HEC-SSP V2.1	N/A	08/2017	N/A	Reach affected by regulation or diversion -. Modified approach to flood frequency analysis.

References:

1. Amec Foster Wheeler. (2017). “Hydrology Report – Colorado River Hydrologic Evaluation Granby to the State Line.

Eagle County FIS Replacement Language and Tables

Secion developed from the 2016 FEMA FIS Template. Most language is boilerplate language from the template. Sections that have been edited to reflect the 2017 Colorado River Hydrology Study from Granby to the State Line are highlighted.

SECTION 5.0 – ENGINEERING METHODS

For the flooding sources in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded at least once on the average during any 10-, 25-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 25-, 50-, 100-, and 500-year floods, have a 10-, 4-, 2-, 1-, and 0.2% annual chance, respectively, of being equaled or exceeded during any year.

Although the recurrence interval represents the long-term, average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 100-year flood (1-percent chance of annual exceedance) during the term of a 30-year mortgage is approximately 26 percent (about 3 in 10); for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

In addition to these flood events, the “1-percent-plus”, or “1%+”, annual chance flood elevation has been modeled and included on the flood profile for certain flooding sources in this FIS Report. While not used for regulatory or insurance purposes, this flood event has been calculated to help illustrate the variability range that exists between the regulatory 1% annual chance flood elevation and a 1% annual chance elevation that has taken into account an additional amount of uncertainty in the flood discharges (thus, the 1% “plus”). This value was derived from the upper 84% confidence interval flow value from the flood frequency analysis of each gage.

5.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak elevation-frequency relationships for floods of the selected recurrence intervals for each flooding source studied. Hydrologic analyses are typically performed at the watershed level. Depending on factors such as watershed size and shape, land use and urbanization, and natural or man-made storage, various models or methodologies may be applied.

Hydrologic analysis for the Colorado River was carried out by Amec Foster Wheeler under contract with the CWCB (Reference 1). Flood frequency curves for the 10%, 4%, 2%, 1%, 1% Plus, and 0.2% annual chance flood events were developed based on records from USGS stream-gaging stations and a Bulletin 17C flood frequency analysis.

A summary of the hydrologic methods applied to develop the discharges used in the hydraulic analyses for each stream is provided in Table 3. Greater detail (including assumptions, analysis, and results) is available in the archived project documentation.

A summary of the discharges is provided in Table 1. Frequency Discharge-Drainage Area Curves used to develop the hydrologic models may also be shown in Figure 1 for selected flooding sources. Stream gage information is provided in Table 2.

Table 1: Summary of Discharges

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)					
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	1% Plus Annual Chance	0.2% Annual Chance
Colorado River	Downstream of Eagle River	4,344	15,800	18,800	21,000	22,800	26,900	27,000
Colorado River	Upstream of Eagle River	3,400	9,900	13,000	15,500	17,700	22,000	22,800

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Figure 1: Frequency Discharge-Drainage Area Curves

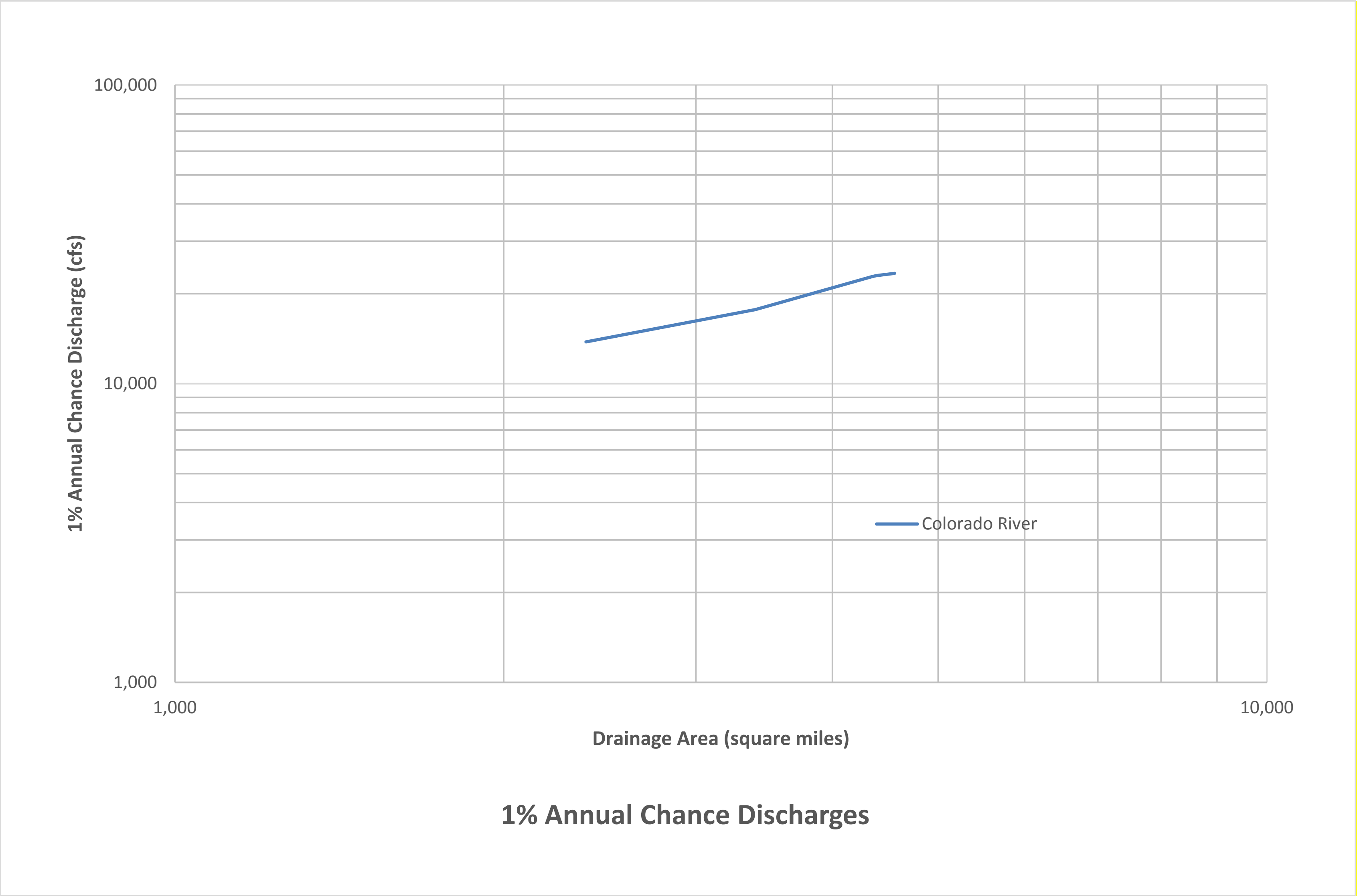

Table 2: Stream Gage Information used to Determine Discharges

Flooding Source	Gage Identifier	Agency that Maintains Gage	Site Name	Drainage Area (Square Miles)	Period of Record	
					From	To
Colorado River	09058000	USGS	Colorado River near Kremmling	2,379	06/04/1905	06/09/2016
Colorado River	09070500	USGS	Colorado River near Dotsero, CO	4,390	05/15/1941	06/10/2016

5.2 Hydraulic Analyses

Table 3: Summary of Hydrologic and Hydraulic Analyses

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Colorado River	Colorado / Utah State Line	Granby, CO	Bulletin 17C / HEC-SSP V2.1	N/A	08/2017	N/A	Reach affected by regulation or diversion -. Modified approach to flood frequency analysis.

References:

1. Amec Foster Wheeler. (2017). “Hydrology Report – Colorado River Hydrologic Evaluation Granby to the State Line.

Garfield County FIS Replacement Language and Tables

Secion developed from the 2014 FEMA FIS Template. Most language is boilerplate language from the template. Sections that have been edited to reflect the 2017 Colorado River Hydrology Study from Granby to the State Line are highlighted.

SECTION 5.0 – ENGINEERING METHODS

For the flooding sources in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded at least once on the average during any 10-, 25-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 25-, 50-, 100-, and 500-year floods, have a 10-, 4-, 2-, 1-, and 0.2% annual chance, respectively, of being equaled or exceeded during any year.

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In addition to these flood events, the “1-percent-plus”, or “1%+”, annual chance flood elevation has been modeled and included on the flood profile for certain flooding sources in this FIS Report. While not used for regulatory or insurance purposes, this flood event has been calculated to help illustrate the variability range that exists between the regulatory 1% annual chance flood elevation and a 1% annual chance elevation that has taken into account an additional amount of uncertainty in the flood discharges (thus, the 1% “plus”).

5.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak elevation-frequency relationships for floods of the selected recurrence intervals for each flooding source studied. Hydrologic analyses are typically performed at the watershed level. Depending on factors such as watershed size and shape, land use and urbanization, and natural or man-made storage, various models or methodologies may be applied.

Hydrologic analysis for the Colorado River was carried out by Amec Foster Wheeler under contract with the CWCB (Reference 1). Flood frequency curves for the 10%, 4%, 2%, 1%, 1% Plus, and 0.2% annual chance flood events were developed based on records from USGS stream-gaging stations and a Bulletin 17C flood frequency analysis.

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A summary of the discharges is provided in Table 1. Frequency Discharge-Drainage Area Curves used to develop the hydrologic models may also be shown in Figure 1 for selected flooding sources. Stream gage information is provided in Table 2.

Table 1: Summary of Discharges

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)					
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	1% Plus Annual Chance	0.2% Annual Chance
Colorado River	At Confluence with Parachute Creek	7,370	28,100	32,500	35,500	38,400	42,100	44,500
Colorado River	At Rifle	6,930	27,000	31,200	34,200	36,900	40,500	42,700
Colorado River	Downstream of the Confluence of Divide Creek	6,590	26,200	30,100	32,700	34,900	38,100	39,000
Colorado River	At New Castle	6,300	25,400	29,300	31,700	33,900	37,000	37,900
Colorado River	Just Downstream of Roraring Fork River	6,020	24,700	28,400	30,800	32,900	35,900	36,800
Colorado River	Upstream of the Confluence with Roaring Fork River	4,560	16,400	19,400	21,500	23,400	27,300	27,200

*

Figure 1: Frequency Discharge-Drainage Area Curves

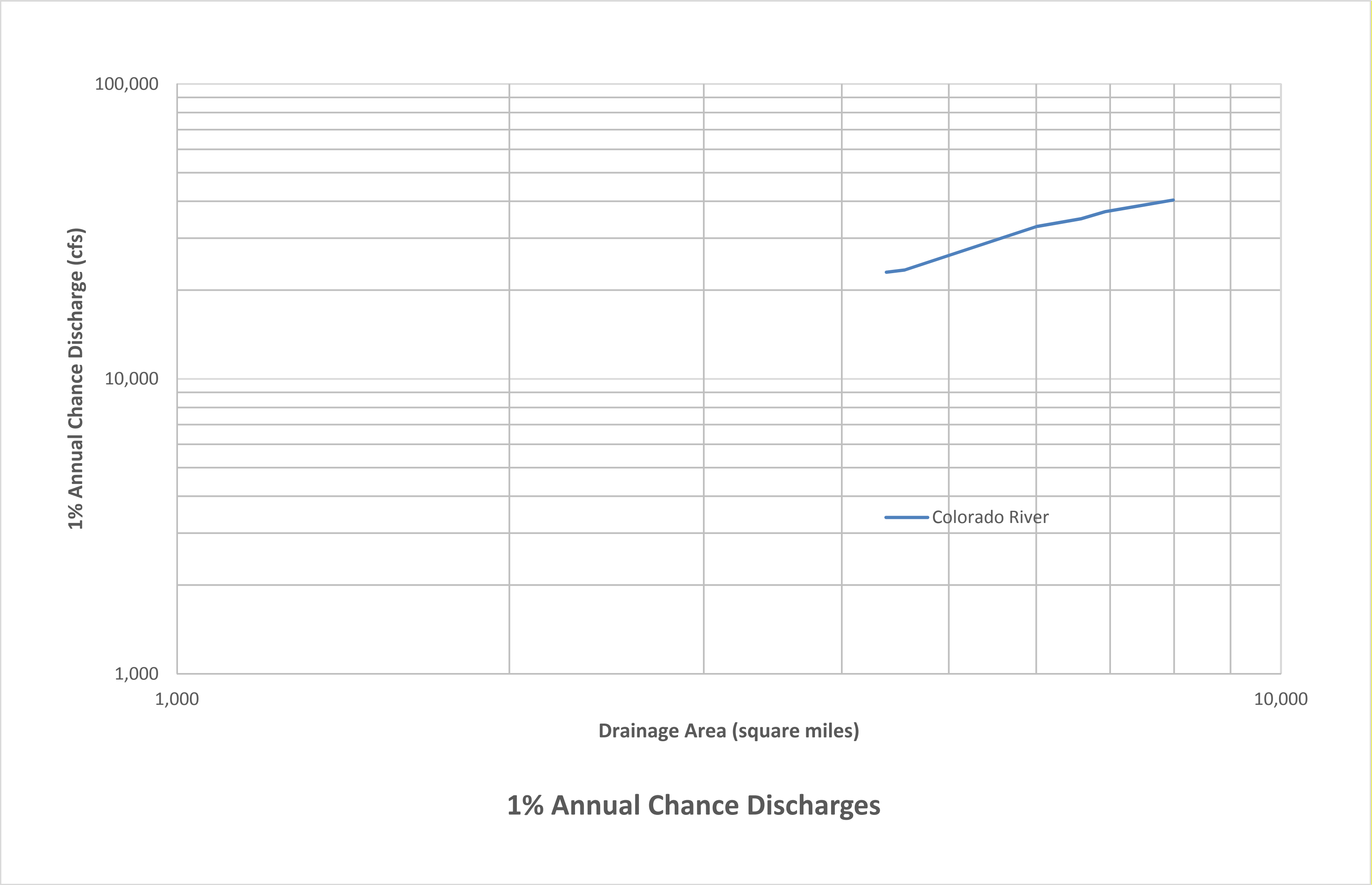

Table 2: Stream Gage Information used to Determine Discharges

Flooding Source	Gage Identifier	Agency that Maintains Gage	Site Name	Drainage Area (Square Miles)	Period of Record	
					From	To
Colorado River	09085100	USGS	Colorado River Below Glenwood Springs	6,014	06/05/1967	06/08/2016
Colorado River	09095500	USGS	Colorado River near Cameo, CO	7,986	05/11/1934	06/11/2016

5.2 Hydraulic Analyses

Table 3: Summary of Hydrologic and Hydraulic Analyses

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Colorado River	Colorado / Utah State Line	Granby, CO	Bulletin 17C / HEC-SSP V2.1	N/A	08/2017	N/A	Reach affected by regulation or diversion -. Modified approach to flood frequency analysis.

References:

1. Amec Foster Wheeler. (2017). “Hydrology Report – Colorado River Hydrologic Evaluation Granby to the State Line.

Mesa County FIS Replacement Language and Tables

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SECTION 5.0 – ENGINEERING METHODS

For the flooding sources in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded at least once on the average during any 10-, 25-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 25-, 50-, 100-, and 500-year floods, have a 10-, 4-, 2-, 1-, and 0.2% annual chance, respectively, of being equaled or exceeded during any year.

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5.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak elevation-frequency relationships for floods of the selected recurrence intervals for each flooding source studied. Hydrologic analyses are typically performed at the watershed level. Depending on factors such as watershed size and shape, land use and urbanization, and natural or man-made storage, various models or methodologies may be applied.

Hydrologic analysis for the Colorado River was carried out by Amec Foster Wheeler under contract with the CWCB (Reference 1). Flood frequency curves for the 10%, 4%, 2%, 1%, 1% Plus, and 0.2% annual chance flood events were developed based on records from USGS stream-gaging stations and a Bulletin 17C flood frequency analysis.

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Table 1: Summary of Discharges

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)					
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	1% Plus Annual Chance	0.2% Annual Chance
Colorado River	Downstream of Confluence with Gunnison River (near Fruita)	17,000	45,500	57,400	66,500	75,700	86,500	97,900
Colorado River	Upstream of Confluence with Gunnison River (near Palisade)	8,800	30,900	38,400	43,800	49,000	55,300	60,500

*

Figure 7: Frequency Discharge-Drainage Area Curves

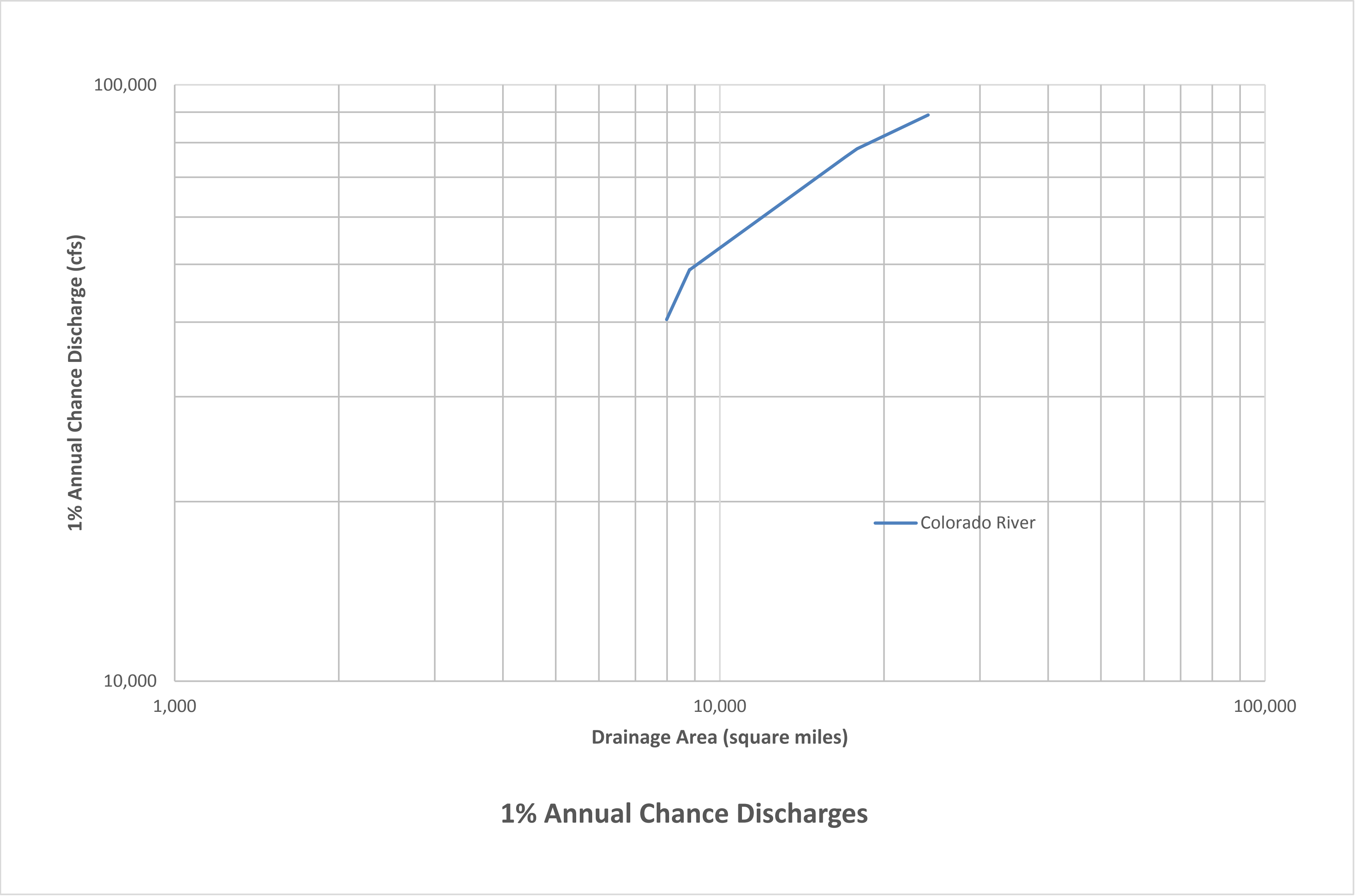

Table 2: Stream Gage Information used to Determine Discharges

Flooding Source	Gage Identifier	Agency that Maintains Gage	Site Name	Drainage Area (Square Miles)	Period of Record	
					From	To
Colorado River	09095500	USGS	Colorado River near Cameo, CO	7,986	05/11/1934	06/11/2016
Colorado River	09106150	USGS	Colorado River Below Grand Valley Diversion near Palisade, CO	8,813	06/15/1991	06/08/2016
Colorado River	09163500	USGS	Colorado River near Colorado-Utah State Line	17,100	06/23/1951	06/09/2016
Colorado River	09180500	USGS	Colorado River near Cisco, UT	24,100	07/04/1884	06/09/2016

5.2 Hydraulic Analyses

Table 3: Summary of Hydrologic and Hydraulic Analyses

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Colorado River	Colorado / Utah State Line	Granby, CO	Bulletin 17C / HEC-SSP V2.1	N/A	08/2017	N/A	Reach affected by regulation or diversion -. Modified approach to flood frequency analysis.

References:

1. Amec Foster Wheeler. (2017). “Hydrology Report – Colorado River Hydrologic Evaluation Granby to the State Line.

HEC-SSP Data and Results

HEC-SSP Bulletin 17C Analysis

Bulletin 17B Frequency Analysis
02 Nov 2017   11:51 AM

--- Input Data ---

Analysis Name: @Granby Below Lake 17C
Description:

Data Set Name: Colorado River-LAKE GRANBY, CO.-FLOW-ANNUAL PEAK
DSS File Name: \\den-fs1\DVOFFICE\PUBLIC\P_Drive\3279 Project files- Water Group\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss
DSS Pathname: /COLORADO RIVER/LAKE GRANBY, CO./FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: \\den-fs1\DVOFFICE\PUBLIC\P_Drive\3279 Project files- Water Group\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Granby_Below_Lake_17C\@Granby_Below_Lake_17C.rpt
XML File Name: \\den-fs1\DVOFFICE\PUBLIC\P_Drive\3279 Project files- Water Group\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Granby_Below_Lake_17C\@Granby_Below_Lake_17C.xml

Start Date:
End Date:

Skew Option: Use Weighted Skew
Regional Skew: -0.18
Regional Skew MSE: 0.302

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.16
Lower Confidence Level: 0.84

Use non-standard frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 4.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

<< EMA Representation of Data >>
Colorado River-LAKE GRANBY, CO.-FLOW-ANNUAL PEAK

```
---------------------------------------------------------------------------------
|                    |          Value           |        Threshold         |      |
```

Year	Peak	Low	High	Low	High	Type
1951	73.0	73.0	73.0	1.0E-99	1.0E99	Syst
1952	437.0	328.0	546.0	1.0E-99	1.0E99	Syst
1953	102.0	102.0	102.0	1.0E-99	1.0E99	Syst
1954	94.0	94.0	94.0	1.0E-99	1.0E99	Syst
1955	79.0	79.0	79.0	1.0E-99	1.0E99	Syst
1956	79.0	79.0	79.0	1.0E-99	1.0E99	Syst
1957	217.0	217.0	217.0	1.0E-99	1.0E99	Syst
1958	172.0	172.0	172.0	1.0E-99	1.0E99	Syst
1959	79.0	79.0	79.0	1.0E-99	1.0E99	Syst
1960	84.0	84.0	84.0	1.0E-99	1.0E99	Syst
1961	96.0	96.0	96.0	1.0E-99	1.0E99	Syst
1962	1,400.0	1,400.0	1,400.0	1.0E-99	1.0E99	Syst
1963	237.0	237.0	237.0	1.0E-99	1.0E99	Syst
1964	96.0	96.0	96.0	1.0E-99	1.0E99	Syst
1965	109.0	109.0	109.0	1.0E-99	1.0E99	Syst
1966	86.0	86.0	86.0	1.0E-99	1.0E99	Syst
1967	103.0	103.0	103.0	1.0E-99	1.0E99	Syst
1968	105.0	105.0	105.0	1.0E-99	1.0E99	Syst
1969	110.0	110.0	110.0	1.0E-99	1.0E99	Syst
1970	107.0	107.0	107.0	1.0E-99	1.0E99	Syst
1971	1,520.0	1,520.0	1,520.0	1.0E-99	1.0E99	Syst
1972	174.0	174.0	174.0	1.0E-99	1.0E99	Syst
1973	1,440.0	1,440.0	1,440.0	1.0E-99	1.0E99	Syst
1974	1,470.0	1,470.0	1,470.0	1.0E-99	1.0E99	Syst
1975	97.0	97.0	97.0	1.0E-99	1.0E99	Syst
1976	105.0	105.0	105.0	1.0E-99	1.0E99	Syst
1977	83.0	83.0	83.0	1.0E-99	1.0E99	Syst
1978	103.0	103.0	103.0	1.0E-99	1.0E99	Syst
1979	93.0	93.0	93.0	1.0E-99	1.0E99	Syst
1980	114.0	114.0	114.0	1.0E-99	1.0E99	Syst
1981	78.0	78.0	78.0	1.0E-99	1.0E99	Syst
1982	102.0	102.0	102.0	1.0E-99	1.0E99	Syst

Fitted log10 Moments	Mean	Variance	Std Dev	Skew
EMA at-site data w/o regional info	2.182092	0.167534	0.409309	1.819129
EMA w/ regional info and B17b MSE(G)	2.182080	0.167523	0.409296	0.520742
EMA w/ regional info and specified MSE(G)	2.182080	0.167523	0.409296	0.520742

EMA Estimate of MSE[G at-site]	0.559637
MSE[G at-site systematic]	0.569495
Effective Record Length [G at-site]	31.546069
Grubbs-Beck Critical Value	0.000000

--- Final Results ---

<< Plotting Positions >>

Colorado River-LAKE GRANBY, CO.-FLOW-ANNUAL PEAK

Events Analyzed				Ordered Events			
Day	Mon	Year	FLOW CFS	Rank	Water Year	FLOW CFS	H-S Plot Pos
13	Jun	1951	73.0	1	1971	1,520.0	3.03
20	Jun	1952	437.0	2	1974	1,470.0	6.06
04	Oct	1952	102.0	3	1973	1,440.0	9.09
01	May	1954	94.0	4	1962	1,400.0	12.12
29	Jun	1955	79.0	5	1952	437.0	15.15
29	May	1956	79.0	6	1963	237.0	18.18
02	May	1957	217.0	7	1957	217.0	21.21
25	Mar	1958	172.0	8	1972	174.0	24.24
05	Jul	1959	79.0	9	1958	172.0	27.27
02	May	1960	84.0	10	1980	114.0	30.30
12	Jun	1961	96.0	11	1969	110.0	33.33
03	Jul	1962	1,400.0	12	1965	109.0	36.36
24	Jul	1963	237.0	13	1970	107.0	39.39
01	Jul	1964	96.0	14	1976	105.0	42.42
18	Jul	1965	109.0	15	1968	105.0	45.45
18	Jul	1966	86.0	16	1978	103.0	48.48
07	Jul	1967	103.0	17	1967	103.0	51.52
15	Jul	1968	105.0	18	1982	102.0	54.55
17	Sep	1969	110.0	19	1953	102.0	57.58
17	Jun	1970	107.0	20	1975	97.0	60.61
27	Jun	1971	1,520.0	21	1964	96.0	63.64
12	Sep	1972	174.0	22	1961	96.0	66.67
03	Jul	1973	1,440.0	23	1954	94.0	69.70
20	Jun	1974	1,470.0	24	1979	93.0	72.73
16	Jun	1975	97.0	25	1966	86.0	75.76
17	Jul	1976	105.0	26	1960	84.0	78.79
05	Jul	1977	83.0	27	1977	83.0	81.82
23	Jul	1978	103.0	28	1959	79.0	84.85
30	Jul	1979	93.0	29	1956	79.0	87.88
14	Jul	1980	114.0	30	1955	79.0	90.91
04	May	1981	78.0	31	1981	78.0	93.94
01	Jun	1982	102.0	32	1951	73.0	96.97

* Low outlier plotting positions are computed using Median parameters.

<< Frequency Curve >>
Colorado River-LAKE GRANBY, CO.-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Variance Log(EMA)	Percent Chance Exceedance	Confidence Limits 0.16 FLOW, CFS	Confidence Limits 0.84 FLOW, CFS
4,166.4	0.09309	0.200	10,683.0	2,372.3
2,719.8	0.06579	0.500	5,926.6	1,682.9
1,937.6	0.04887	1.000	3,750.7	1,273.6
1,355.3	0.03505	2.000	2,343.3	943.7
925.6	0.02419	4.000	1,439.9	680.1
529.8	0.01405	10.000	729.2	414.5
325.2	0.00923	20.000	415.9	264.4
140.2	0.00576	50.000	168.1	118.0
67.8	0.00514	80.000	80.0	57.1
48.5	0.00607	90.000	57.5	39.8
37.6	0.00808	95.000	45.3	29.6
24.5	0.01688	99.000	31.8	17.3

<< Systematic Statistics >>
Colorado River-LAKE GRANBY, CO.-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	2.182	Historic Events	0
Standard Dev	0.409	High Outliers	0
Station Skew	1.819	Low Outliers	0
Regional Skew	-0.180	Zero Events	0
Weighted Skew	0.521	Missing Events	0
Adopted Skew	0.521	Systematic Events	32

--- End of Analytical Frequency Curve ---

```
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Bulletin 17B Frequency Analysis
    02 Nov 2017   11:52 AM
-------------------------------
```

--- Input Data ---

Analysis Name: @Granby - 17C
Description:

Data Set Name: Colorado River-GRANBY, CO-FLOW-ANNUAL PEAK
DSS File Name: \\den-fs1\DVOFFICE\PUBLIC\P_Drive\3279 Project files- Water Group\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss
DSS Pathname: /COLORADO RIVER/GRANBY, CO/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: \\den-fs1\DVOFFICE\PUBLIC\P_Drive\3279 Project files- Water Group\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Granby_-_17C\@Granby_-_17C.rpt
XML File Name: \\den-fs1\DVOFFICE\PUBLIC\P_Drive\3279 Project files- Water Group\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Granby_-_17C\@Granby_-_17C.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -0.18
Regional Skew MSE: 0.302

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.16
Lower Confidence Level: 0.84
Use Low Outlier Threshold
Low Outlier Threshold: 1600.0

Use non-standard frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 4.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

<< EMA Representation of Data >>
Colorado River-GRANBY, CO-FLOW-ANNUAL PEAK

		Value		Threshold		
Year	Peak	Low	High	Low	High	Type

1908	1,480.0	1.0E-6	1,600.0	1,600.0	1.0E99	Hist
1909	4,100.0	3,075.0	5,125.0	1,600.0	1.0E99	Hist
1910	2,320.0	1,740.0	2,900.0	1,600.0	1.0E99	Hist
1911	2,800.0	2,100.0	3,500.0	1,600.0	1.0E99	Hist
1912	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1913	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1914	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1915	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1916	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1917	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1918	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1919	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1920	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1921	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1922	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1923	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1924	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1925	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1926	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1927	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1928	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1929	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1930	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1931	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1932	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1933	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1934	1,240.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1935	3,370.0	3,370.0	3,370.0	1,600.0	1.0E99	Syst
1936	2,640.0	2,640.0	2,640.0	1,600.0	1.0E99	Syst
1937	1,590.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1938	3,010.0	3,010.0	3,010.0	1,600.0	1.0E99	Syst
1939	2,070.0	2,070.0	2,070.0	1,600.0	1.0E99	Syst
1940	1,860.0	1,860.0	1,860.0	1,600.0	1.0E99	Syst
1941	2,070.0	2,070.0	2,070.0	1,600.0	1.0E99	Syst
1942	2,260.0	2,260.0	2,260.0	1,600.0	1.0E99	Syst
1943	1,870.0	1,870.0	1,870.0	1,600.0	1.0E99	Syst
1944	1,950.0	1,950.0	1,950.0	1,600.0	1.0E99	Syst
1945	2,240.0	2,240.0	2,240.0	1,600.0	1.0E99	Syst
1946	2,070.0	2,070.0	2,070.0	1,600.0	1.0E99	Syst
1947	2,830.0	2,830.0	2,830.0	1,600.0	1.0E99	Syst
1948	2,390.0	2,390.0	2,390.0	1,600.0	1.0E99	Syst
1949	2,960.0	2,960.0	2,960.0	1,600.0	1.0E99	Syst
1950	59.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1951	80.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1952	435.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1953	112.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1954	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1955	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1956	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1957	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1958	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1959	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1960	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1961	90.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1962	1,420.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1963	104.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1964	95.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1965	121.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1966	80.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1967	118.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1968	86.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1969	120.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst

1970	154.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1971	1,450.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1972	112.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1973	1,460.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1974	1,370.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1975	133.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1976	117.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1977	83.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1978	99.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1979	112.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1980	100.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1981	81.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1982	102.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1983	2,510.0	2,510.0	2,510.0	1,600.0	1.0E99	Syst
1984	2,140.0	2,140.0	2,140.0	1,600.0	1.0E99	Syst
1985	305.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1986	460.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1987	91.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1988	---	1.0E-99	4,100.0	1,600.0	1.0E99	Cens
1989	100.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1990	108.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1991	153.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1992	91.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1993	857.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1994	101.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1995	887.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1996	2,520.0	2,520.0	2,520.0	1,600.0	1.0E99	Syst
1997	1,980.0	1,980.0	1,980.0	1,600.0	1.0E99	Syst
1998	1,200.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
1999	1,260.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
2000	1,030.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
2001	90.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
2002	92.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
2003	115.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
2004	82.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
2005	100.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
2006	183.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
2007	123.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
2008	173.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
2009	123.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
2010	125.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
2011	2,290.0	2,290.0	2,290.0	1,600.0	1.0E99	Syst
2012	176.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
2013	105.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
2014	716.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst
2015	2,480.0	2,480.0	2,480.0	1,600.0	1.0E99	Syst
2016	1,190.0	1.0E-6	1,600.0	1,600.0	1.0E99	Syst

Fitted log10 Moments	Mean	Variance	Std Dev	Skew
EMA at-site data w/o regional info	2.945250	0.164447	0.405520	-0.888212
EMA w/ regional info and B17b MSE(G)	2.945250	0.164447	0.405520	-0.888212
EMA w/ regional info and specified MSE(G)	2.945250	0.164447	0.405520	-0.888212

EMA Estimate of MSE[G at-site] 0.044714
MSE[G at-site systematic] 0.132002
Effective Record Length [G at-site] 221.410193
Grubbs-Beck Critical Value 1,600.000000

--- Final Results ---

<< Plotting Positions >>
Colorado River-GRANBY, CO-FLOW-ANNUAL PEAK

Events Analyzed				Ordered Events			
Day	Mon	Year	FLOW CFS	Rank	Water Year	FLOW CFS	H-S Plot Pos
17	Jun	1908	1,480.0	1	1909	4,100.0	0.88
20	Jun	1909	4,100.0	2	1935	3,370.0	1.76
01	Jun	1910	2,320.0	3	1938	3,010.0	2.64
16	Jun	1911	2,800.0	4	1949	2,960.0	3.52
01	Jan	1912	---	5	1947	2,830.0	4.40
01	Jan	1913	---	6	1911	2,800.0	5.28
01	Jan	1914	---	7	1936	2,640.0	6.15
01	Jan	1915	---	8	1996	2,520.0	7.03
01	Jan	1916	---	9	1983	2,510.0	7.91
01	Jan	1917	---	10	2015	2,480.0	8.79
01	Jan	1918	---	11	1948	2,390.0	9.67
01	Jan	1919	---	12	1910	2,320.0	12.31
01	Jan	1920	---	13	2011	2,290.0	10.55
01	Jan	1921	---	14	1942	2,260.0	11.43
01	Jan	1922	---	15	1945	2,240.0	13.19
01	Jan	1923	---	16	1984	2,140.0	14.07
01	Jan	1924	---	17	1946	2,070.0	14.95
01	Jan	1925	---	18	1941	2,070.0	15.83
01	Jan	1926	---	19	1939	2,070.0	16.70
01	Jan	1927	---	20	1997	1,980.0	17.58
01	Jan	1928	---	21	1944	1,950.0	18.46
01	Jan	1929	---	22	1943	1,870.0	19.34
01	Jan	1930	---	23	1940	1,860.0	20.22
01	Jan	1931	---	24	1937	1,590.0*	29.85
01	Jan	1932	---	25	1908	1,480.0*	31.11
01	Jan	1933	---	26	1973	1,460.0*	32.37
12	May	1934	1,240.0	27	1971	1,450.0*	33.63
16	Jun	1935	3,370.0	28	1962	1,420.0*	34.89
01	Jun	1936	2,640.0	29	1974	1,370.0*	36.15
26	Jun	1937	1,590.0	30	1999	1,260.0*	37.41
22	Jun	1938	3,010.0	31	1934	1,240.0*	38.66
01	Jun	1939	2,070.0	32	1998	1,200.0*	39.92
02	Jun	1940	1,860.0	33	2016	1,190.0*	41.18
14	May	1941	2,070.0	34	2000	1,030.0*	42.44
12	Jun	1942	2,260.0	35	1995	887.0*	43.70
23	Jun	1943	1,870.0	36	1993	857.0*	44.96
11	Jun	1944	1,950.0	37	2014	716.0*	46.22
25	May	1945	2,240.0	38	1986	460.0*	47.48
08	Jun	1946	2,070.0	39	1952	435.0*	48.74
10	Jun	1947	2,830.0	40	1985	305.0*	50.00
22	May	1948	2,390.0	41	2006	183.0*	51.26
18	Jun	1949	2,960.0	42	2012	176.0*	52.52
23	Jul	1950	59.0	43	2008	173.0*	53.78
14	Jun	1951	80.0	44	1970	154.0*	55.04

23 Jun 1952	435.0	45	1991	153.0*	56.30
19 Jun 1953	112.0	46	1975	133.0*	57.56
01 Jan 1954	---	47	2010	125.0*	58.82
01 Jan 1955	---	48	2009	123.0*	60.08
01 Jan 1956	---	49	2007	123.0*	61.34
01 Jan 1957	---	50	1965	121.0*	62.59
01 Jan 1958	---	51	1969	120.0*	63.85
01 Jan 1959	---	52	1967	118.0*	65.11
01 Jan 1960	---	53	1976	117.0*	66.37
09 Jun 1961	90.0	54	2003	115.0*	67.63
03 Jul 1962	1,420.0	55	1979	112.0*	68.89
24 Jul 1963	104.0	56	1972	112.0*	70.15
21 May 1964	95.0	57	1953	112.0*	71.41
01 May 1965	121.0	58	1990	108.0*	72.67
26 Jul 1966	80.0	59	2013	105.0*	73.93
07 Jul 1967	118.0	60	1963	104.0*	75.19
12 Jul 1968	86.0	61	1982	102.0*	76.45
14 Jun 1969	120.0	62	1994	101.0*	77.71
03 May 1970	154.0	63	2005	100.0*	78.97
25 Jun 1971	1,450.0	64	1989	100.0*	80.23
22 May 1972	112.0	65	1980	100.0*	81.49
01 Jul 1973	1,460.0	66	1978	99.0*	82.75
21 Jun 1974	1,370.0	67	1964	95.0*	84.01
16 Jul 1975	133.0	68	2002	92.0*	85.26
17 Jun 1976	117.0	69	1992	91.0*	86.52
16 Mar 1977	83.0	70	1987	91.0*	87.78
18 May 1978	99.0	71	2001	90.0*	89.04
07 Jun 1979	112.0	72	1961	90.0*	90.30
01 Jun 1980	100.0	73	1968	86.0*	91.56
14 Jul 1981	81.0	74	1977	83.0*	92.82
18 Jun 1982	102.0	75	2004	82.0*	94.08
11 Jul 1983	2,510.0	76	1981	81.0*	95.34
01 Jul 1984	2,140.0	77	1966	80.0*	96.60
02 May 1985	305.0	78	1951	80.0*	97.86
02 Jul 1986	460.0	79	1950	59.0*	99.12
23 Jun 1987	91.0	80	1988	---*	---
01 Jan 1988	---	81	1960	---*	---
21 Jul 1989	100.0	82	1959	---*	---
29 May 1990	108.0	83	1958	---*	---
01 Jun 1991	153.0	84	1957	---*	---
26 May 1992	91.0	85	1956	---*	---
26 Aug 1993	857.0	86	1955	---*	---
19 Jun 1994	101.0	87	1954	---*	---
24 Jul 1995	887.0	88	1933	---*	---
22 Jun 1996	2,520.0	89	1932	---*	---
12 Jun 1997	1,980.0	90	1931	---*	---
01 Jul 1998	1,200.0	91	1930	---*	---
01 Jul 1999	1,260.0	92	1929	---*	---
01 Jun 2000	1,030.0	93	1928	---*	---
17 May 2001	90.0	94	1927	---*	---
20 Jun 2002	92.0	95	1926	---*	---
12 Jun 2003	115.0	96	1925	---*	---
21 Jul 2004	82.0	97	1924	---*	---
25 Jul 2005	100.0	98	1923	---*	---
28 Jun 2006	183.0	99	1922	---*	---
03 Jul 2007	123.0	100	1921	---*	---
16 Jul 2008	173.0	101	1920	---*	---
02 May 2009	123.0	102	1919	---*	---
15 Jun 2010	125.0	103	1918	---*	---
25 Jun 2011	2,290.0	104	1917	---*	---
05 Jul 2012	176.0	105	1916	---*	---
01 May 2013	105.0	106	1915	---*	---
01 Aug 2014	716.0	107	1914	---*	---

18 Jun 2015	2,480.0	108	1913	---*	---
22 Jun 2016	1,190.0	109	1912	---*	---

* Outlier

* Low outlier plotting positions are computed using Median parameters.

<< Frequency Curve >>

Colorado River-GRANBY, CO-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Variance Log(EMA)	Percent Chance Exceedance	Confidence Limits 0.16 FLOW, CFS	Confidence Limits 0.84 FLOW, CFS
4,981.6	0.03882	0.200	12,740.3	3,729.0
4,557.4	0.02725	0.500	10,107.8	3,596.2
4,186.7	0.01911	1.000	8,284.0	3,452.1
3,767.7	0.01180	2.000	6,543.7	3,263.2
3,295.1	0.00577	4.000	4,848.3	3,014.5
2,578.3	0.00115	10.000	3,062.9	2,478.7
1,957.8	0.00230	20.000	2,064.9	1,534.1
1,010.5	0.02004	50.000	1,292.3	623.1
429.4	0.05884	80.000	642.6	174.7
252.6	0.08778	90.000	391.3	64.9
155.8	0.11635	95.000	244.7	32.3
56.1	0.18201	99.000	89.4	7.4

<< Systematic Statistics >>

Colorado River-GRANBY, CO-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	2.945	Historic Events	4
Standard Dev	0.406	High Outliers	0
Station Skew	-0.888	Low Outliers	56
Regional Skew	-0.180	Zero Events	0
Weighted Skew	---	Missing Events	30
Adopted Skew	-0.888	Systematic Events	75
		Historic Period	109

--- End of Analytical Frequency Curve ---

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Bulletin 17B Frequency Analysis
    12 Dec 2017   12:06 PM
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--- Input Data ---

Analysis Name: @HSS-Windy Gap - 17C
Description:

Data Set Name: HSS-Windy Gap Combined Data
DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4
HH2\HEC-SSP\Post\@HSS-Windy Gap Combo\HSS-Windy_Gap_Combo\HSS-Windy_Gap_Combo.dss
DSS Pathname: ////01jan1900/IR-CENTURY//

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4
HH2\HEC-SSP\Post\@HSS-Windy Gap
Combo\HSS-Windy_Gap_Combo\Bulletin17Results\@HSS-Windy_Gap_-_17C\@HSS-Windy_Gap_-_17
C.rpt
XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4
HH2\HEC-SSP\Post\@HSS-Windy Gap
Combo\HSS-Windy_Gap_Combo\Bulletin17Results\@HSS-Windy_Gap_-_17C\@HSS-Windy_Gap_-_17
C.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.16
Lower Confidence Level: 0.84
Use Low Outlier Threshold
Low Outlier Threshold: 500.0

Use non-standard frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 4.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 3 digits in fraction part of value

--- End of Input Data ---



<< EMA Representation of Data >>
HSS-Windy Gap Combined Data
---------------------------------------------------------------------------------
|                    |          Value           |         Threshold        |      |
```

Year	Peak	Low	High	Low	High	Type
1953	1,930.000	1,930.000	1,930.000	500.000	1.0E99	Syst
1954	358.000	1.0E-6	500.000	500.000	1.0E99	Syst
1955	485.000	1.0E-6	500.000	500.000	1.0E99	Syst
1956	2,220.000	2,220.000	2,220.000	500.000	1.0E99	Syst
1957	3,430.000	3,430.000	3,430.000	500.000	1.0E99	Syst
1958	2,830.000	2,830.000	2,830.000	500.000	1.0E99	Syst
1959	832.000	832.000	832.000	500.000	1.0E99	Syst
1960	1,220.000	1,220.000	1,220.000	500.000	1.0E99	Syst
1961	638.000	638.000	638.000	500.000	1.0E99	Syst
1962	2,720.000	2,720.000	2,720.000	500.000	1.0E99	Syst
1963	562.000	562.000	562.000	500.000	1.0E99	Syst
1964	768.000	768.000	768.000	500.000	1.0E99	Syst
1965	1,760.000	1,760.000	1,760.000	500.000	1.0E99	Syst
1966	424.000	1.0E-6	500.000	500.000	1.0E99	Syst
1967	876.000	876.000	876.000	500.000	1.0E99	Syst
1968	760.000	760.000	760.000	500.000	1.0E99	Syst
1969	1,510.000	1,510.000	1,510.000	500.000	1.0E99	Syst
1970	2,500.000	2,500.000	2,500.000	500.000	1.0E99	Syst
1971	2,880.000	2,880.000	2,880.000	500.000	1.0E99	Syst
1972	1,150.000	1,150.000	1,150.000	500.000	1.0E99	Syst
1973	2,200.000	2,200.000	2,200.000	500.000	1.0E99	Syst
1974	2,820.000	2,820.000	2,820.000	500.000	1.0E99	Syst
1975	970.000	970.000	970.000	500.000	1.0E99	Syst
1976	424.000	1.0E-6	500.000	500.000	1.0E99	Syst
1977	351.000	1.0E-6	500.000	500.000	1.0E99	Syst
1978	1,200.000	1,200.000	1,200.000	500.000	1.0E99	Syst
1979	1,580.000	1,580.000	1,580.000	500.000	1.0E99	Syst
1980	1,810.000	1,810.000	1,810.000	500.000	1.0E99	Syst
1981	595.000	595.000	595.000	500.000	1.0E99	Syst
1982	1,100.000	1,100.000	1,100.000	500.000	1.0E99	Syst
1983	4,620.000	4,620.000	4,620.000	500.000	1.0E99	Syst
1984	5,720.000	5,720.000	5,720.000	500.000	1.0E99	Syst
1985	1,890.000	1,890.000	1,890.000	500.000	1.0E99	Syst
1986	1,740.000	1,740.000	1,740.000	500.000	1.0E99	Syst
1987	983.000	983.000	983.000	500.000	1.0E99	Syst
1988	1,550.000	1,550.000	1,550.000	500.000	1.0E99	Syst
1989	393.000	1.0E-6	500.000	500.000	1.0E99	Syst
1990	474.000	1.0E-6	500.000	500.000	1.0E99	Syst
1991	873.000	873.000	873.000	500.000	1.0E99	Syst
1992	439.000	1.0E-6	500.000	500.000	1.0E99	Syst
1993	1,910.000	1,910.000	1,910.000	500.000	1.0E99	Syst
1994	795.000	795.000	795.000	500.000	1.0E99	Syst
1995	2,787.000	2,787.000	2,787.000	500.000	1.0E99	Syst
1996	4,800.000	4,800.000	4,800.000	500.000	1.0E99	Syst
1997	4,614.000	4,614.000	4,614.000	500.000	1.0E99	Syst
1998	1,497.000	1,497.000	1,497.000	500.000	1.0E99	Syst
1999	2,064.000	2,064.000	2,064.000	500.000	1.0E99	Syst
2000	2,405.000	2,405.000	2,405.000	500.000	1.0E99	Syst
2001	436.000	1.0E-6	500.000	500.000	1.0E99	Syst
2002	310.000	1.0E-6	500.000	500.000	1.0E99	Syst
2003	2,044.000	2,044.000	2,044.000	500.000	1.0E99	Syst
2004	436.000	1.0E-6	500.000	500.000	1.0E99	Syst
2005	997.000	997.000	997.000	500.000	1.0E99	Syst
2006	889.000	889.000	889.000	500.000	1.0E99	Syst
2007	951.000	951.000	951.000	500.000	1.0E99	Syst
2008	2,095.000	2,095.000	2,095.000	500.000	1.0E99	Syst
2009	1,590.000	1,590.000	1,590.000	500.000	1.0E99	Syst
2010	2,415.000	2,415.000	2,415.000	500.000	1.0E99	Syst
2011	5,264.000	5,264.000	5,264.000	500.000	1.0E99	Syst
2012	340.000	1.0E-6	500.000	500.000	1.0E99	Syst
2013	1,073.000	1,073.000	1,073.000	500.000	1.0E99	Syst

2014	3,613.000	3,613.000	3,613.000	500.000	1.0E99	Syst
2015	4,438.000	4,438.000	4,438.000	500.000	1.0E99	Syst
2016	2,549.000	2,549.000	2,549.000	500.000	1.0E99	Syst

Fitted log10 Moments	Mean	Variance	Std Dev	Skew
EMA at-site data w/o regional info	3.067765	0.198817	0.445889	-1.040198
EMA w/ regional info and B17b MSE(G)	3.067765	0.198817	0.445889	-1.040198
EMA w/ regional info and specified MSE(G)	3.067765	0.198817	0.445889	-1.040198

EMA Estimate of MSE[G at-site]	0.081461
MSE[G at-site systematic]	0.178765
Effective Record Length [G at-site]	140.447865
Grubbs-Beck Critical Value	500.000000

--- Final Results ---

<< Plotting Positions >>
HSS-Windy Gap Combined Data

Events Analyzed		Ordered Events			
Day Mon Year	FLOW CFS	Rank	Water Year	FLOW CFS	H-S Plot Pos
20 Jun 1953	1,930.000	1	1984	5,720.000	1.53
23 May 1954	358.000	2	2011	5,264.000	3.07
16 May 1955	485.000	3	1996	4,800.000	4.60
23 May 1956	2,220.000	4	1983	4,620.000	6.13
08 Jun 1957	3,430.000	5	1997	4,614.000	7.67
27 May 1958	2,830.000	6	2015	4,438.000	9.20
28 Jun 1959	832.000	7	2014	3,613.000	10.73
18 Jun 1960	1,220.000	8	1957	3,430.000	12.26
29 Sep 1961	638.000	9	1971	2,880.000	13.80
13 May 1962	2,720.000	10	1958	2,830.000	15.33
08 Apr 1963	562.000	11	1974	2,820.000	16.86
27 May 1964	768.000	12	1995	2,787.000	18.40
18 Jun 1965	1,760.000	13	1962	2,720.000	19.93
10 May 1966	424.000	14	2016	2,549.000	21.46
23 Jun 1967	876.000	15	1970	2,500.000	23.00
06 Jun 1968	760.000	16	2010	2,415.000	24.53
18 Jun 1969	1,510.000	17	2000	2,405.000	26.06
23 May 1970	2,500.000	18	1956	2,220.000	27.59
26 Jun 1971	2,880.000	19	1973	2,200.000	29.13
09 Jun 1972	1,150.000	20	2008	2,095.000	30.66
14 Jun 1973	2,200.000	21	1999	2,064.000	32.19
19 Jun 1974	2,820.000	22	2003	2,044.000	33.73
09 Jul 1975	970.000	23	1953	1,930.000	35.26
17 Jun 1976	424.000	24	1993	1,910.000	36.79
07 Jun 1977	351.000	25	1985	1,890.000	38.33

26 May 1978	1,200.000	26	1980	1,810.000	39.86
15 Jun 1979	1,580.000	27	1965	1,760.000	41.39
12 Jun 1980	1,810.000	28	1986	1,740.000	42.92
29 May 1981	595.000	29	2009	1,590.000	44.46
03 Jul 1982	1,100.000	30	1979	1,580.000	45.99
11 Jul 1983	4,620.000	31	1988	1,550.000	47.52
25 May 1984	5,720.000	32	1969	1,510.000	49.06
10 Jun 1985	1,890.000	33	1998	1,497.000	50.59
20 Jun 1986	1,740.000	34	1960	1,220.000	52.12
10 Jun 1987	983.000	35	1978	1,200.000	53.66
20 May 1988	1,550.000	36	1972	1,150.000	55.19
12 May 1989	393.000	37	1982	1,100.000	56.72
08 Jul 1990	474.000	38	2013	1,073.000	58.25
16 Jun 1991	873.000	39	2005	997.000	59.79
15 Jun 1992	439.000	40	1987	983.000	61.32
29 May 1993	1,910.000	41	1975	970.000	62.85
01 Jun 1994	795.000	42	2007	951.000	64.39
18 Jun 1995	2,787.000	43	2006	889.000	65.92
23 Jun 1996	4,800.000	44	1967	876.000	67.45
09 Jun 1997	4,614.000	45	1991	873.000	68.99
02 Jul 1998	1,497.000	46	1959	832.000	70.52
26 Jun 1999	2,064.000	47	1994	795.000	72.05
01 Jun 2000	2,405.000	48	1964	768.000	73.58
13 Jul 2001	436.000	49	1968	760.000	75.12
05 Jun 2002	310.000	50	1961	638.000	76.65
30 May 2003	2,044.000	51	1981	595.000	78.18
30 Jun 2004	436.000	52	1963	562.000	79.72
20 Jun 2005	997.000	53	1955	485.000*	81.83
14 Apr 2006	889.000	54	1990	474.000*	83.39
18 Jun 2007	951.000	55	1992	439.000*	84.94
22 May 2008	2,095.000	56	2004	436.000*	86.49
27 Jun 2009	1,590.000	57	2001	436.000*	88.04
08 Jun 2010	2,415.000	58	1976	424.000*	89.60
25 Jun 2011	5,264.000	59	1966	424.000*	91.15
05 Jul 2012	340.000	60	1989	393.000*	92.70
16 May 2013	1,073.000	61	1954	358.000*	94.25
31 May 2014	3,613.000	62	1977	351.000*	95.81
14 Jun 2015	4,438.000	63	2012	340.000*	97.36
23 Jun 2016	2,549.000	64	2002	310.000*	98.91

* Outlier

* Low outlier plotting positions are computed using Median parameters.

<< Frequency Curve >>
HSS-Windy Gap Combined Data

Computed Curve FLOW, CFS	Variance Log(EMA)	Percent Chance Exceedance	Confidence Limits 0.16 FLOW, CFS	Confidence Limits 0.84 FLOW, CFS
6,701.342	0.00826	0.200	8,658.852	5,610.967
6,232.975	0.00591	0.500	7,690.483	5,344.615
5,798.646	0.00439	1.000	6,922.421	5,065.903
5,282.138	0.00318	2.000	6,122.064	4,695.774
4,670.023	0.00236	4.000	5,285.675	4,204.696
3,689.376	0.00198	10.000	4,104.678	3,329.538
2,798.358	0.00224	20.000	3,120.528	2,503.383
1,392.209	0.00350	50.000	1,589.644	1,203.679
539.681	0.00980	80.000	651.230	398.044
295.088	0.02066	90.000	382.672	186.165
168.957	0.03784	95.000	239.213	90.323

51.109	0.10482	99.000	91.207	18.211

<< Systematic Statistics >>
HSS-Windy Gap Combined Data

Log Transform: FLOW, CFS		Number of Events	
Mean	3.068	Historic Events	0
Standard Dev	0.446	High Outliers	0
Station Skew	-1.040	Low Outliers	12
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-1.040	Systematic Events	64

--- End of Analytical Frequency Curve ---

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Bulletin 17B Frequency Analysis
    27 Oct 2017   11:14 AM
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--- Input Data ---

Analysis Name: @Kremmling Post 17C
Description:

Data Set Name: Kremmling no Historical
DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4
HH2\HEC-SSP\Post\@Kremmling_no_Historical\Kremmling_no_Historical.dss
DSS Pathname: ////01jan1900/IR-CENTURY//

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4
HH2\HEC-SSP\Post\@Kremmling_no_Historical\Bulletin17Results\@Kremmling_Post_17C\@Kre
mmling_Post_17C.rpt
XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4
HH2\HEC-SSP\Post\@Kremmling_no_Historical\Bulletin17Results\@Kremmling_Post_17C\@Kre
mmling_Post_17C.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -0.28
Regional Skew MSE: 0.302

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.16
Lower Confidence Level: 0.84
Use Low Outlier Threshold
Low Outlier Threshold: 1875.0

Use non-standard frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 4.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 3 digits in fraction part of value

--- End of Input Data ---



<< EMA Representation of Data >>
Kremmling no Historical
```

Year	Peak	Value Low	Value High	Threshold Low	Threshold High	Type

1962	6,310.000	6,310.000	6,310.000	1,875.000	1.0E99	Syst
1963	1,860.000	1.0E-6	1,875.000	1,875.000	1.0E99	Syst
1964	1,630.000	1.0E-6	1,875.000	1,875.000	1.0E99	Syst
1965	3,100.000	3,100.000	3,100.000	1,875.000	1.0E99	Syst
1966	1,700.000	1.0E-6	1,875.000	1,875.000	1.0E99	Syst
1967	1,890.000	1,890.000	1,890.000	1,875.000	1.0E99	Syst
1968	2,050.000	2,050.000	2,050.000	1,875.000	1.0E99	Syst
1969	3,540.000	3,540.000	3,540.000	1,875.000	1.0E99	Syst
1970	6,220.000	6,220.000	6,220.000	1,875.000	1.0E99	Syst
1971	---	1.0E-99	10,100.000	10,100.000	1.0E99	Cens
1972	2,910.000	2,910.000	2,910.000	1,875.000	1.0E99	Syst
1973	4,370.000	4,370.000	4,370.000	1,875.000	1.0E99	Syst
1974	4,960.000	4,960.000	4,960.000	1,875.000	1.0E99	Syst
1975	2,940.000	2,940.000	2,940.000	1,875.000	1.0E99	Syst
1976	1,840.000	1.0E-6	1,875.000	1,875.000	1.0E99	Syst
1977	1,240.000	1.0E-6	1,875.000	1,875.000	1.0E99	Syst
1978	3,100.000	3,100.000	3,100.000	1,875.000	1.0E99	Syst
1979	4,120.000	4,120.000	4,120.000	1,875.000	1.0E99	Syst
1980	4,200.000	4,200.000	4,200.000	1,875.000	1.0E99	Syst
1981	1,110.000	1.0E-6	1,875.000	1,875.000	1.0E99	Syst
1982	2,080.000	2,080.000	2,080.000	1,875.000	1.0E99	Syst
1983	10,100.000	10,100.000	10,100.000	1,875.000	1.0E99	Syst
1984	13,600.000	13,600.000	13,600.000	1,875.000	1.0E99	Syst
1985	3,620.000	3,620.000	3,620.000	1,875.000	1.0E99	Syst
1986	4,530.000	4,530.000	4,530.000	1,875.000	1.0E99	Syst
1987	1,940.000	1,940.000	1,940.000	1,875.000	1.0E99	Syst
1988	3,280.000	3,280.000	3,280.000	1,875.000	1.0E99	Syst
1989	1,530.000	1.0E-6	1,875.000	1,875.000	1.0E99	Syst
1990	1,490.000	1.0E-6	1,875.000	1,875.000	1.0E99	Syst
1991	2,180.000	2,180.000	2,180.000	1,875.000	1.0E99	Syst
1992	1,250.000	1.0E-6	1,875.000	1,875.000	1.0E99	Syst
1993	4,190.000	4,190.000	4,190.000	1,875.000	1.0E99	Syst
1994	1,630.000	1.0E-6	1,875.000	1,875.000	1.0E99	Syst
1995	7,080.000	7,080.000	7,080.000	1,875.000	1.0E99	Syst
1996	8,450.000	8,450.000	8,450.000	1,875.000	1.0E99	Syst
1997	8,340.000	8,340.000	8,340.000	1,875.000	1.0E99	Syst
1998	3,270.000	3,270.000	3,270.000	1,875.000	1.0E99	Syst
1999	4,170.000	4,170.000	4,170.000	1,875.000	1.0E99	Syst
2000	3,110.000	3,110.000	3,110.000	1,875.000	1.0E99	Syst
2001	1,530.000	1.0E-6	1,875.000	1,875.000	1.0E99	Syst
2002	991.000	1.0E-6	1,875.000	1,875.000	1.0E99	Syst
2003	2,620.000	2,620.000	2,620.000	1,875.000	1.0E99	Syst
2004	1,260.000	1.0E-6	1,875.000	1,875.000	1.0E99	Syst
2005	2,600.000	2,600.000	2,600.000	1,875.000	1.0E99	Syst
2006	2,760.000	2,760.000	2,760.000	1,875.000	1.0E99	Syst
2007	4,140.000	4,140.000	4,140.000	1,875.000	1.0E99	Syst
2008	6,230.000	6,230.000	6,230.000	1,875.000	1.0E99	Syst
2009	5,380.000	5,380.000	5,380.000	1,875.000	1.0E99	Syst
2010	6,080.000	6,080.000	6,080.000	1,875.000	1.0E99	Syst
2011	9,540.000	9,540.000	9,540.000	1,875.000	1.0E99	Syst
2012	1,280.000	1.0E-6	1,875.000	1,875.000	1.0E99	Syst
2013	1,750.000	1.0E-6	1,875.000	1,875.000	1.0E99	Syst
2014	7,830.000	7,830.000	7,830.000	1,875.000	1.0E99	Syst
2015	7,860.000	7,860.000	7,860.000	1,875.000	1.0E99	Syst
2016	4,830.000	4,830.000	4,830.000	1,875.000	1.0E99	Syst

Fitted log10 Moments	Mean	Variance	Std Dev	Skew

EMA at-site data w/o regional info	3.458428	0.126801	0.356092	-0.549630
EMA w/ regional info and B17b MSE(G)	3.458428	0.126801	0.356092	-0.549630
EMA w/ regional info and specified MSE(G)	3.458428	0.126801	0.356092	-0.549630

EMA Estimate of MSE[G at-site]	0.110921
MSE[G at-site systematic]	0.134953
Effective Record Length [G at-site]	65.699441
Grubbs-Beck Critical Value	1,875.000000

--- Final Results ---

<< Plotting Positions >>
Kremmling no Historical

Events Analyzed				Ordered Events			
Day	Mon	Year	FLOW CFS	Rank	Water Year	FLOW CFS	H-S Plot Pos
13	May	1962	6,310.000	1	1984	13,600.000	1.21
02	Nov	1962	1,860.000	2	1983	10,100.000	2.42
22	May	1964	1,630.000	3	2011	9,540.000	5.44
24	May	1965	3,100.000	4	1996	8,450.000	7.25
04	Apr	1966	1,700.000	5	1997	8,340.000	9.05
10	Apr	1967	1,890.000	6	2015	7,860.000	10.85
07	Jun	1968	2,050.000	7	2014	7,830.000	12.66
25	Jun	1969	3,540.000	8	1995	7,080.000	14.46
23	May	1970	6,220.000	9	1962	6,310.000	16.27
01	Jan	1971	---	10	2008	6,230.000	18.07
10	Jun	1972	2,910.000	11	1970	6,220.000	19.88
15	Jun	1973	4,370.000	12	2010	6,080.000	21.68
11	May	1974	4,960.000	13	2009	5,380.000	23.48
10	Jun	1975	2,940.000	14	1974	4,960.000	25.29
23	May	1976	1,840.000	15	2016	4,830.000	27.09
23	Jul	1977	1,240.000	16	1986	4,530.000	28.90
25	May	1978	3,100.000	17	1973	4,370.000	30.70
30	May	1979	4,120.000	18	1980	4,200.000	32.51
25	May	1980	4,200.000	19	1993	4,190.000	34.31
30	May	1981	1,110.000	20	1999	4,170.000	36.12
03	Jul	1982	2,080.000	21	2007	4,140.000	37.92
12	Jul	1983	10,100.000	22	1979	4,120.000	39.72
26	May	1984	13,600.000	23	1985	3,620.000	41.53
11	May	1985	3,620.000	24	1969	3,540.000	43.33
09	Jun	1986	4,530.000	25	1988	3,280.000	45.14
10	Jun	1987	1,940.000	26	1998	3,270.000	46.94
20	May	1988	3,280.000	27	2000	3,110.000	48.75
25	Apr	1989	1,530.000	28	1978	3,100.000	50.55
04	Sep	1990	1,490.000	29	1965	3,100.000	52.35
07	Jun	1991	2,180.000	30	1975	2,940.000	54.16
01	May	1992	1,250.000	31	1972	2,910.000	55.96
30	May	1993	4,190.000	32	2006	2,760.000	57.77
21	May	1994	1,630.000	33	2003	2,620.000	59.57
13	Jul	1995	7,080.000	34	2005	2,600.000	61.38
23	Jun	1996	8,450.000	35	1991	2,180.000	63.18
12	Jun	1997	8,340.000	36	1982	2,080.000	64.99

31 May 1998	3,270.000	37	1968	2,050.000	66.79
05 Jun 1999	4,170.000	38	1987	1,940.000	68.59
01 Jun 2000	3,110.000	39	1967	1,890.000	70.40
31 Aug 2001	1,530.000	40	1963	1,860.000*	72.98
01 Oct 2001	991.000	41	1976	1,840.000*	74.82
01 Jun 2003	2,620.000	42	2013	1,750.000*	76.65
06 Oct 2003	1,260.000	43	1966	1,700.000*	78.49
28 Jun 2005	2,600.000	44	1994	1,630.000*	80.33
22 May 2006	2,760.000	45	1964	1,630.000*	82.17
18 Jun 2007	4,140.000	46	2001	1,530.000*	84.01
23 May 2008	6,230.000	47	1989	1,530.000*	85.85
27 Jun 2009	5,380.000	48	1990	1,490.000*	87.68
13 Jun 2010	6,080.000	49	2012	1,280.000*	89.52
26 Jun 2011	9,540.000	50	2004	1,260.000*	91.36
06 Oct 2011	1,280.000	51	1992	1,250.000*	93.20
18 May 2013	1,750.000	52	1977	1,240.000*	95.04
31 May 2014	7,830.000	53	1981	1,110.000*	96.87
19 Jun 2015	7,860.000	54	2002	991.000*	98.71
09 Jun 2016	4,830.000	55	1971	---*	---

* Outlier

* Low outlier plotting positions are computed using Median parameters.

<< Frequency Curve >>
Kremmling no Historical

Computed Curve FLOW, CFS	Variance Log(EMA)	Percent Chance Exceedance	Confidence Limits 0.16 FLOW, CFS	0.84
17,829.190	0.01160	0.200	24,347.689	14,479.484
15,591.515	0.00833	0.500	20,165.877	13,018.427
13,845.926	0.00635	1.000	17,249.226	11,789.222
12,056.787	0.00481	2.000	14,524.851	10,445.137
10,225.578	0.00367	4.000	11,970.256	8,984.061
7,739.827	0.00274	10.000	8,805.254	6,887.091
5,802.057	0.00239	20.000	6,518.128	5,191.272
3,096.693	0.00279	50.000	3,477.780	2,697.504
1,486.366	0.00799	80.000	1,742.537	1,096.253
968.917	0.01606	90.000	1,206.225	626.639
664.595	0.02787	95.000	887.393	377.563
308.855	0.07015	99.000	492.611	129.800

<< Systematic Statistics >>
Kremmling no Historical

Log Transform: FLOW, CFS		Number of Events	
Mean	3.458	Historic Events	0
Standard Dev	0.356	High Outliers	0
Station Skew	-0.550	Low Outliers	15
Regional Skew	-0.280	Zero Events	0
Weighted Skew	---	Missing Events	1
Adopted Skew	-0.550	Systematic Events	54
		Historic Period	55

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis
27 Oct 2017 11:11 AM

--- Input Data ---

Analysis Name: @Dotsero Post 1968 - 17C
Description:

Data Set Name: Dotsero Post 1968
DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH2\HEC-SSP\Post\@Dotsero_Post_68\Dotsero_Post_68.dss
DSS Pathname: ////01jan1900/IR-CENTURY//

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH2\HEC-SSP\Post\@Dotsero_Post_68\Bulletin17Results\@Dotsero_Post_1968_-_17C\@Dotsero_Post_1968_-_17C.rpt
XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH2\HEC-SSP\Post\@Dotsero_Post_68\Bulletin17Results\@Dotsero_Post_1968_-_17C\@Dotsero_Post_1968_-_17C.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.16
Lower Confidence Level: 0.84

Use non-standard frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 4.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 3 digits in fraction part of value

--- End of Input Data ---

<< EMA Representation of Data >>
Dotsero Post 1968

		Value		Threshold		
Year	Peak	Low	High	Low	High	Type
1968	9,270.000	9,270.000	9,270.000	4,400.000	1.0E99	Syst
1969	6,730.000	6,730.000	6,730.000	4,400.000	1.0E99	Syst

1970	13,900.000	13,900.000	13,900.000	4,400.000	1.0E99	Syst
1971	10,300.000	10,300.000	10,300.000	4,400.000	1.0E99	Syst
1972	8,420.000	8,420.000	8,420.000	4,400.000	1.0E99	Syst
1973	11,300.000	11,300.000	11,300.000	4,400.000	1.0E99	Syst
1974	11,200.000	11,200.000	11,200.000	4,400.000	1.0E99	Syst
1975	9,410.000	9,410.000	9,410.000	4,400.000	1.0E99	Syst
1976	7,310.000	7,310.000	7,310.000	4,400.000	1.0E99	Syst
1977	2,800.000	1.0E-6	4,400.000	4,400.000	1.0E99	Syst
1978	11,600.000	11,600.000	11,600.000	4,400.000	1.0E99	Syst
1979	11,800.000	11,800.000	11,800.000	4,400.000	1.0E99	Syst
1980	10,700.000	10,700.000	10,700.000	4,400.000	1.0E99	Syst
1981	4,900.000	4,900.000	4,900.000	4,400.000	1.0E99	Syst
1982	6,820.000	6,820.000	6,820.000	4,400.000	1.0E99	Syst
1983	17,700.000	17,700.000	17,700.000	4,400.000	1.0E99	Syst
1984	22,200.000	22,200.000	22,200.000	4,400.000	1.0E99	Syst
1985	11,600.000	11,600.000	11,600.000	4,400.000	1.0E99	Syst
1986	11,100.000	11,100.000	11,100.000	4,400.000	1.0E99	Syst
1987	5,840.000	5,840.000	5,840.000	4,400.000	1.0E99	Syst
1988	6,300.000	6,300.000	6,300.000	4,400.000	1.0E99	Syst
1989	4,420.000	4,420.000	4,420.000	4,400.000	1.0E99	Syst
1990	5,060.000	5,060.000	5,060.000	4,400.000	1.0E99	Syst
1991	7,200.000	7,200.000	7,200.000	4,400.000	1.0E99	Syst
1992	3,700.000	1.0E-6	4,400.000	4,400.000	1.0E99	Syst
1993	11,500.000	11,500.000	11,500.000	4,400.000	1.0E99	Syst
1994	4,630.000	4,630.000	4,630.000	4,400.000	1.0E99	Syst
1995	15,400.000	15,400.000	15,400.000	4,400.000	1.0E99	Syst
1996	13,800.000	13,800.000	13,800.000	4,400.000	1.0E99	Syst
1997	16,100.000	16,100.000	16,100.000	4,400.000	1.0E99	Syst
1998	7,550.000	7,550.000	7,550.000	4,400.000	1.0E99	Syst
1999	8,310.000	8,310.000	8,310.000	4,400.000	1.0E99	Syst
2000	8,790.000	8,790.000	8,790.000	4,400.000	1.0E99	Syst
2001	4,400.000	4,400.000	4,400.000	4,400.000	1.0E99	Syst
2002	2,020.000	1.0E-6	4,400.000	4,400.000	1.0E99	Syst
2003	11,700.000	11,700.000	11,700.000	4,400.000	1.0E99	Syst
2004	3,240.000	1.0E-6	4,400.000	4,400.000	1.0E99	Syst
2005	7,390.000	7,390.000	7,390.000	4,400.000	1.0E99	Syst
2006	9,600.000	9,600.000	9,600.000	4,400.000	1.0E99	Syst
2007	6,720.000	6,720.000	6,720.000	4,400.000	1.0E99	Syst
2008	13,000.000	13,000.000	13,000.000	4,400.000	1.0E99	Syst
2009	10,400.000	10,400.000	10,400.000	4,400.000	1.0E99	Syst
2010	14,600.000	14,600.000	14,600.000	4,400.000	1.0E99	Syst
2011	18,500.000	18,500.000	18,500.000	4,400.000	1.0E99	Syst
2012	5,020.000	5,020.000	5,020.000	4,400.000	1.0E99	Syst
2013	5,990.000	5,990.000	5,990.000	4,400.000	1.0E99	Syst
2014	17,200.000	17,200.000	17,200.000	4,400.000	1.0E99	Syst
2015	13,000.000	13,000.000	13,000.000	4,400.000	1.0E99	Syst
2016	11,700.000	11,700.000	11,700.000	4,400.000	1.0E99	Syst

Fitted log10 Moments	Mean	Variance	Std Dev	Skew
EMA at-site data w/o regional info	3.936345	0.047296	0.217476	-0.495669
EMA w/ regional info and B17b MSE(G)	3.936345	0.047296	0.217476	-0.495669
EMA w/ regional info and specified MSE(G)	3.936345	0.047296	0.217476	-0.495669

EMA Estimate of MSE[G at-site] 0.141194
MSE[G at-site systematic] 0.141194
Effective Record Length [G at-site] 49.000000
Grubbs-Beck Critical Value 4,400.000000

--- Final Results ---

<< Plotting Positions >>
Dotsero Post 1968

Events Analyzed				Ordered Events			
Day	Mon	Year	FLOW CFS	Rank	Water Year	FLOW CFS	H-S Plot Pos
06	Jun	1968	9,270.000	1	1984	22,200.000	2.00
25	Jun	1969	6,730.000	2	2011	18,500.000	3.99
22	May	1970	13,900.000	3	1983	17,700.000	5.99
25	Jun	1971	10,300.000	4	2014	17,200.000	7.99
07	Jun	1972	8,420.000	5	1997	16,100.000	9.98
15	Jun	1973	11,300.000	6	1995	15,400.000	11.98
10	May	1974	11,200.000	7	2010	14,600.000	13.98
09	Jun	1975	9,410.000	8	1970	13,900.000	15.97
12	Jul	1976	7,310.000	9	1996	13,800.000	17.97
07	Jun	1977	2,800.000	10	2015	13,000.000	19.96
16	Jun	1978	11,600.000	11	2008	13,000.000	21.96
29	May	1979	11,800.000	12	1979	11,800.000	23.96
12	Jun	1980	10,700.000	13	2016	11,700.000	25.95
09	Jun	1981	4,900.000	14	2003	11,700.000	27.95
29	Jun	1982	6,820.000	15	1985	11,600.000	29.95
27	Jun	1983	17,700.000	16	1978	11,600.000	31.94
25	May	1984	22,200.000	17	1993	11,500.000	33.94
09	Jun	1985	11,600.000	18	1973	11,300.000	35.94
07	Jun	1986	11,100.000	19	1974	11,200.000	37.93
17	May	1987	5,840.000	20	1986	11,100.000	39.93
07	Jun	1988	6,300.000	21	1980	10,700.000	41.93
24	May	1989	4,420.000	22	2009	10,400.000	43.92
08	Jun	1990	5,060.000	23	1971	10,300.000	45.92
15	Jun	1991	7,200.000	24	2006	9,600.000	47.91
27	May	1992	3,700.000	25	1975	9,410.000	49.91
29	May	1993	11,500.000	26	1968	9,270.000	51.91
02	Jun	1994	4,630.000	27	2000	8,790.000	53.90
18	Jun	1995	15,400.000	28	1972	8,420.000	55.90
20	May	1996	13,800.000	29	1999	8,310.000	57.90
04	Jun	1997	16,100.000	30	1998	7,550.000	59.89
02	Jun	1998	7,550.000	31	2005	7,390.000	61.89
09	Jun	1999	8,310.000	32	1976	7,310.000	63.89
30	May	2000	8,790.000	33	1991	7,200.000	65.88
20	May	2001	4,400.000	34	1982	6,820.000	67.88
01	Jun	2002	2,020.000	35	1969	6,730.000	69.88
02	Jun	2003	11,700.000	36	2007	6,720.000	71.87
08	Jun	2004	3,240.000	37	1988	6,300.000	73.87
24	May	2005	7,390.000	38	2013	5,990.000	75.87
23	May	2006	9,600.000	39	1987	5,840.000	77.86
19	Jun	2007	6,720.000	40	1990	5,060.000	79.86
22	May	2008	13,000.000	41	2012	5,020.000	81.85
21	May	2009	10,400.000	42	1981	4,900.000	83.85
08	Jun	2010	14,600.000	43	1994	4,630.000	85.85
07	Jun	2011	18,500.000	44	1989	4,420.000	87.84

24 Jul 2012	5,020.000	45	2001	4,400.000	89.84
18 May 2013	5,990.000	46	1992	3,700.000*	92.51
01 Jun 2014	17,200.000	47	2004	3,240.000*	94.53
18 Jun 2015	13,000.000	48	1977	2,800.000*	96.56
10 Jun 2016	11,700.000	49	2002	2,020.000*	98.58

* Outlier

* Low outlier plotting positions are computed using Median parameters.

<< Frequency Curve >>

Dotsero Post 1968

Computed Curve FLOW, CFS	Variance Log(EMA)	Percent Chance Exceedance	Confidence Limits 0.16 FLOW, CFS	0.84
27,161.528	0.00669	0.200	34,495.885	23,231.437
24,871.791	0.00460	0.500	30,237.550	21,805.005
23,022.495	0.00333	1.000	27,129.247	20,546.013
21,055.632	0.00234	2.000	24,100.523	19,093.102
18,948.739	0.00163	4.000	21,129.638	17,402.405
15,884.700	0.00112	10.000	17,256.275	14,729.287
13,261.995	0.00101	20.000	14,284.161	12,323.927
9,000.035	0.00111	50.000	9,715.613	8,322.855
5,760.793	0.00190	80.000	6,304.423	5,106.769
4,453.074	0.00341	90.000	4,976.847	3,727.812
3,553.864	0.00588	95.000	4,088.119	2,786.165
2,253.844	0.01578	99.000	2,816.525	1,497.845

<< Systematic Statistics >>

Dotsero Post 1968

Log Transform: FLOW, CFS		Number of Events	
Mean	3.936	Historic Events	0
Standard Dev	0.217	High Outliers	0
Station Skew	-0.496	Low Outliers	4
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-0.496	Systematic Events	49

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis
27 Oct 2017 10:52 AM

--- Input Data ---

Analysis Name: @At Glenwood - 17C
Description:

Data Set Name: Colorado River-GLENWOOD SPRINGS, CO.-FLOW-ANNUAL PEAK
DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss
DSS Pathname: /COLORADO RIVER/GLENWOOD SPRINGS, CO./FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@At_Glenwood_-_17C\@At_Glenwood_-_17C.rpt
XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@At_Glenwood_-_17C\@At_Glenwood_-_17C.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -0.1
Regional Skew MSE: 0.302

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.16
Lower Confidence Level: 0.84

Use non-standard frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 4.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

<< EMA Representation of Data >>
Colorado River-GLENWOOD SPRINGS, CO.-FLOW-ANNUAL PEAK

		Value		Threshold		
Year	Peak	Low	High	Low	High	Type
1900	20,000.0	20,000.0	20,000.0	7,580.0	1.0E99	Syst

1901	20,000.0	20,000.0	20,000.0	7,580.0	1.0E99	Syst
1902	12,000.0	12,000.0	12,000.0	7,580.0	1.0E99	Syst
1903	16,500.0	16,500.0	16,500.0	7,580.0	1.0E99	Syst
1904	16,500.0	16,500.0	16,500.0	7,580.0	1.0E99	Syst
1905	22,500.0	22,500.0	22,500.0	7,580.0	1.0E99	Syst
1906	22,100.0	22,100.0	22,100.0	7,580.0	1.0E99	Syst
1907	20,400.0	20,400.0	20,400.0	7,580.0	1.0E99	Syst
1908	11,500.0	11,500.0	11,500.0	7,580.0	1.0E99	Syst
1909	27,900.0	27,900.0	27,900.0	7,580.0	1.0E99	Syst
1910	14,600.0	14,600.0	14,600.0	7,580.0	1.0E99	Syst
1911	15,200.0	15,200.0	15,200.0	7,580.0	1.0E99	Syst
1912	27,700.0	27,700.0	27,700.0	7,580.0	1.0E99	Syst
1913	12,400.0	12,400.0	12,400.0	7,580.0	1.0E99	Syst
1914	28,100.0	28,100.0	28,100.0	7,580.0	1.0E99	Syst
1915	13,400.0	13,400.0	13,400.0	7,580.0	1.0E99	Syst
1916	14,800.0	14,800.0	14,800.0	7,580.0	1.0E99	Syst
1917	29,400.0	29,400.0	29,400.0	7,580.0	1.0E99	Syst
1918	30,100.0	30,100.0	30,100.0	7,580.0	1.0E99	Syst
1919	12,300.0	12,300.0	12,300.0	7,580.0	1.0E99	Syst
1920	24,300.0	24,300.0	24,300.0	7,580.0	1.0E99	Syst
1921	29,000.0	29,000.0	29,000.0	7,580.0	1.0E99	Syst
1922	16,100.0	16,100.0	16,100.0	7,580.0	1.0E99	Syst
1923	20,400.0	20,400.0	20,400.0	7,580.0	1.0E99	Syst
1924	24,500.0	24,500.0	24,500.0	7,580.0	1.0E99	Syst
1925	11,200.0	11,200.0	11,200.0	7,580.0	1.0E99	Syst
1926	23,000.0	17,250.0	28,750.0	7,580.0	1.0E99	Syst
1927	18,400.0	18,400.0	18,400.0	7,580.0	1.0E99	Syst
1928	27,400.0	27,400.0	27,400.0	7,580.0	1.0E99	Syst
1929	21,400.0	21,400.0	21,400.0	7,580.0	1.0E99	Syst
1930	15,500.0	15,500.0	15,500.0	7,580.0	1.0E99	Syst
1931	9,710.0	9,710.0	9,710.0	7,580.0	1.0E99	Syst
1932	17,300.0	17,300.0	17,300.0	7,580.0	1.0E99	Syst
1933	20,600.0	20,600.0	20,600.0	7,580.0	1.0E99	Syst
1934	8,140.0	8,140.0	8,140.0	7,580.0	1.0E99	Syst
1935	21,300.0	21,300.0	21,300.0	7,580.0	1.0E99	Syst
1936	16,900.0	16,900.0	16,900.0	7,580.0	1.0E99	Syst
1937	11,400.0	11,400.0	11,400.0	7,580.0	1.0E99	Syst
1938	20,900.0	20,900.0	20,900.0	7,580.0	1.0E99	Syst
1939	13,100.0	13,100.0	13,100.0	7,580.0	1.0E99	Syst
1940	11,100.0	11,100.0	11,100.0	7,580.0	1.0E99	Syst
1941	14,900.0	14,900.0	14,900.0	7,580.0	1.0E99	Syst
1942	16,800.0	16,800.0	16,800.0	7,580.0	1.0E99	Syst
1943	13,000.0	13,000.0	13,000.0	7,580.0	1.0E99	Syst
1944	10,600.0	10,600.0	10,600.0	7,580.0	1.0E99	Syst
1945	10,600.0	10,600.0	10,600.0	7,580.0	1.0E99	Syst
1946	9,720.0	9,720.0	9,720.0	7,580.0	1.0E99	Syst
1947	14,200.0	14,200.0	14,200.0	7,580.0	1.0E99	Syst
1948	16,600.0	16,600.0	16,600.0	7,580.0	1.0E99	Syst
1949	16,300.0	16,300.0	16,300.0	7,580.0	1.0E99	Syst
1950	10,100.0	10,100.0	10,100.0	7,580.0	1.0E99	Syst
1951	14,400.0	14,400.0	14,400.0	7,580.0	1.0E99	Syst
1952	20,800.0	20,800.0	20,800.0	7,580.0	1.0E99	Syst
1953	14,000.0	14,000.0	14,000.0	7,580.0	1.0E99	Syst
1954	4,060.0	1.0E-6	7,580.0	7,580.0	1.0E99	Syst
1955	5,400.0	1.0E-6	7,580.0	7,580.0	1.0E99	Syst
1956	12,600.0	12,600.0	12,600.0	7,580.0	1.0E99	Syst
1957	18,900.0	18,900.0	18,900.0	7,580.0	1.0E99	Syst
1958	16,000.0	16,000.0	16,000.0	7,580.0	1.0E99	Syst
1959	8,480.0	8,480.0	8,480.0	7,580.0	1.0E99	Syst
1960	9,730.0	9,730.0	9,730.0	7,580.0	1.0E99	Syst
1961	7,680.0	7,680.0	7,680.0	7,580.0	1.0E99	Syst
1962	14,600.0	14,600.0	14,600.0	7,580.0	1.0E99	Syst
1963	5,470.0	1.0E-6	7,580.0	7,580.0	1.0E99	Syst

1964	7,580.0	7,580.0	7,580.0	7,580.0	1.0E99	Syst
1965	11,900.0	11,900.0	11,900.0	7,580.0	1.0E99	Syst
1966	4,840.0	1.0E-6	7,580.0	7,580.0	1.0E99	Syst

Fitted log10 Moments	Mean	Variance	Std Dev	Skew
EMA at-site data w/o regional info	4.172554	0.033272	0.182406	-0.473282
EMA w/ regional info and B17b MSE(G)	4.172554	0.033272	0.182406	-0.473282
EMA w/ regional info and specified MSE(G)	4.172554	0.033272	0.182406	-0.473282

EMA Estimate of MSE[G at-site]	0.107896
MSE[G at-site systematic]	0.109229
Effective Record Length [G at-site]	66.815820
Grubbs-Beck Critical Value	7,580.000000

--- Final Results ---

<< Plotting Positions >>
Colorado River-GLENWOOD SPRINGS, CO.-FLOW-ANNUAL PEAK

Events Analyzed				Ordered Events			
Day	Mon	Year	FLOW CFS	Rank	Water Year	FLOW CFS	H-S Plot Pos
30	May	1900	20,000.0	1	1918	30,100.0	1.47
22	May	1901	20,000.0	2	1917	29,400.0	2.94
16	May	1902	12,000.0	3	1921	29,000.0	4.41
18	Jun	1903	16,500.0	4	1914	28,100.0	5.88
25	May	1904	16,500.0	5	1909	27,900.0	7.35
06	Jun	1905	22,500.0	6	1912	27,700.0	8.82
14	Jun	1906	22,100.0	7	1928	27,400.0	10.28
17	Jun	1907	20,400.0	8	1924	24,500.0	11.75
12	Jun	1908	11,500.0	9	1920	24,300.0	13.22
21	Jun	1909	27,900.0	10	1926	23,000.0	16.16
01	Jun	1910	14,600.0	11	1905	22,500.0	14.69
09	Jun	1911	15,200.0	12	1906	22,100.0	17.63
09	Jun	1912	27,700.0	13	1929	21,400.0	19.10
01	Jun	1913	12,400.0	14	1935	21,300.0	20.57
03	Jun	1914	28,100.0	15	1938	20,900.0	22.04
21	Jun	1915	13,400.0	16	1952	20,800.0	23.51
14	Jun	1916	14,800.0	17	1933	20,600.0	24.98
19	Jun	1917	29,400.0	18	1923	20,400.0	26.45
14	Jun	1918	30,100.0	19	1907	20,400.0	27.92
29	May	1919	12,300.0	20	1901	20,000.0	29.38
01	Jun	1920	24,300.0	21	1900	20,000.0	30.85
15	Jun	1921	29,000.0	22	1957	18,900.0	32.32
10	Jun	1922	16,100.0	23	1927	18,400.0	33.79
17	Jun	1923	20,400.0	24	1932	17,300.0	35.26
15	Jun	1924	24,500.0	25	1936	16,900.0	36.73

31 May 1925	11,200.0	26	1942	16,800.0	38.20
07 Jun 1926	23,000.0	27	1948	16,600.0	39.67
22 May 1927	18,400.0	28	1904	16,500.0	41.14
31 May 1928	27,400.0	29	1903	16,500.0	42.61
10 Jun 1929	21,400.0	30	1949	16,300.0	44.08
01 Jun 1930	15,500.0	31	1922	16,100.0	45.55
08 Jun 1931	9,710.0	32	1958	16,000.0	47.01
24 May 1932	17,300.0	33	1930	15,500.0	48.48
13 Jun 1933	20,600.0	34	1911	15,200.0	49.95
13 May 1934	8,140.0	35	1941	14,900.0	51.42
16 Jun 1935	21,300.0	36	1916	14,800.0	52.89
01 Jun 1936	16,900.0	37	1962	14,600.0	54.36
17 May 1937	11,400.0	38	1910	14,600.0	55.83
06 Jun 1938	20,900.0	39	1951	14,400.0	57.30
23 May 1939	13,100.0	40	1947	14,200.0	58.77
03 Jun 1940	11,100.0	41	1953	14,000.0	60.24
15 May 1941	14,900.0	42	1915	13,400.0	61.71
28 May 1942	16,800.0	43	1939	13,100.0	63.18
02 Jun 1943	13,000.0	44	1943	13,000.0	64.65
02 Jun 1944	10,600.0	45	1956	12,600.0	66.11
29 May 1945	10,600.0	46	1913	12,400.0	67.58
09 Jun 1946	9,720.0	47	1919	12,300.0	69.05
21 Jun 1947	14,200.0	48	1902	12,000.0	70.52
22 May 1948	16,600.0	49	1965	11,900.0	71.99
18 Jun 1949	16,300.0	50	1908	11,500.0	73.46
13 Jun 1950	10,100.0	51	1937	11,400.0	74.93
21 Jun 1951	14,400.0	52	1925	11,200.0	76.40
08 Jun 1952	20,800.0	53	1940	11,100.0	77.87
14 Jun 1953	14,000.0	54	1945	10,600.0	79.34
22 May 1954	4,060.0	55	1944	10,600.0	80.81
24 May 1955	5,400.0	56	1950	10,100.0	82.28
24 May 1956	12,600.0	57	1960	9,730.0	83.75
08 Jun 1957	18,900.0	58	1946	9,720.0	85.21
29 May 1958	16,000.0	59	1931	9,710.0	86.68
10 Jun 1959	8,480.0	60	1959	8,480.0	88.15
04 Jun 1960	9,730.0	61	1934	8,140.0	89.62
31 May 1961	7,680.0	62	1961	7,680.0	91.09
13 May 1962	14,600.0	63	1964	7,580.0	92.56
07 May 1963	5,470.0	64	1963	5,470.0*	94.51
25 May 1964	7,580.0	65	1955	5,400.0*	95.99
18 Jun 1965	11,900.0	66	1966	4,840.0*	97.48
08 May 1966	4,840.0	67	1954	4,060.0*	98.96

* Outlier

* Low outlier plotting positions are computed using Median parameters.

<< Frequency Curve >>

Colorado River-GLENWOOD SPRINGS, CO.-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Variance Log(EMA)	Percent Chance Exceedance	Confidence Limits 0.16 FLOW, CFS	Confidence Limits 0.84 FLOW, CFS
39,322.5	0.00385	0.200	46,531.2	34,761.6
36,442.9	0.00262	0.500	41,838.5	32,898.2
34,098.9	0.00187	1.000	38,309.2	31,253.9
31,584.7	0.00130	2.000	34,775.8	29,351.4
28,862.8	0.00089	4.000	31,208.5	27,120.9
24,839.1	0.00059	10.000	26,366.4	23,532.3
21,317.3	0.00052	20.000	22,487.8	20,224.8
15,377.8	0.00058	50.000	16,249.9	14,542.4

10,585.5	0.00092	80.000	11,290.3	9,786.3
8,541.0	0.00160	90.000	9,246.0	7,629.9
7,080.4	0.00275	95.000	7,822.9	6,064.0
4,853.7	0.00748	99.000	5,687.8	3,721.4

<< Systematic Statistics >>
Colorado River-GLENWOOD SPRINGS, CO.-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.173	Historic Events	0
Standard Dev	0.182	High Outliers	0
Station Skew	-0.473	Low Outliers	4
Regional Skew	-0.100	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-0.473	Systematic Events	67

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis
13 Dec 2017 11:28 AM

--- Input Data ---

Analysis Name: @Below Glenwood - RF - 17C
Description:

Data Set Name: Below Glenwood - RF
DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH2\HEC-SSP\Post\@Below_Glenwood_-_No_RF\@Below_Glenwood_-_No_RF.dss
DSS Pathname: ////01jan1900/IR-CENTURY//

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH2\HEC-SSP\Post\@Below_Glenwood_-_No_RF\Bulletin17Results\@Below_Glenwood_-_RF_-_17C\@Below_Glenwood_-_RF_-_17C.rpt
XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH2\HEC-SSP\Post\@Below_Glenwood_-_No_RF\Bulletin17Results\@Below_Glenwood_-_RF_-_17C\@Below_Glenwood_-_RF_-_17C.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.16
Lower Confidence Level: 0.84

Use non-standard frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 4.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 3 digits in fraction part of value

--- End of Input Data ---

<< EMA Representation of Data >>
Below Glenwood - RF

Year	Peak	Value Low	Value High	Threshold Low	Threshold High	Type
1967	9,590.000	9,590.000	9,590.000	1.0E-99	1.0E99	Syst
1968	10,500.000	10,500.000	10,500.000	1.0E-99	1.0E99	Syst

1969	7,730.000	7,730.000	7,730.000	1.0E-99	1.0E99	Syst
1970	13,700.000	13,700.000	13,700.000	1.0E-99	1.0E99	Syst
1971	10,700.000	10,700.000	10,700.000	1.0E-99	1.0E99	Syst
1972	8,590.000	8,590.000	8,590.000	1.0E-99	1.0E99	Syst
1973	13,210.000	13,210.000	13,210.000	1.0E-99	1.0E99	Syst
1974	10,320.000	10,320.000	10,320.000	1.0E-99	1.0E99	Syst
1975	8,820.000	8,820.000	8,820.000	1.0E-99	1.0E99	Syst
1976	5,910.000	5,910.000	5,910.000	1.0E-99	1.0E99	Syst
1977	2,830.000	2,830.000	2,830.000	1.0E-99	1.0E99	Syst
1978	12,170.000	12,170.000	12,170.000	1.0E-99	1.0E99	Syst
1979	11,360.000	11,360.000	11,360.000	1.0E-99	1.0E99	Syst
1980	11,630.000	11,630.000	11,630.000	1.0E-99	1.0E99	Syst
1981	5,200.000	5,200.000	5,200.000	1.0E-99	1.0E99	Syst
1982	7,230.000	7,230.000	7,230.000	1.0E-99	1.0E99	Syst
1983	16,700.000	16,700.000	16,700.000	1.0E-99	1.0E99	Syst
1984	22,870.000	22,870.000	22,870.000	1.0E-99	1.0E99	Syst
1985	11,910.000	11,910.000	11,910.000	1.0E-99	1.0E99	Syst
1986	13,180.000	13,180.000	13,180.000	1.0E-99	1.0E99	Syst
1987	5,380.000	5,380.000	5,380.000	1.0E-99	1.0E99	Syst
1988	6,910.000	6,910.000	6,910.000	1.0E-99	1.0E99	Syst
1989	4,800.000	4,800.000	4,800.000	1.0E-99	1.0E99	Syst
1990	5,430.000	5,430.000	5,430.000	1.0E-99	1.0E99	Syst
1991	7,430.000	7,430.000	7,430.000	1.0E-99	1.0E99	Syst
1992	3,720.000	3,720.000	3,720.000	1.0E-99	1.0E99	Syst
1993	11,030.000	11,030.000	11,030.000	1.0E-99	1.0E99	Syst
1994	5,150.000	5,150.000	5,150.000	1.0E-99	1.0E99	Syst
1995	13,600.000	13,600.000	13,600.000	1.0E-99	1.0E99	Syst
1996	12,420.000	12,420.000	12,420.000	1.0E-99	1.0E99	Syst
1997	15,810.000	15,810.000	15,810.000	1.0E-99	1.0E99	Syst
1998	7,850.000	7,850.000	7,850.000	1.0E-99	1.0E99	Syst
1999	8,550.000	8,550.000	8,550.000	1.0E-99	1.0E99	Syst
2000	8,480.000	8,480.000	8,480.000	1.0E-99	1.0E99	Syst
2001	4,670.000	4,670.000	4,670.000	1.0E-99	1.0E99	Syst
2002	2,310.000	2,310.000	2,310.000	1.0E-99	1.0E99	Syst
2003	12,350.000	12,350.000	12,350.000	1.0E-99	1.0E99	Syst
2004	3,370.000	3,370.000	3,370.000	1.0E-99	1.0E99	Syst
2005	7,600.000	7,600.000	7,600.000	1.0E-99	1.0E99	Syst
2006	8,960.000	8,960.000	8,960.000	1.0E-99	1.0E99	Syst
2007	7,490.000	7,490.000	7,490.000	1.0E-99	1.0E99	Syst
2008	14,170.000	14,170.000	14,170.000	1.0E-99	1.0E99	Syst
2009	11,750.000	11,750.000	11,750.000	1.0E-99	1.0E99	Syst
2010	15,650.000	15,650.000	15,650.000	1.0E-99	1.0E99	Syst
2011	20,070.000	20,070.000	20,070.000	1.0E-99	1.0E99	Syst
2012	3,846.000	3,846.000	3,846.000	1.0E-99	1.0E99	Syst
2013	6,550.000	6,550.000	6,550.000	1.0E-99	1.0E99	Syst
2014	18,650.000	18,650.000	18,650.000	1.0E-99	1.0E99	Syst
2015	14,160.000	14,160.000	14,160.000	1.0E-99	1.0E99	Syst
2016	12,790.000	12,790.000	12,790.000	1.0E-99	1.0E99	Syst

Fitted log10 Moments	Mean	Variance	Std Dev	Skew
EMA at-site data w/o regional info	3.944522	0.050199	0.224051	-0.583224
EMA w/ regional info and B17b MSE(G)	3.944522	0.050199	0.224051	-0.583224
EMA w/ regional info and specified MSE(G)	3.944522	0.050199	0.224051	-0.583224

EMA Estimate of MSE[G at-site]	0.146426
MSE[G at-site systematic]	0.146426
Effective Record Length [G at-site]	50.000000
Grubbs-Beck Critical Value	0.000000

--- Final Results ---

<< Plotting Positions >>
Below Glenwood - RF

Events Analyzed				Ordered Events			
			FLOW		Water	FLOW	H-S
Day	Mon	Year	CFS	Rank	Year	CFS	Plot Pos
05	Jun	1967	9,590.000	1	1984	22,870.000	1.96
06	Jun	1968	10,500.000	2	2011	20,070.000	3.92
28	May	1969	7,730.000	3	2014	18,650.000	5.88
23	May	1970	13,700.000	4	1983	16,700.000	7.84
25	Jun	1971	10,700.000	5	1997	15,810.000	9.80
08	Jun	1972	8,590.000	6	2010	15,650.000	11.76
15	Jun	1973	13,210.000	7	2008	14,170.000	13.73
30	May	1974	10,320.000	8	2015	14,160.000	15.69
16	Jun	1975	8,820.000	9	1970	13,700.000	17.65
06	Jun	1976	5,910.000	10	1995	13,600.000	19.61
07	Jun	1977	2,830.000	11	1973	13,210.000	21.57
16	Jun	1978	12,170.000	12	1986	13,180.000	23.53
16	Jun	1979	11,360.000	13	2016	12,790.000	25.49
12	Jun	1980	11,630.000	14	1996	12,420.000	27.45
10	Jun	1981	5,200.000	15	2003	12,350.000	29.41
29	Jun	1982	7,230.000	16	1978	12,170.000	31.37
25	Jun	1983	16,700.000	17	1985	11,910.000	33.33
25	May	1984	22,870.000	18	2009	11,750.000	35.29
09	Jun	1985	11,910.000	19	1980	11,630.000	37.25
07	Jun	1986	13,180.000	20	1979	11,360.000	39.22
09	Jun	1987	5,380.000	21	1993	11,030.000	41.18
07	Jun	1988	6,910.000	22	1971	10,700.000	43.14
30	May	1989	4,800.000	23	1968	10,500.000	45.10
11	Jun	1990	5,430.000	24	1974	10,320.000	47.06
15	Jun	1991	7,430.000	25	1967	9,590.000	49.02
27	May	1992	3,720.000	26	2006	8,960.000	50.98
28	May	1993	11,030.000	27	1975	8,820.000	52.94
02	Jun	1994	5,150.000	28	1972	8,590.000	54.90
18	Jun	1995	13,600.000	29	1999	8,550.000	56.86
20	May	1996	12,420.000	30	2000	8,480.000	58.82
05	Jun	1997	15,810.000	31	1998	7,850.000	60.78
02	Jun	1998	7,850.000	32	1969	7,730.000	62.75
09	Jun	1999	8,550.000	33	2005	7,600.000	64.71
30	May	2000	8,480.000	34	2007	7,490.000	66.67
02	Jun	2001	4,670.000	35	1991	7,430.000	68.63
01	Jun	2002	2,310.000	36	1982	7,230.000	70.59
02	Jun	2003	12,350.000	37	1988	6,910.000	72.55
08	Jun	2004	3,370.000	38	2013	6,550.000	74.51
23	May	2005	7,600.000	39	1976	5,910.000	76.47
23	May	2006	8,960.000	40	1990	5,430.000	78.43
20	Jun	2007	7,490.000	41	1987	5,380.000	80.39
03	Jun	2008	14,170.000	42	1981	5,200.000	82.35
21	May	2009	11,750.000	43	1994	5,150.000	84.31

08 Jun 2010	15,650.000		44	1989	4,800.000	86.27
26 Jun 2011	20,070.000		45	2001	4,670.000	88.24
24 Jul 2012	3,846.000		46	2012	3,846.000	90.20
11 Jun 2013	6,550.000		47	1992	3,720.000	92.16
02 Jun 2014	18,650.000		48	2004	3,370.000	94.12
18 Jun 2015	14,160.000		49	1977	2,830.000	96.08
08 Jun 2016	12,790.000		50	2002	2,310.000	98.04

* Low outlier plotting positions are computed using Median parameters.

<< Frequency Curve >>
Below Glenwood - RF

Computed Curve FLOW, CFS	Variance Log(EMA)	Percent Chance Exceedance	Confidence Limits 0.16 FLOW, CFS	Confidence Limits 0.84 FLOW, CFS
27,209.037	0.00844	0.200	33,972.725	22,201.441
25,104.016	0.00575	0.500	30,159.194	21,221.224
23,366.613	0.00408	1.000	27,306.132	20,303.398
21,483.525	0.00275	2.000	24,468.025	19,178.488
19,427.667	0.00178	4.000	21,623.780	17,762.756
16,370.397	0.00107	10.000	17,776.203	15,232.665
13,695.030	0.00095	20.000	14,716.760	12,738.093
9,250.980	0.00121	50.000	10,033.566	8,531.314
5,821.729	0.00182	80.000	6,392.668	5,229.360
4,436.674	0.00290	90.000	4,962.261	3,840.067
3,489.297	0.00481	95.000	4,004.311	2,862.996
2,137.096	0.01315	99.000	2,639.993	1,486.620

<< Systematic Statistics >>
Below Glenwood - RF

Log Transform: FLOW, CFS		Number of Events	
Mean	3.945	Historic Events	0
Standard Dev	0.224	High Outliers	0
Station Skew	-0.583	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-0.583	Systematic Events	50

--- End of Analytical Frequency Curve ---

```
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Bulletin 17B Frequency Analysis
    03 Nov 2017   11:55 AM
------------------------------


--- Input Data ---

Analysis Name: @Below Glenwood - 17C
Description:

Data Set Name: COLORADO RIVER- BELOW GLENWOOD SPRINGS,
DSS File Name: \\den-fs1\DVOFFICE\PUBLIC\P_Drive\3279 Project files- Water
Group\32790068 - Granby to the State Line\8.0 Project Design\8.4
HH\HEC-SSP\Colorado_River\Colorado_River.dss
DSS Pathname: /COLORADO RIVER/GLENWOOD SPRINGS, CO/FLOW-ANNUAL
PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: \\den-fs1\DVOFFICE\PUBLIC\P_Drive\3279 Project files- Water
Group\32790068 - Granby to the State Line\8.0 Project Design\8.4
HH\HEC-SSP\Colorado_River\Bulletin17Results\@Below_Glenwood_-_17C\@Below_Glenwood_-_
17C.rpt
XML File Name: \\den-fs1\DVOFFICE\PUBLIC\P_Drive\3279 Project files- Water
Group\32790068 - Granby to the State Line\8.0 Project Design\8.4
HH\HEC-SSP\Colorado_River\Bulletin17Results\@Below_Glenwood_-_17C\@Below_Glenwood_-_
17C.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.16
Lower Confidence Level: 0.84

Use non-standard frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 4.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---



<< EMA Representation of Data >>
COLORADO RIVER- BELOW GLENWOOD SPRINGS,
---------------------------------------------------------------------------------
|                   |          Value            |        Threshold         |      |
```

Year	Peak	Low	High	Low	High	Type
1921	44,400.0	33,300.0	55,500.0	6,550.0	1.0E99	Hist
1922	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1923	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1924	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1925	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1926	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1927	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1928	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1929	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1930	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1931	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1932	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1933	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1934	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1935	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1936	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1937	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1938	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1939	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1940	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1941	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1942	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1943	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1944	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1945	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1946	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1947	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1948	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1949	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1950	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1951	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1952	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1953	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1954	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1955	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1956	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1957	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1958	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1959	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1960	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1961	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1962	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1963	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1964	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1965	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1966	---	1.0E-99	31,500.0	31,500.0	1.0E99	Cens
1967	14,200.0	14,200.0	14,200.0	6,550.0	1.0E99	Syst
1968	17,400.0	17,400.0	17,400.0	6,550.0	1.0E99	Syst
1969	13,300.0	13,300.0	13,300.0	6,550.0	1.0E99	Syst
1970	19,200.0	19,200.0	19,200.0	6,550.0	1.0E99	Syst
1971	17,600.0	17,600.0	17,600.0	6,550.0	1.0E99	Syst
1972	14,400.0	14,400.0	14,400.0	6,550.0	1.0E99	Syst
1973	20,500.0	20,500.0	20,500.0	6,550.0	1.0E99	Syst
1974	15,100.0	15,100.0	15,100.0	6,550.0	1.0E99	Syst
1975	14,200.0	14,200.0	14,200.0	6,550.0	1.0E99	Syst
1976	9,960.0	9,960.0	9,960.0	6,550.0	1.0E99	Syst
1977	4,830.0	1.0E-6	6,550.0	6,550.0	1.0E99	Syst
1978	19,400.0	19,400.0	19,400.0	6,550.0	1.0E99	Syst
1979	17,700.0	17,700.0	17,700.0	6,550.0	1.0E99	Syst
1980	18,800.0	18,800.0	18,800.0	6,550.0	1.0E99	Syst
1981	9,310.0	9,310.0	9,310.0	6,550.0	1.0E99	Syst

1982	12,600.0	12,600.0	12,600.0	6,550.0	1.0E99	Syst
1983	27,900.0	27,900.0	27,900.0	6,550.0	1.0E99	Syst
1984	31,500.0	31,500.0	31,500.0	6,550.0	1.0E99	Syst
1985	21,600.0	21,600.0	21,600.0	6,550.0	1.0E99	Syst
1986	20,200.0	20,200.0	20,200.0	6,550.0	1.0E99	Syst
1987	11,100.0	11,100.0	11,100.0	6,550.0	1.0E99	Syst
1988	11,000.0	11,000.0	11,000.0	6,550.0	1.0E99	Syst
1989	7,620.0	7,620.0	7,620.0	6,550.0	1.0E99	Syst
1990	9,810.0	9,810.0	9,810.0	6,550.0	1.0E99	Syst
1991	12,100.0	12,100.0	12,100.0	6,550.0	1.0E99	Syst
1992	6,550.0	6,550.0	6,550.0	6,550.0	1.0E99	Syst
1993	17,700.0	17,700.0	17,700.0	6,550.0	1.0E99	Syst
1994	9,180.0	9,180.0	9,180.0	6,550.0	1.0E99	Syst
1995	23,800.0	23,800.0	23,800.0	6,550.0	1.0E99	Syst
1996	18,200.0	18,200.0	18,200.0	6,550.0	1.0E99	Syst
1997	23,400.0	23,400.0	23,400.0	6,550.0	1.0E99	Syst
1998	12,800.0	12,800.0	12,800.0	6,550.0	1.0E99	Syst
1999	13,000.0	13,000.0	13,000.0	6,550.0	1.0E99	Syst
2000	13,800.0	13,800.0	13,800.0	6,550.0	1.0E99	Syst
2001	8,130.0	8,130.0	8,130.0	6,550.0	1.0E99	Syst
2002	4,480.0	1.0E-6	6,550.0	6,550.0	1.0E99	Syst
2003	18,500.0	18,500.0	18,500.0	6,550.0	1.0E99	Syst
2004	6,920.0	6,920.0	6,920.0	6,550.0	1.0E99	Syst
2005	12,800.0	12,800.0	12,800.0	6,550.0	1.0E99	Syst
2006	14,600.0	14,600.0	14,600.0	6,550.0	1.0E99	Syst
2007	10,700.0	10,700.0	10,700.0	6,550.0	1.0E99	Syst
2008	20,500.0	20,500.0	20,500.0	6,550.0	1.0E99	Syst
2009	17,800.0	17,800.0	17,800.0	6,550.0	1.0E99	Syst
2010	24,300.0	24,300.0	24,300.0	6,550.0	1.0E99	Syst
2011	27,600.0	27,600.0	27,600.0	6,550.0	1.0E99	Syst
2012	4,480.0	1.0E-6	6,550.0	6,550.0	1.0E99	Syst
2013	10,500.0	10,500.0	10,500.0	6,550.0	1.0E99	Syst
2014	24,900.0	24,900.0	24,900.0	6,550.0	1.0E99	Syst
2015	21,200.0	21,200.0	21,200.0	6,550.0	1.0E99	Syst
2016	18,700.0	18,700.0	18,700.0	6,550.0	1.0E99	Syst

Fitted log10 Moments	Mean	Variance	Std Dev	Skew
EMA at-site data w/o regional info	4.152909	0.041446	0.203584	-0.723761
EMA w/ regional info and B17b MSE(G)	4.152909	0.041446	0.203584	-0.723761
EMA w/ regional info and specified MSE(G)	4.152909	0.041446	0.203584	-0.723761

EMA Estimate of MSE[G at-site]	0.097590
MSE[G at-site systematic]	0.159367
Effective Record Length [G at-site]	81.651122
Grubbs-Beck Critical Value	6,550.000000

--- Final Results ---

<< Plotting Positions >>

COLORADO RIVER- BELOW GLENWOOD SPRINGS,

Events Analyzed				Ordered Events			
Day	Mon	Year	FLOW CFS	Rank	Water Year	FLOW CFS	H-S Plot Pos
16	Jun	1921	44,400.0	1	1921	44,400.0	0.69
05	Jun	1922	---	2	1984	31,500.0	1.39
05	Jun	1923	---	3	1983	27,900.0	4.04
05	Jun	1924	---	4	2011	27,600.0	5.99
05	Jun	1925	---	5	2014	24,900.0	7.95
05	Jun	1926	---	6	2010	24,300.0	9.91
05	Jun	1927	---	7	1995	23,800.0	11.86
05	Jun	1928	---	8	1997	23,400.0	13.82
05	Jun	1929	---	9	1985	21,600.0	15.77
05	Jun	1930	---	10	2015	21,200.0	17.73
05	Jun	1931	---	11	2008	20,500.0	19.69
05	Jun	1932	---	12	1973	20,500.0	21.64
05	Jun	1933	---	13	1986	20,200.0	23.60
05	Jun	1934	---	14	1978	19,400.0	25.55
05	Jun	1935	---	15	1970	19,200.0	27.51
05	Jun	1936	---	16	1980	18,800.0	29.46
05	Jun	1937	---	17	2016	18,700.0	31.42
05	Jun	1938	---	18	2003	18,500.0	33.38
05	Jun	1939	---	19	1996	18,200.0	35.33
05	Jun	1940	---	20	2009	17,800.0	37.29
05	Jun	1941	---	21	1993	17,700.0	39.24
05	Jun	1942	---	22	1979	17,700.0	41.20
05	Jun	1943	---	23	1971	17,600.0	43.15
05	Jun	1944	---	24	1968	17,400.0	45.11
05	Jun	1945	---	25	1974	15,100.0	47.07
05	Jun	1946	---	26	2006	14,600.0	49.02
05	Jun	1947	---	27	1972	14,400.0	50.98
05	Jun	1948	---	28	1975	14,200.0	52.93
05	Jun	1949	---	29	1967	14,200.0	54.89
05	Jun	1950	---	30	2000	13,800.0	56.85
05	Jun	1951	---	31	1969	13,300.0	58.80
05	Jun	1952	---	32	1999	13,000.0	60.76
05	Jun	1953	---	33	2005	12,800.0	62.71
05	Jun	1954	---	34	1998	12,800.0	64.67
05	Jun	1955	---	35	1982	12,600.0	66.62
05	Jun	1956	---	36	1991	12,100.0	68.58
05	Jun	1957	---	37	1987	11,100.0	70.54
05	Jun	1958	---	38	1988	11,000.0	72.49
05	Jun	1959	---	39	2007	10,700.0	74.45
05	Jun	1960	---	40	2013	10,500.0	76.40
05	Jun	1961	---	41	1976	9,960.0	78.36
05	Jun	1962	---	42	1990	9,810.0	80.31
05	Jun	1963	---	43	1981	9,310.0	82.27
05	Jun	1964	---	44	1994	9,180.0	84.23
05	Jun	1965	---	45	2001	8,130.0	86.18
05	Jun	1966	---	46	1989	7,620.0	88.14
05	Jun	1967	14,200.0	47	2004	6,920.0	90.09
06	Jun	1968	17,400.0	48	1992	6,550.0*	92.05
28	May	1969	13,300.0	49	1977	4,830.0*	94.75
23	May	1970	19,200.0	50	2012	4,480.0*	96.69
25	Jun	1971	17,600.0	51	2002	4,480.0*	98.64
08	Jun	1972	14,400.0	52	1966	---*	---
15	Jun	1973	20,500.0	53	1965	---*	---
30	May	1974	15,100.0	54	1964	---*	---
16	Jun	1975	14,200.0	55	1963	---*	---
06	Jun	1976	9,960.0	56	1962	---*	---

07 Jun 1977	4,830.0	57	1961	---*	---
16 Jun 1978	19,400.0	58	1960	---*	---
16 Jun 1979	17,700.0	59	1959	---*	---
12 Jun 1980	18,800.0	60	1958	---*	---
10 Jun 1981	9,310.0	61	1957	---*	---
29 Jun 1982	12,600.0	62	1956	---*	---
25 Jun 1983	27,900.0	63	1955	---*	---
25 May 1984	31,500.0	64	1954	---*	---
09 Jun 1985	21,600.0	65	1953	---*	---
07 Jun 1986	20,200.0	66	1952	---*	---
09 Jun 1987	11,100.0	67	1951	---*	---
07 Jun 1988	11,000.0	68	1950	---*	---
30 May 1989	7,620.0	69	1949	---*	---
11 Jun 1990	9,810.0	70	1948	---*	---
15 Jun 1991	12,100.0	71	1947	---*	---
27 May 1992	6,550.0	72	1946	---*	---
28 May 1993	17,700.0	73	1945	---*	---
02 Jun 1994	9,180.0	74	1944	---*	---
18 Jun 1995	23,800.0	75	1943	---*	---
20 May 1996	18,200.0	76	1942	---*	---
05 Jun 1997	23,400.0	77	1941	---*	---
02 Jun 1998	12,800.0	78	1940	---*	---
09 Jun 1999	13,000.0	79	1939	---*	---
30 May 2000	13,800.0	80	1938	---*	---
02 Jun 2001	8,130.0	81	1937	---*	---
01 Jun 2002	4,480.0	82	1936	---*	---
02 Jun 2003	18,500.0	83	1935	---*	---
08 Jun 2004	6,920.0	84	1934	---*	---
23 May 2005	12,800.0	85	1933	---*	---
23 May 2006	14,600.0	86	1932	---*	---
20 Jun 2007	10,700.0	87	1931	---*	---
03 Jun 2008	20,500.0	88	1930	---*	---
21 May 2009	17,800.0	89	1929	---*	---
08 Jun 2010	24,300.0	90	1928	---*	---
26 Jun 2011	27,600.0	91	1927	---*	---
24 Jul 2012	4,480.0	92	1926	---*	---
11 Jun 2013	10,500.0	93	1925	---*	---
02 Jun 2014	24,900.0	94	1924	---*	---
18 Jun 2015	21,200.0	95	1923	---*	---
08 Jun 2016	18,700.0	96	1922	---*	---

* Outlier

* Low outlier plotting positions are computed using Median parameters.

<< Frequency Curve >>

COLORADO RIVER- BELOW GLENWOOD SPRINGS,

Computed Curve FLOW, CFS	Variance Log(EMA)	Percent Chance Exceedance	Confidence Limits 0.16 FLOW, CFS	0.84
36,843.2	0.00244	0.200	42,053.9	33,337.7
34,723.7	0.00163	0.500	38,618.1	31,942.9
32,889.4	0.00116	1.000	35,919.0	30,601.2
30,814.4	0.00083	2.000	33,118.7	28,927.9
28,445.0	0.00063	4.000	30,202.9	26,834.8
24,717.5	0.00059	10.000	26,111.1	23,316.8
21,249.8	0.00070	20.000	22,573.1	19,972.3
15,040.7	0.00096	50.000	16,160.4	13,993.2
9,830.0	0.00169	80.000	10,714.3	8,803.0
7,609.5	0.00301	90.000	8,470.5	6,482.3

6,048.5	0.00519	95.000	6,924.1	4,855.4
3,756.6	0.01397	99.000	4,651.6	2,583.2

<< Systematic Statistics >>
COLORADO RIVER- BELOW GLENWOOD SPRINGS,

Log Transform: FLOW, CFS		Number of Events	
Mean	4.153	Historic Events	1
Standard Dev	0.204	High Outliers	0
Station Skew	-0.724	Low Outliers	3
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	45
Adopted Skew	-0.724	Systematic Events	50
		Historic Period	96

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis
27 Oct 2017 10:54 AM

--- Input Data ---

Analysis Name: @De Beque - 17C
Description:

Data Set Name: Colorado River-DE BEQUE, CO.-FLOW-ANNUAL PEAK
DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss
DSS Pathname: /COLORADO RIVER/DE BEQUE, CO./FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@De_Beque_-_17C\@De_Beque_-_17C.rpt
XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@De_Beque_-_17C\@De_Beque_-_17C.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: 0.0
Regional Skew MSE: 0.302

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.16
Lower Confidence Level: 0.84

Use non-standard frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 4.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

<< EMA Representation of Data >>
Colorado River-DE BEQUE, CO.-FLOW-ANNUAL PEAK

		Value		Threshold		
Year	Peak	Low	High	Low	High	Type
1921	47,733.0	35,800.0	59,666.0	7,700.0	1.0E99	Syst
1922	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1923	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens

1924	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1925	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1926	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1927	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1928	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1929	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1930	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1931	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1932	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1933	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1934	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1935	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1936	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1937	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1938	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1939	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1940	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1941	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1942	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1943	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1944	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1945	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1946	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1947	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1948	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1949	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1950	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1951	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1952	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1953	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1954	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1955	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1956	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1957	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1958	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1959	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1960	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1961	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1962	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1963	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1964	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1965	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1966	---	1.0E-99	32,300.0	32,300.0	1.0E99	Cens
1967	14,400.0	14,400.0	14,400.0	7,700.0	1.0E99	Syst
1968	18,600.0	18,600.0	18,600.0	7,700.0	1.0E99	Syst
1969	13,200.0	13,200.0	13,200.0	7,700.0	1.0E99	Syst
1970	22,200.0	22,200.0	22,200.0	7,700.0	1.0E99	Syst
1971	18,600.0	18,600.0	18,600.0	7,700.0	1.0E99	Syst
1972	15,900.0	15,900.0	15,900.0	7,700.0	1.0E99	Syst
1973	22,500.0	22,500.0	22,500.0	7,700.0	1.0E99	Syst
1974	15,900.0	15,900.0	15,900.0	7,700.0	1.0E99	Syst
1975	17,800.0	17,800.0	17,800.0	7,700.0	1.0E99	Syst
1976	11,400.0	11,400.0	11,400.0	7,700.0	1.0E99	Syst
1977	5,040.0	1.0E-6	7,700.0	7,700.0	1.0E99	Syst
1978	20,200.0	20,200.0	20,200.0	7,700.0	1.0E99	Syst
1979	21,200.0	21,200.0	21,200.0	7,700.0	1.0E99	Syst
1980	19,700.0	19,700.0	19,700.0	7,700.0	1.0E99	Syst
1981	10,300.0	10,300.0	10,300.0	7,700.0	1.0E99	Syst
1982	13,500.0	13,500.0	13,500.0	7,700.0	1.0E99	Syst
1983	32,300.0	32,300.0	32,300.0	7,700.0	1.0E99	Syst
1984	38,200.0	38,200.0	38,200.0	7,700.0	1.0E99	Syst
1985	25,000.0	25,000.0	25,000.0	7,700.0	1.0E99	Syst
1986	22,100.0	22,100.0	22,100.0	7,700.0	1.0E99	Syst

1987	11,900.0	11,900.0	11,900.0	7,700.0	1.0E99	Syst
1988	11,500.0	11,500.0	11,500.0	7,700.0	1.0E99	Syst
1989	8,430.0	8,430.0	8,430.0	7,700.0	1.0E99	Syst
1990	11,000.0	11,000.0	11,000.0	7,700.0	1.0E99	Syst
1991	14,000.0	14,000.0	14,000.0	7,700.0	1.0E99	Syst
1992	7,700.0	7,700.0	7,700.0	7,700.0	1.0E99	Syst
1993	22,900.0	22,900.0	22,900.0	7,700.0	1.0E99	Syst
1994	9,780.0	9,780.0	9,780.0	7,700.0	1.0E99	Syst
1995	29,500.0	29,500.0	29,500.0	7,700.0	1.0E99	Syst
1996	20,900.0	20,900.0	20,900.0	7,700.0	1.0E99	Syst
1997	26,800.0	26,800.0	26,800.0	7,700.0	1.0E99	Syst

Fitted log10 Moments	Mean	Variance	Std Dev	Skew
EMA at-site data w/o regional info	4.204870	0.033680	0.183522	-0.264386
EMA w/ regional info and B17b MSE(G)	4.204870	0.033680	0.183522	-0.264386
EMA w/ regional info and specified MSE(G)	4.204870	0.033680	0.183522	-0.264386

EMA Estimate of MSE[G at-site]	0.082944
MSE[G at-site systematic]	0.183251
Effective Record Length [G at-site]	68.489130
Grubbs-Beck Critical Value	7,700.000000

--- Final Results ---

<< Plotting Positions >>
Colorado River-DE BEQUE, CO.-FLOW-ANNUAL PEAK

Events Analyzed Day Mon Year	FLOW CFS	Ordered Events Rank	Water Year	FLOW CFS	H-S Plot Pos
26 May 1921	47,733.0	1	1921	47,733.0	0.97
26 May 1922	---	2	1984	38,200.0	1.95
26 May 1923	---	3	1983	32,300.0	2.92
26 May 1924	---	4	1995	29,500.0	7.10
26 May 1925	---	5	1997	26,800.0	10.30
26 May 1926	---	6	1985	25,000.0	13.50
26 May 1927	---	7	1993	22,900.0	16.69
26 May 1928	---	8	1973	22,500.0	19.89
26 May 1929	---	9	1970	22,200.0	23.09
26 May 1930	---	10	1986	22,100.0	26.29
26 May 1931	---	11	1979	21,200.0	29.49
26 May 1932	---	12	1996	20,900.0	32.69
26 May 1933	---	13	1978	20,200.0	35.89
26 May 1934	---	14	1980	19,700.0	39.09
26 May 1935	---	15	1971	18,600.0	42.29
26 May 1936	---	16	1968	18,600.0	45.49
26 May 1937	---	17	1975	17,800.0	48.69

26 May 1938	---	18	1974	15,900.0	51.89
26 May 1939	---	19	1972	15,900.0	55.09
26 May 1940	---	20	1967	14,400.0	58.29
26 May 1941	---	21	1991	14,000.0	61.49
26 May 1942	---	22	1982	13,500.0	64.69
26 May 1943	---	23	1969	13,200.0	67.89
26 May 1944	---	24	1987	11,900.0	71.09
26 May 1945	---	25	1988	11,500.0	74.29
26 May 1946	---	26	1976	11,400.0	77.49
26 May 1947	---	27	1990	11,000.0	80.69
26 May 1948	---	28	1981	10,300.0	83.89
26 May 1949	---	29	1994	9,780.0	87.09
26 May 1950	---	30	1989	8,430.0	90.29
26 May 1951	---	31	1992	7,700.0	93.49
26 May 1952	---	32	1977	5,040.0*	97.84
26 May 1953	---	33	1966	---*	---
26 May 1954	---	34	1965	---*	---
26 May 1955	---	35	1964	---*	---
26 May 1956	---	36	1963	---*	---
26 May 1957	---	37	1962	---*	---
26 May 1958	---	38	1961	---*	---
26 May 1959	---	39	1960	---*	---
26 May 1960	---	40	1959	---*	---
26 May 1961	---	41	1958	---*	---
26 May 1962	---	42	1957	---*	---
26 May 1963	---	43	1956	---*	---
26 May 1964	---	44	1955	---*	---
26 May 1965	---	45	1954	---*	---
26 May 1966	---	46	1953	---*	---
26 May 1967	14,400.0	47	1952	---*	---
06 Jun 1968	18,600.0	48	1951	---*	---
28 May 1969	13,200.0	49	1950	---*	---
23 May 1970	22,200.0	50	1949	---*	---
25 Jun 1971	18,600.0	51	1948	---*	---
08 Jun 1972	15,900.0	52	1947	---*	---
15 Jun 1973	22,500.0	53	1946	---*	---
30 May 1974	15,900.0	54	1945	---*	---
16 Jun 1975	17,800.0	55	1944	---*	---
06 Jun 1976	11,400.0	56	1943	---*	---
07 Jun 1977	5,040.0	57	1942	---*	---
16 Jun 1978	20,200.0	58	1941	---*	---
29 May 1979	21,200.0	59	1940	---*	---
12 Jun 1980	19,700.0	60	1939	---*	---
10 Jun 1981	10,300.0	61	1938	---*	---
19 Jun 1982	13,500.0	62	1937	---*	---
26 Jun 1983	32,300.0	63	1936	---*	---
26 May 1984	38,200.0	64	1935	---*	---
10 Jun 1985	25,000.0	65	1934	---*	---
07 Jun 1986	22,100.0	66	1933	---*	---
09 Jun 1987	11,900.0	67	1932	---*	---
07 Jun 1988	11,500.0	68	1931	---*	---
30 May 1989	8,430.0	69	1930	---*	---
11 Jun 1990	11,000.0	70	1929	---*	---
15 Jun 1991	14,000.0	71	1928	---*	---
27 May 1992	7,700.0	72	1927	---*	---
28 May 1993	22,900.0	73	1926	---*	---
02 Jun 1994	9,780.0	74	1925	---*	---
18 Jun 1995	29,500.0	75	1924	---*	---
20 May 1996	20,900.0	76	1923	---*	---
05 Jun 1997	26,800.0	77	1922	---*	---

* Outlier

* Low outlier plotting positions are computed using Median parameters.

<< Frequency Curve >>
Colorado River-DE BEQUE, CO.-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Variance Log(EMA)	Percent Chance Exceedance	Confidence Limits 0.16 FLOW, CFS	Confidence Limits 0.84 FLOW, CFS
47,276.0	0.00454	0.200	57,669.3	41,576.7
42,857.8	0.00304	0.500	50,267.1	38,486.7
39,433.0	0.00218	1.000	44,976.8	35,899.4
35,915.6	0.00155	2.000	39,926.0	33,053.3
32,274.9	0.00114	4.000	35,116.2	29,913.7
27,180.5	0.00091	10.000	29,108.8	25,290.9
22,972.4	0.00093	20.000	24,588.7	21,361.4
16,328.6	0.00111	50.000	17,611.0	15,082.0
11,304.2	0.00169	80.000	12,338.0	10,127.8
9,227.8	0.00265	90.000	10,213.2	7,928.9
7,759.8	0.00417	95.000	8,756.5	6,348.1
5,528.9	0.01007	99.000	6,616.2	3,998.6

<< Systematic Statistics >>
Colorado River-DE BEQUE, CO.-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.205	Historic Events	0
Standard Dev	0.184	High Outliers	0
Station Skew	-0.264	Low Outliers	1
Regional Skew	0.000	Zero Events	0
Weighted Skew	---	Missing Events	45
Adopted Skew	-0.264	Systematic Events	32
		Historic Period	77

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis
27 Oct 2017   10:55 AM

--- Input Data ---

Analysis Name: @Cameo - 17C
Description:

Data Set Name: Colorado River-CAMEO, CO.-FLOW-ANNUAL PEAK
DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss
DSS Pathname: /COLORADO RIVER/CAMEO, CO./FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Cameo_-_17C\@Cameo_-_17C.rpt
XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Cameo_-_17C\@Cameo_-_17C.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: 0.0
Regional Skew MSE: 0.302

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.16
Lower Confidence Level: 0.84

Use non-standard frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 4.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

<< EMA Representation of Data >>
Colorado River-CAMEO, CO.-FLOW-ANNUAL PEAK

Year	Peak	Value Low	Value High	Threshold Low	Threshold High	Type
1921	50,249.0	37,687.0	62,811.0	15,600.0	1.0E99	Syst
1922	---	1.0E-99	36,000.0	36,000.0	1.0E99	Cens
1923	---	1.0E-99	36,000.0	36,000.0	1.0E99	Cens
1924	---	1.0E-99	36,000.0	36,000.0	1.0E99	Cens

1925	---	1.0E-99	36,000.0	36,000.0	1.0E99	Cens
1926	---	1.0E-99	36,000.0	36,000.0	1.0E99	Cens
1927	---	1.0E-99	36,000.0	36,000.0	1.0E99	Cens
1928	---	1.0E-99	36,000.0	36,000.0	1.0E99	Cens
1929	---	1.0E-99	36,000.0	36,000.0	1.0E99	Cens
1930	---	1.0E-99	36,000.0	36,000.0	1.0E99	Cens
1931	---	1.0E-99	36,000.0	36,000.0	1.0E99	Cens
1932	---	1.0E-99	36,000.0	36,000.0	1.0E99	Cens
1933	---	1.0E-99	36,000.0	36,000.0	1.0E99	Cens
1934	14,700.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1935	36,000.0	36,000.0	36,000.0	15,600.0	1.0E99	Syst
1936	26,500.0	26,500.0	26,500.0	15,600.0	1.0E99	Syst
1937	20,200.0	20,200.0	20,200.0	15,600.0	1.0E99	Syst
1938	31,200.0	31,200.0	31,200.0	15,600.0	1.0E99	Syst
1939	19,900.0	19,900.0	19,900.0	15,600.0	1.0E99	Syst
1940	16,600.0	16,600.0	16,600.0	15,600.0	1.0E99	Syst
1941	27,500.0	27,500.0	27,500.0	15,600.0	1.0E99	Syst
1942	26,900.0	26,900.0	26,900.0	15,600.0	1.0E99	Syst
1943	22,600.0	22,600.0	22,600.0	15,600.0	1.0E99	Syst
1944	19,000.0	19,000.0	19,000.0	15,600.0	1.0E99	Syst
1945	18,800.0	18,800.0	18,800.0	15,600.0	1.0E99	Syst
1946	19,400.0	19,400.0	19,400.0	15,600.0	1.0E99	Syst
1947	26,400.0	26,400.0	26,400.0	15,600.0	1.0E99	Syst
1948	27,600.0	27,600.0	27,600.0	15,600.0	1.0E99	Syst
1949	27,700.0	27,700.0	27,700.0	15,600.0	1.0E99	Syst
1950	17,600.0	17,600.0	17,600.0	15,600.0	1.0E99	Syst
1951	22,800.0	22,800.0	22,800.0	15,600.0	1.0E99	Syst
1952	32,500.0	32,500.0	32,500.0	15,600.0	1.0E99	Syst
1953	24,700.0	24,700.0	24,700.0	15,600.0	1.0E99	Syst
1954	8,490.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1955	10,400.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1956	20,600.0	20,600.0	20,600.0	15,600.0	1.0E99	Syst
1957	31,400.0	31,400.0	31,400.0	15,600.0	1.0E99	Syst
1958	25,900.0	25,900.0	25,900.0	15,600.0	1.0E99	Syst
1959	16,400.0	16,400.0	16,400.0	15,600.0	1.0E99	Syst
1960	16,700.0	16,700.0	16,700.0	15,600.0	1.0E99	Syst
1961	13,100.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1962	25,500.0	25,500.0	25,500.0	15,600.0	1.0E99	Syst
1963	8,070.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1964	14,000.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1965	23,000.0	23,000.0	23,000.0	15,600.0	1.0E99	Syst
1966	8,750.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1967	14,400.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1968	18,400.0	18,400.0	18,400.0	15,600.0	1.0E99	Syst
1969	13,300.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1970	22,000.0	22,000.0	22,000.0	15,600.0	1.0E99	Syst
1971	19,200.0	19,200.0	19,200.0	15,600.0	1.0E99	Syst
1972	16,200.0	16,200.0	16,200.0	15,600.0	1.0E99	Syst
1973	22,400.0	22,400.0	22,400.0	15,600.0	1.0E99	Syst
1974	16,000.0	16,000.0	16,000.0	15,600.0	1.0E99	Syst
1975	17,400.0	17,400.0	17,400.0	15,600.0	1.0E99	Syst
1976	11,500.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1977	4,930.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1978	20,100.0	20,100.0	20,100.0	15,600.0	1.0E99	Syst
1979	21,600.0	21,600.0	21,600.0	15,600.0	1.0E99	Syst
1980	20,500.0	20,500.0	20,500.0	15,600.0	1.0E99	Syst
1981	10,100.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1982	13,600.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1983	36,000.0	36,000.0	36,000.0	15,600.0	1.0E99	Syst
1984	39,300.0	39,300.0	39,300.0	15,600.0	1.0E99	Syst
1985	26,500.0	26,500.0	26,500.0	15,600.0	1.0E99	Syst
1986	23,200.0	23,200.0	23,200.0	15,600.0	1.0E99	Syst
1987	13,100.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst

1988	13,000.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1989	8,530.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1990	11,700.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1991	14,400.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1992	8,240.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1993	23,300.0	23,300.0	23,300.0	15,600.0	1.0E99	Syst
1994	12,600.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
1995	29,600.0	29,600.0	29,600.0	15,600.0	1.0E99	Syst
1996	21,500.0	21,500.0	21,500.0	15,600.0	1.0E99	Syst
1997	26,300.0	26,300.0	26,300.0	15,600.0	1.0E99	Syst
1998	15,700.0	15,700.0	15,700.0	15,600.0	1.0E99	Syst
1999	15,600.0	15,600.0	15,600.0	15,600.0	1.0E99	Syst
2000	16,400.0	16,400.0	16,400.0	15,600.0	1.0E99	Syst
2001	9,720.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
2002	4,260.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
2003	21,000.0	21,000.0	21,000.0	15,600.0	1.0E99	Syst
2004	7,450.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
2005	17,200.0	17,200.0	17,200.0	15,600.0	1.0E99	Syst
2006	17,700.0	17,700.0	17,700.0	15,600.0	1.0E99	Syst
2007	10,900.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
2008	23,100.0	23,100.0	23,100.0	15,600.0	1.0E99	Syst
2009	19,400.0	19,400.0	19,400.0	15,600.0	1.0E99	Syst
2010	24,500.0	24,500.0	24,500.0	15,600.0	1.0E99	Syst
2011	29,700.0	29,700.0	29,700.0	15,600.0	1.0E99	Syst
2012	4,440.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
2013	10,300.0	1.0E-6	15,600.0	15,600.0	1.0E99	Syst
2014	25,800.0	25,800.0	25,800.0	15,600.0	1.0E99	Syst
2015	21,800.0	21,800.0	21,800.0	15,600.0	1.0E99	Syst
2016	20,000.0	20,000.0	20,000.0	15,600.0	1.0E99	Syst

Fitted log10 Moments	Mean	Variance	Std Dev	Skew
EMA at-site data w/o regional info	4.266365	0.027425	0.165604	-0.364624
EMA w/ regional info and B17b MSE(G)	4.266365	0.027425	0.165604	-0.364624
EMA w/ regional info and specified MSE(G)	4.266365	0.027425	0.165604	-0.364624

EMA Estimate of MSE[G at-site]	0.073953
MSE[G at-site systematic]	0.083631
Effective Record Length [G at-site]	93.861780
Grubbs-Beck Critical Value	15,600.000000

--- Final Results ---

<< Plotting Positions >>
Colorado River-CAMEO, CO.-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
	FLOW		Water	FLOW	H-S
Day Mon Year	CFS	Rank	Year	CFS	Plot Pos

11 May 1921	50,249.0	1	1921	50,249.0	0.83
11 May 1922	---	2	1984	39,300.0	1.67
11 May 1923	---	3	1983	36,000.0	2.50
11 May 1924	---	4	1935	36,000.0	3.33
11 May 1925	---	5	1952	32,500.0	5.34
11 May 1926	---	6	1957	31,400.0	6.52
11 May 1927	---	7	1938	31,200.0	7.70
11 May 1928	---	8	2011	29,700.0	8.87
11 May 1929	---	9	1995	29,600.0	10.05
11 May 1930	---	10	1949	27,700.0	11.22
11 May 1931	---	11	1948	27,600.0	12.40
11 May 1932	---	12	1941	27,500.0	13.58
11 May 1933	---	13	1942	26,900.0	14.75
11 May 1934	14,700.0	14	1985	26,500.0	15.93
16 Jun 1935	36,000.0	15	1936	26,500.0	17.10
01 Jun 1936	26,500.0	16	1947	26,400.0	18.28
18 May 1937	20,200.0	17	1997	26,300.0	19.46
06 Jun 1938	31,200.0	18	1958	25,900.0	20.63
23 May 1939	19,900.0	19	2014	25,800.0	21.81
03 Jun 1940	16,600.0	20	1962	25,500.0	22.98
14 May 1941	27,500.0	21	1953	24,700.0	24.16
28 May 1942	26,900.0	22	2010	24,500.0	25.34
03 Jun 1943	22,600.0	23	1993	23,300.0	26.51
31 May 1944	19,000.0	24	1986	23,200.0	27.69
25 Jun 1945	18,800.0	25	2008	23,100.0	28.87
18 Jun 1946	19,400.0	26	1965	23,000.0	30.04
22 Jun 1947	26,400.0	27	1951	22,800.0	31.22
22 May 1948	27,600.0	28	1943	22,600.0	32.39
18 Jun 1949	27,700.0	29	1973	22,400.0	33.57
13 Jun 1950	17,600.0	30	1970	22,000.0	34.75
22 Jun 1951	22,800.0	31	2015	21,800.0	35.92
08 Jun 1952	32,500.0	32	1979	21,600.0	37.10
14 Jun 1953	24,700.0	33	1996	21,500.0	38.27
22 May 1954	8,490.0	34	2003	21,000.0	39.45
09 Jun 1955	10,400.0	35	1956	20,600.0	40.63
03 Jun 1956	20,600.0	36	1980	20,500.0	41.80
01 Jul 1957	31,400.0	37	1937	20,200.0	42.98
30 May 1958	25,900.0	38	1978	20,100.0	44.16
10 Jun 1959	16,400.0	39	2016	20,000.0	45.33
05 Jun 1960	16,700.0	40	1939	19,900.0	46.51
01 Jun 1961	13,100.0	41	2009	19,400.0	47.68
13 May 1962	25,500.0	42	1946	19,400.0	48.86
19 May 1963	8,070.0	43	1971	19,200.0	50.04
25 May 1964	14,000.0	44	1944	19,000.0	51.21
18 Jun 1965	23,000.0	45	1945	18,800.0	52.39
10 May 1966	8,750.0	46	1968	18,400.0	53.56
26 May 1967	14,400.0	47	2006	17,700.0	54.74
06 Jun 1968	18,400.0	48	1950	17,600.0	55.92
28 May 1969	13,300.0	49	1975	17,400.0	57.09
23 May 1970	22,000.0	50	2005	17,200.0	58.27
25 Jun 1971	19,200.0	51	1960	16,700.0	59.45
08 Jun 1972	16,200.0	52	1940	16,600.0	60.62
15 Jun 1973	22,400.0	53	2000	16,400.0	61.80
30 May 1974	16,000.0	54	1959	16,400.0	62.97
16 Jun 1975	17,400.0	55	1972	16,200.0	64.15
06 Jun 1976	11,500.0	56	1974	16,000.0	65.33
07 Jun 1977	4,930.0	57	1998	15,700.0	66.50
16 Jun 1978	20,100.0	58	1999	15,600.0	67.68
29 May 1979	21,600.0	59	1934	14,700.0*	69.55
12 Jun 1980	20,500.0	60	1991	14,400.0*	70.73
10 Jun 1981	10,100.0	61	1967	14,400.0*	71.92
19 Jun 1982	13,600.0	62	1964	14,000.0*	73.10

26 Jun 1983	36,000.0	63	1982	13,600.0*	74.29
26 May 1984	39,300.0	64	1969	13,300.0*	75.47
09 Jun 1985	26,500.0	65	1987	13,100.0*	76.66
07 Jun 1986	23,200.0	66	1961	13,100.0*	77.84
17 May 1987	13,100.0	67	1988	13,000.0*	79.03
07 Jun 1988	13,000.0	68	1994	12,600.0*	80.21
30 May 1989	8,530.0	69	1990	11,700.0*	81.40
11 Jun 1990	11,700.0	70	1976	11,500.0*	82.58
15 Jun 1991	14,400.0	71	2007	10,900.0*	83.77
27 May 1992	8,240.0	72	1955	10,400.0*	84.95
28 May 1993	23,300.0	73	2013	10,300.0*	86.14
02 Jun 1994	12,600.0	74	1981	10,100.0*	87.32
18 Jun 1995	29,600.0	75	2001	9,720.0*	88.51
20 May 1996	21,500.0	76	1966	8,750.0*	89.69
05 Jun 1997	26,300.0	77	1989	8,530.0*	90.88
02 Jun 1998	15,700.0	78	1954	8,490.0*	92.06
10 Jun 1999	15,600.0	79	1992	8,240.0*	93.25
30 May 2000	16,400.0	80	1963	8,070.0*	94.43
02 Jun 2001	9,720.0	81	2004	7,450.0*	95.62
01 Jun 2002	4,260.0	82	1977	4,930.0*	96.80
02 Jun 2003	21,000.0	83	2012	4,440.0*	97.99
08 Jun 2004	7,450.0	84	2002	4,260.0*	99.17
24 May 2005	17,200.0	85	1933	---*	---
23 May 2006	17,700.0	86	1932	---*	---
22 May 2007	10,900.0	87	1931	---*	---
03 Jun 2008	23,100.0	88	1930	---*	---
24 May 2009	19,400.0	89	1929	---*	---
08 Jun 2010	24,500.0	90	1928	---*	---
07 Jun 2011	29,700.0	91	1927	---*	---
24 May 2012	4,440.0	92	1926	---*	---
11 Jun 2013	10,300.0	93	1925	---*	---
02 Jun 2014	25,800.0	94	1924	---*	---
18 Jun 2015	21,800.0	95	1923	---*	---
11 Jun 2016	20,000.0	96	1922	---*	---

* Outlier

* Low outlier plotting positions are computed using Median parameters.

<< Frequency Curve >>

Colorado River-CAMEO, CO.-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Variance Log(EMA)	Percent Chance Exceedance	Confidence Limits 0.16 FLOW, CFS	0.84
46,838.3	0.00221	0.200	53,735.9	42,787.4
43,281.5	0.00152	0.500	48,335.8	40,077.6
40,439.1	0.00112	1.000	44,330.4	37,793.7
37,437.5	0.00081	2.000	40,373.4	35,270.3
34,237.0	0.00060	4.000	36,432.7	32,465.9
29,585.9	0.00044	10.000	31,113.6	28,230.5
25,577.2	0.00037	20.000	26,767.4	24,485.1
18,897.7	0.00039	50.000	19,741.1	17,986.4
13,512.1	0.00115	80.000	14,373.9	12,136.6
11,187.3	0.00241	90.000	12,213.8	9,565.0
9,504.2	0.00427	95.000	10,689.1	7,732.4
6,877.0	0.01098	99.000	8,328.3	4,979.5

<< Systematic Statistics >>

Colorado River-CAMEO, CO.-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.266	Historic Events	0
Standard Dev	0.166	High Outliers	0
Station Skew	-0.365	Low Outliers	26
Regional Skew	0.000	Zero Events	0
Weighted Skew	---	Missing Events	12
Adopted Skew	-0.365	Systematic Events	84
		Historic Period	96

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis
27 Oct 2017 10:58 AM

--- Input Data ---

Analysis Name: @Palisade - 17C
Description:

Data Set Name: Colorado River-PALISADE, CO.-FLOW-ANNUAL PEAK
DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss
DSS Pathname: /COLORADO RIVER/PALISADE, CO./FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Palisade_-_17C\@Palisade_-_17C.rpt
XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Palisade_-_17C\@Palisade_-_17C.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: 0.0
Regional Skew MSE: 0.302

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.16
Lower Confidence Level: 0.84

Use non-standard frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 4.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

<< EMA Representation of Data >>
Colorado River-PALISADE, CO.-FLOW-ANNUAL PEAK

		Value		Threshold		
Year	Peak	Low	High	Low	High	Type
1884	81,339.0	61,004.0	101,674.0	4,260.0	1.0E99	Syst
1885	---	1.0E-99	51,000.0	51,000.0	1.0E99	Cens
1886	---	1.0E-99	51,000.0	51,000.0	1.0E99	Cens

1887	---	1.0E-99	51,000.0	51,000.0	1.0E99	Cens
1888	---	1.0E-99	51,000.0	51,000.0	1.0E99	Cens
1889	---	1.0E-99	51,000.0	51,000.0	1.0E99	Cens
1890	---	1.0E-99	51,000.0	51,000.0	1.0E99	Cens
1891	---	1.0E-99	51,000.0	51,000.0	1.0E99	Cens
1892	---	1.0E-99	51,000.0	51,000.0	1.0E99	Cens
1893	---	1.0E-99	51,000.0	51,000.0	1.0E99	Cens
1894	---	1.0E-99	51,000.0	51,000.0	1.0E99	Cens
1895	---	1.0E-99	51,000.0	51,000.0	1.0E99	Cens
1896	---	1.0E-99	51,000.0	51,000.0	1.0E99	Cens
1897	---	1.0E-99	51,000.0	51,000.0	1.0E99	Cens
1898	---	1.0E-99	51,000.0	51,000.0	1.0E99	Cens
1899	---	1.0E-99	51,000.0	51,000.0	1.0E99	Cens
1900	---	1.0E-99	51,000.0	51,000.0	1.0E99	Cens
1901	---	1.0E-99	51,000.0	51,000.0	1.0E99	Cens
1902	18,400.0	13,800.0	23,000.0	4,260.0	1.0E99	Syst
1903	26,500.0	19,875.0	33,125.0	4,260.0	1.0E99	Syst
1904	25,300.0	18,975.0	31,625.0	4,260.0	1.0E99	Syst
1905	37,200.0	27,900.0	46,500.0	4,260.0	1.0E99	Syst
1906	37,200.0	27,900.0	46,500.0	4,260.0	1.0E99	Syst
1907	30,800.0	23,100.0	38,500.0	4,260.0	1.0E99	Syst
1908	21,300.0	15,975.0	26,625.0	4,260.0	1.0E99	Syst
1909	43,400.0	32,550.0	54,250.0	4,260.0	1.0E99	Syst
1910	27,400.0	20,550.0	34,250.0	4,260.0	1.0E99	Syst
1911	26,300.0	19,725.0	32,875.0	4,260.0	1.0E99	Syst
1912	45,200.0	33,900.0	56,500.0	4,260.0	1.0E99	Syst
1913	21,800.0	16,350.0	27,250.0	4,260.0	1.0E99	Syst
1914	43,200.0	32,400.0	54,000.0	4,260.0	1.0E99	Syst
1915	21,500.0	16,125.0	26,875.0	4,260.0	1.0E99	Syst
1916	26,300.0	19,725.0	32,875.0	4,260.0	1.0E99	Syst
1917	51,000.0	38,250.0	63,750.0	4,260.0	1.0E99	Syst
1918	49,500.0	37,125.0	61,875.0	4,260.0	1.0E99	Syst
1919	22,000.0	16,500.0	27,500.0	4,260.0	1.0E99	Syst
1920	43,000.0	32,250.0	53,750.0	4,260.0	1.0E99	Syst
1921	52,400.0	39,300.0	65,500.0	4,260.0	1.0E99	Syst
1922	31,300.0	23,475.0	39,125.0	4,260.0	1.0E99	Syst
1923	31,300.0	23,475.0	39,125.0	4,260.0	1.0E99	Syst
1924	37,900.0	28,425.0	47,375.0	4,260.0	1.0E99	Syst
1925	19,200.0	14,400.0	24,000.0	4,260.0	1.0E99	Syst
1926	34,300.0	25,725.0	42,875.0	4,260.0	1.0E99	Syst
1927	31,300.0	23,475.0	39,125.0	4,260.0	1.0E99	Syst
1928	44,400.0	33,300.0	55,500.0	4,260.0	1.0E99	Syst
1929	38,900.0	29,175.0	48,625.0	4,260.0	1.0E99	Syst
1930	26,800.0	20,100.0	33,500.0	4,260.0	1.0E99	Syst
1931	15,200.0	11,400.0	19,000.0	4,260.0	1.0E99	Syst
1932	30,800.0	23,100.0	38,500.0	4,260.0	1.0E99	Syst
1933	37,100.0	27,825.0	46,375.0	4,260.0	1.0E99	Syst

Fitted log10 Moments	Mean	Variance	Std Dev	Skew
EMA at-site data w/o regional info	4.483985	0.017023	0.130470	0.148306
EMA w/ regional info and B17b MSE(G)	4.483985	0.017023	0.130470	0.148306
EMA w/ regional info and specified MSE(G)	4.483985	0.017023	0.130470	0.148306

EMA Estimate of MSE[G at-site]	0.144497
MSE[G at-site systematic]	0.480689
Effective Record Length [G at-site]	33.266415
Grubbs-Beck Critical Value	4,260.000000

--- Final Results ---

<< Plotting Positions >>
Colorado River-PALISADE, CO.-FLOW-ANNUAL PEAK

Events Analyzed				Ordered Events			
			FLOW		Water	FLOW	H-S
Day	Mon	Year	CFS	Rank	Year	CFS	Plot Pos
17	May	1884	81,339.0	1	1884	81,339.0	1.00
17	May	1885	---	2	1921	52,400.0	4.97
17	May	1886	---	3	1917	51,000.0	7.94
17	May	1887	---	4	1918	49,500.0	10.91
17	May	1888	---	5	1912	45,200.0	13.88
17	May	1889	---	6	1928	44,400.0	16.85
17	May	1890	---	7	1909	43,400.0	19.82
17	May	1891	---	8	1914	43,200.0	22.79
17	May	1892	---	9	1920	43,000.0	25.76
17	May	1893	---	10	1929	38,900.0	28.73
17	May	1894	---	11	1924	37,900.0	31.70
17	May	1895	---	12	1906	37,200.0	34.67
17	May	1896	---	13	1905	37,200.0	37.64
17	May	1897	---	14	1933	37,100.0	40.61
17	May	1898	---	15	1926	34,300.0	43.58
17	May	1899	---	16	1927	31,300.0	46.55
17	May	1900	---	17	1923	31,300.0	49.52
17	May	1901	---	18	1922	31,300.0	52.48
17	May	1902	18,400.0	19	1932	30,800.0	55.45
18	Jun	1903	26,500.0	20	1907	30,800.0	58.42
25	May	1904	25,300.0	21	1910	27,400.0	61.39
05	Jun	1905	37,200.0	22	1930	26,800.0	64.36
14	Jun	1906	37,200.0	23	1903	26,500.0	67.33
18	Jun	1907	30,800.0	24	1916	26,300.0	70.30
12	Jun	1908	21,300.0	25	1911	26,300.0	73.27
20	Jun	1909	43,400.0	26	1904	25,300.0	76.24
01	Jun	1910	27,400.0	27	1919	22,000.0	79.21
09	Jun	1911	26,300.0	28	1913	21,800.0	82.18
10	Jun	1912	45,200.0	29	1915	21,500.0	85.15
01	Jun	1913	21,800.0	30	1908	21,300.0	88.12
03	Jun	1914	43,200.0	31	1925	19,200.0	91.09
21	Jun	1915	21,500.0	32	1902	18,400.0	94.06
13	Jun	1916	26,300.0	33	1931	15,200.0	97.03
19	Jun	1917	51,000.0	34	1901	---*	---
14	Jun	1918	49,500.0	35	1900	---*	---
30	May	1919	22,000.0	36	1899	---*	---
01	Jun	1920	43,000.0	37	1898	---*	---
16	Jun	1921	52,400.0	38	1897	---*	---
29	May	1922	31,300.0	39	1896	---*	---
17	Jun	1923	31,300.0	40	1895	---*	---
16	Jun	1924	37,900.0	41	1894	---*	---
31	May	1925	19,200.0	42	1893	---*	---
07	Jun	1926	34,300.0	43	1892	---*	---
20	May	1927	31,300.0	44	1891	---*	---

01 Jun 1928	44,400.0	45	1890	---*	---
10 Jun 1929	38,900.0	46	1889	---*	---
01 Jun 1930	26,800.0	47	1888	---*	---
08 Jun 1931	15,200.0	48	1887	---*	---
23 May 1932	30,800.0	49	1886	---*	---
02 Jun 1933	37,100.0	50	1885	---*	---

* Low outlier plotting positions are computed using Median parameters.

<< Frequency Curve >>
Colorado River-PALISADE, CO.-FLOW-ANNUAL PEAK

Computed Curve	Variance Log(EMA)	Percent Chance Exceedance	Confidence Limits 0.16	0.84
FLOW, CFS			FLOW, CFS	
76,392.0	0.00547	0.200	96,084.8	66,654.5
68,896.6	0.00374	0.500	82,970.4	61,406.2
63,336.2	0.00271	1.000	73,918.1	57,303.8
57,836.0	0.00190	2.000	65,535.6	53,047.5
52,350.1	0.00130	4.000	57,757.8	48,588.3
44,990.9	0.00081	10.000	48,296.2	42,255.7
39,151.3	0.00063	20.000	41,533.5	36,967.2
30,252.5	0.00057	50.000	31,941.8	28,609.7
23,623.5	0.00064	80.000	25,004.2	22,214.7
20,844.4	0.00082	90.000	22,171.9	19,342.2
18,837.3	0.00116	95.000	20,199.9	17,156.6
15,658.8	0.00261	99.000	17,302.7	13,553.6

<< Systematic Statistics >>
Colorado River-PALISADE, CO.-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.484	Historic Events	0
Standard Dev	0.130	High Outliers	0
Station Skew	0.148	Low Outliers	0
Regional Skew	0.000	Zero Events	0
Weighted Skew	---	Missing Events	17
Adopted Skew	0.148	Systematic Events	33
		Historic Period	50

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis
03 Nov 2017 12:29 PM

--- Input Data ---

Analysis Name: @Grand Valley Div - 17C
Description:

Data Set Name: Colorado River- BELOW PALISADE
DSS File Name: \\den-fs1\DVOFFICE\PUBLIC\P_Drive\3279 Project files- Water Group\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss
DSS Pathname: /COLO RIVER BELOW GRAND VALLEY DIV/PALISADE, CO/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: \\den-fs1\DVOFFICE\PUBLIC\P_Drive\3279 Project files- Water Group\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Grand_Valley_Div_-_17C\@Grand_Valley_Div_-_17C.rpt
XML File Name: \\den-fs1\DVOFFICE\PUBLIC\P_Drive\3279 Project files- Water Group\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Grand_Valley_Div_-_17C\@Grand_Valley_Div_-_17C.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.16
Lower Confidence Level: 0.84

Use non-standard frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 4.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

<< EMA Representation of Data >>
Colorado River- BELOW PALISADE

	Value	Threshold	

Year	Peak	Low	High	Low	High	Type
1884	81,785.0	61,339.0	102,231.0	1.0E-99	1.0E99	Hist
1885	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1886	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1887	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1888	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1889	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1890	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1891	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1892	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1893	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1894	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1895	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1896	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1897	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1898	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1899	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1900	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1901	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1902	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1903	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1904	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1905	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1906	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1907	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1908	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1909	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1910	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1911	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1912	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1913	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1914	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1915	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1916	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1917	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1918	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1919	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1920	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1921	53,062.0	39,797.0	66,328.0	1.0E-99	1.0E99	Syst
1922	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1923	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1924	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1925	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1926	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1927	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1928	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1929	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1930	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1931	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1932	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1933	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1934	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1935	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1936	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1937	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1938	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1939	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1940	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1941	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1942	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1943	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1944	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens

1945	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1946	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1947	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1948	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1949	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1950	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1951	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1952	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1953	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1954	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1955	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1956	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1957	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1958	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1959	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1960	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1961	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1962	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1963	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1964	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1965	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1966	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1967	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1968	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1969	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1970	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1971	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1972	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1973	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1974	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1975	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1976	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1977	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1978	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1979	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1980	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1981	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1982	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1983	---	1.0E-99	42,000.0	42,000.0	1.0E99	Cens
1984	42,065.0	42,065.0	42,065.0	1.0E-99	1.0E99	Syst
1985	---	1.0E-99	28,364.0	28,364.0	1.0E99	Cens
1986	---	1.0E-99	28,364.0	28,364.0	1.0E99	Cens
1987	---	1.0E-99	28,364.0	28,364.0	1.0E99	Cens
1988	---	1.0E-99	28,364.0	28,364.0	1.0E99	Cens
1989	---	1.0E-99	28,364.0	28,364.0	1.0E99	Cens
1990	---	1.0E-99	28,364.0	28,364.0	1.0E99	Cens
1991	14,100.0	14,100.0	14,100.0	1.0E-99	1.0E99	Syst
1992	8,070.0	8,070.0	8,070.0	1.0E-99	1.0E99	Syst
1993	27,400.0	27,400.0	27,400.0	1.0E-99	1.0E99	Syst
1994	11,600.0	11,600.0	11,600.0	1.0E-99	1.0E99	Syst
1995	29,600.0	29,600.0	31,376.0	1.0E-99	1.0E99	Syst
1996	21,500.0	21,500.0	21,500.0	1.0E-99	1.0E99	Syst
1997	28,400.0	28,400.0	28,400.0	1.0E-99	1.0E99	Syst
1998	14,800.0	14,800.0	14,800.0	1.0E-99	1.0E99	Syst
1999	13,300.0	13,300.0	13,300.0	1.0E-99	1.0E99	Syst
2000	14,400.0	14,400.0	14,400.0	1.0E-99	1.0E99	Syst
2001	8,010.0	8,010.0	8,010.0	1.0E-99	1.0E99	Syst
2002	4,520.0	4,520.0	4,520.0	1.0E-99	1.0E99	Syst
2003	21,500.0	21,500.0	21,500.0	1.0E-99	1.0E99	Syst
2004	5,970.0	5,970.0	5,970.0	1.0E-99	1.0E99	Syst
2005	19,300.0	19,300.0	19,300.0	1.0E-99	1.0E99	Syst
2006	18,000.0	18,000.0	18,000.0	1.0E-99	1.0E99	Syst
2007	10,300.0	10,300.0	10,300.0	1.0E-99	1.0E99	Syst

2008	25,000.0	25,000.0	25,000.0	1.0E-99	1.0E99	Syst
2009	18,900.0	18,900.0	18,900.0	1.0E-99	1.0E99	Syst
2010	25,600.0	25,600.0	25,600.0	1.0E-99	1.0E99	Syst
2011	32,700.0	32,700.0	32,700.0	1.0E-99	1.0E99	Syst
2012	5,170.0	5,170.0	5,170.0	1.0E-99	1.0E99	Syst
2013	8,930.0	8,930.0	8,930.0	1.0E-99	1.0E99	Syst
2014	25,200.0	25,200.0	25,200.0	1.0E-99	1.0E99	Syst
2015	20,800.0	20,800.0	20,800.0	1.0E-99	1.0E99	Syst
2016	18,500.0	18,500.0	18,500.0	1.0E-99	1.0E99	Syst

Fitted log10 Moments	Mean	Variance	Std Dev	Skew
EMA at-site data w/o regional info	4.180342	0.063457	0.251907	-0.407235
EMA w/ regional info and B17b MSE(G)	4.180342	0.063457	0.251907	-0.407235
EMA w/ regional info and specified MSE(G)	4.180342	0.063457	0.251907	-0.407235

EMA Estimate of MSE[G at-site]	0.117549
MSE[G at-site systematic]	0.227217
Effective Record Length [G at-site]	50.256921
Grubbs-Beck Critical Value	0.000000

--- Final Results ---

<< Plotting Positions >>
Colorado River- BELOW PALISADE

Events Analyzed		Ordered Events			
Day Mon Year	FLOW CFS	Rank	Water Year	FLOW CFS	H-S Plot Pos
15 Jun 1884	81,785.0	1	1884	81,785.0	0.56
01 Jan 1885	---	2	1921	53,062.0	1.13
01 Jan 1886	---	3	1984	42,065.0	1.69
01 Jan 1887	---	4	2011	32,700.0	4.55
01 Jan 1888	---	5	1995	29,600.0	6.84
01 Jan 1889	---	6	1997	28,400.0	9.13
01 Jan 1890	---	7	1993	27,400.0	15.11
01 Jan 1891	---	8	2010	25,600.0	18.80
01 Jan 1892	---	9	2014	25,200.0	22.49
01 Jan 1893	---	10	2008	25,000.0	26.18
01 Jan 1894	---	11	2003	21,500.0	29.87
01 Jan 1895	---	12	1996	21,500.0	33.56
01 Jan 1896	---	13	2015	20,800.0	37.26
01 Jan 1897	---	14	2005	19,300.0	40.95
01 Jan 1898	---	15	2009	18,900.0	44.64
01 Jan 1899	---	16	2016	18,500.0	48.33
01 Jan 1900	---	17	2006	18,000.0	52.02
01 Jan 1901	---	18	1998	14,800.0	55.71
01 Jan 1902	---	19	2000	14,400.0	59.40

01 Jan 1903	---	20	1991	14,100.0	63.09
01 Jan 1904	---	21	1999	13,300.0	66.78
01 Jan 1905	---	22	1994	11,600.0	70.47
01 Jan 1906	---	23	2007	10,300.0	74.16
01 Jan 1907	---	24	2013	8,930.0	77.85
01 Jan 1908	---	25	1992	8,070.0	81.55
01 Jan 1909	---	26	2001	8,010.0	85.24
01 Jan 1910	---	27	2004	5,970.0	88.93
01 Jan 1911	---	28	2012	5,170.0	92.62
01 Jan 1912	---	29	2002	4,520.0	96.31
01 Jan 1913	---	30	1990	---*	---
01 Jan 1914	---	31	1989	---*	---
01 Jan 1915	---	32	1988	---*	---
01 Jan 1916	---	33	1987	---*	---
01 Jan 1917	---	34	1986	---*	---
01 Jan 1918	---	35	1985	---*	---
01 Jan 1919	---	36	1983	---*	---
01 Jan 1920	---	37	1982	---*	---
15 Jun 1921	53,062.0	38	1981	---*	---
01 Jan 1922	---	39	1980	---*	---
01 Jan 1923	---	40	1979	---*	---
01 Jan 1924	---	41	1978	---*	---
01 Jan 1925	---	42	1977	---*	---
01 Jan 1926	---	43	1976	---*	---
01 Jan 1927	---	44	1975	---*	---
01 Jan 1928	---	45	1974	---*	---
01 Jan 1929	---	46	1973	---*	---
01 Jan 1930	---	47	1972	---*	---
01 Jan 1931	---	48	1971	---*	---
01 Jan 1932	---	49	1970	---*	---
01 Jan 1933	---	50	1969	---*	---
01 Jan 1934	---	51	1968	---*	---
01 Jan 1935	---	52	1967	---*	---
01 Jan 1936	---	53	1966	---*	---
01 Jan 1937	---	54	1965	---*	---
01 Jan 1938	---	55	1964	---*	---
01 Jan 1939	---	56	1963	---*	---
01 Jan 1940	---	57	1962	---*	---
01 Jan 1941	---	58	1961	---*	---
01 Jan 1942	---	59	1960	---*	---
01 Jan 1943	---	60	1959	---*	---
01 Jan 1944	---	61	1958	---*	---
01 Jan 1945	---	62	1957	---*	---
01 Jan 1946	---	63	1956	---*	---
01 Jan 1947	---	64	1955	---*	---
01 Jan 1948	---	65	1954	---*	---
01 Jan 1949	---	66	1953	---*	---
01 Jan 1950	---	67	1952	---*	---
01 Jan 1951	---	68	1951	---*	---
01 Jan 1952	---	69	1950	---*	---
01 Jan 1953	---	70	1949	---*	---
01 Jan 1954	---	71	1948	---*	---
01 Jan 1955	---	72	1947	---*	---
01 Jan 1956	---	73	1946	---*	---
01 Jan 1957	---	74	1945	---*	---
01 Jan 1958	---	75	1944	---*	---
01 Jan 1959	---	76	1943	---*	---
01 Jan 1960	---	77	1942	---*	---
01 Jan 1961	---	78	1941	---*	---
01 Jan 1962	---	79	1940	---*	---
01 Jan 1963	---	80	1939	---*	---
01 Jan 1964	---	81	1938	---*	---
01 Jan 1965	---	82	1937	---*	---

01 Jan 1966	---	83	1936	---*	---
01 Jan 1967	---	84	1935	---*	---
01 Jan 1968	---	85	1934	---*	---
01 Jan 1969	---	86	1933	---*	---
01 Jan 1970	---	87	1932	---*	---
01 Jan 1971	---	88	1931	---*	---
01 Jan 1972	---	89	1930	---*	---
01 Jan 1973	---	90	1929	---*	---
01 Jan 1974	---	91	1928	---*	---
01 Jan 1975	---	92	1927	---*	---
01 Jan 1976	---	93	1926	---*	---
01 Jan 1977	---	94	1925	---*	---
01 Jan 1978	---	95	1924	---*	---
01 Jan 1979	---	96	1923	---*	---
01 Jan 1980	---	97	1922	---*	---
01 Jan 1981	---	98	1920	---*	---
01 Jan 1982	---	99	1919	---*	---
01 Jan 1983	---	100	1918	---*	---
15 Jun 1984	42,065.0	101	1917	---*	---
15 Jun 1985	---	102	1916	---*	---
15 Jun 1986	---	103	1915	---*	---
15 Jun 1987	---	104	1914	---*	---
15 Jun 1988	---	105	1913	---*	---
15 Jun 1989	---	106	1912	---*	---
15 Jun 1990	---	107	1911	---*	---
15 Jun 1991	14,100.0	108	1910	---*	---
28 May 1992	8,070.0	109	1909	---*	---
29 May 1993	27,400.0	110	1908	---*	---
02 Jun 1994	11,600.0	111	1907	---*	---
17 Jun 1995	29,600.0	112	1906	---*	---
20 May 1996	21,500.0	113	1905	---*	---
06 Jun 1997	28,400.0	114	1904	---*	---
22 May 1998	14,800.0	115	1903	---*	---
09 Jun 1999	13,300.0	116	1902	---*	---
30 May 2000	14,400.0	117	1901	---*	---
20 May 2001	8,010.0	118	1900	---*	---
14 Mar 2002	4,520.0	119	1899	---*	---
02 Jun 2003	21,500.0	120	1898	---*	---
08 Jun 2004	5,970.0	121	1897	---*	---
23 May 2005	19,300.0	122	1896	---*	---
23 May 2006	18,000.0	123	1895	---*	---
20 May 2007	10,300.0	124	1894	---*	---
03 Jun 2008	25,000.0	125	1893	---*	---
24 May 2009	18,900.0	126	1892	---*	---
08 Jun 2010	25,600.0	127	1891	---*	---
07 Jun 2011	32,700.0	128	1890	---*	---
07 Nov 2011	5,170.0	129	1889	---*	---
18 May 2013	8,930.0	130	1888	---*	---
02 Jun 2014	25,200.0	131	1887	---*	---
12 Jun 2015	20,800.0	132	1886	---*	---
08 Jun 2016	18,500.0	133	1885	---*	---

* Low outlier plotting positions are computed using Median parameters.

<< Frequency Curve >>
Colorado River- BELOW PALISADE

Computed Curve FLOW, CFS	Variance Log(EMA)	Percent Chance Exceedance	Confidence Limits 0.16 FLOW, CFS	0.84

60,623.3	0.00470	0.200	73,085.9	52,851.0
54,084.9	0.00303	0.500	62,781.0	48,352.0
48,998.8	0.00213	1.000	55,377.9	44,460.5
43,774.2	0.00154	2.000	48,293.9	40,072.6
38,383.8	0.00125	4.000	41,608.7	35,224.3
30,917.9	0.00130	10.000	33,444.1	28,305.5
24,875.7	0.00159	20.000	27,245.5	22,632.0
15,754.2	0.00225	50.000	17,586.1	14,073.1
9,437.0	0.00354	80.000	10,730.4	8,093.6
7,055.5	0.00541	90.000	8,209.4	5,767.7
5,482.0	0.00830	95.000	6,565.0	4,215.1
3,313.0	0.01940	99.000	4,292.6	2,146.1

<< Systematic Statistics >>
Colorado River- BELOW PALISADE

Log Transform: FLOW, CFS		Number of Events	
Mean	4.180	Historic Events	1
Standard Dev	0.252	High Outliers	0
Station Skew	-0.407	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	104
Adopted Skew	-0.407	Systematic Events	28
		Historic Period	133

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis
02 Nov 2017   10:16 AM

--- Input Data ---

Analysis Name: @Fruita - 17C
Description:

Data Set Name: Colorado River-FRUITA, CO.-FLOW-ANNUAL PEAK
DSS File Name: \\den-fs1\DVOFFICE\PUBLIC\P_Drive\3279 Project files- Water Group\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss
DSS Pathname: /COLORADO RIVER/FRUITA, CO./FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: \\den-fs1\DVOFFICE\PUBLIC\P_Drive\3279 Project files- Water Group\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Fruita_-_17C\@Fruita_-_17C.rpt
XML File Name: \\den-fs1\DVOFFICE\PUBLIC\P_Drive\3279 Project files- Water Group\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Fruita_-_17C\@Fruita_-_17C.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: 0.0
Regional Skew MSE: 0.302

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.16
Lower Confidence Level: 0.84

Use non-standard frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 4.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

<< EMA Representation of Data >>
Colorado River-FRUITA, CO.-FLOW-ANNUAL PEAK

		Value		Threshold		
Year	Peak	Low	High	Low	High	Type

1884	125,000.0	93,750.0	156,250.0	1.0E-99	1.0E99	Hist
1885	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1886	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1887	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1888	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1889	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1890	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1891	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1892	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1893	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1894	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1895	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1896	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1897	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1898	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1899	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1900	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1901	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1902	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1903	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1904	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1905	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1906	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1907	---	1.0E-99	81,100.0	81,100.0	1.0E99	Cens
1908	27,300.0	20,475.0	34,125.0	1.0E-99	1.0E99	Syst
1909	64,000.0	48,000.0	80,000.0	1.0E-99	1.0E99	Syst
1910	34,100.0	25,575.0	42,625.0	1.0E-99	1.0E99	Syst
1911	38,800.0	38,800.0	38,800.0	1.0E-99	1.0E99	Syst
1912	59,600.0	59,600.0	59,600.0	1.0E-99	1.0E99	Syst
1913	27,600.0	27,600.0	27,600.0	1.0E-99	1.0E99	Syst
1914	59,600.0	59,600.0	59,600.0	1.0E-99	1.0E99	Syst
1915	27,600.0	27,600.0	27,600.0	1.0E-99	1.0E99	Syst
1916	39,600.0	39,600.0	39,600.0	1.0E-99	1.0E99	Syst
1917	64,000.0	64,000.0	64,000.0	1.0E-99	1.0E99	Syst
1918	57,000.0	57,000.0	57,000.0	1.0E-99	1.0E99	Syst
1919	32,200.0	32,200.0	32,200.0	1.0E-99	1.0E99	Syst
1920	79,100.0	79,100.0	79,100.0	1.0E-99	1.0E99	Syst
1921	81,100.0	81,100.0	81,100.0	1.0E-99	1.0E99	Syst
1922	54,100.0	54,100.0	54,100.0	1.0E-99	1.0E99	Syst
1923	51,100.0	51,100.0	51,100.0	1.0E-99	1.0E99	Syst

Fitted log10 Moments	Mean	Variance	Std Dev	Skew
EMA at-site data w/o regional info	4.662375	0.025665	0.160202	-0.012836
EMA w/ regional info and B17b MSE(G)	4.662375	0.025665	0.160202	-0.012846
EMA w/ regional info and specified MSE(G)	4.662375	0.025665	0.160202	-0.012790

EMA Estimate of MSE[G at-site]	0.206313
MSE[G at-site systematic]	0.366691
Effective Record Length [G at-site]	23.105629
Grubbs-Beck Critical Value	0.000000

--- Final Results ---

<< Plotting Positions >>
Colorado River-FRUITA, CO.-FLOW-ANNUAL PEAK

Events Analyzed Day Mon Year	FLOW CFS	Rank	Water Year	FLOW CFS	H-S Plot Pos
04 Jul 1884	125,000.0	1	1884	125,000.0	1.67
01 Jan 1885	---	2	1921	81,100.0	3.33
01 Jan 1886	---	3	1920	79,100.0	10.94
01 Jan 1887	---	4	1917	64,000.0	16.88
01 Jan 1888	---	5	1909	64,000.0	22.81
01 Jan 1889	---	6	1914	59,600.0	28.75
01 Jan 1890	---	7	1912	59,600.0	34.69
01 Jan 1891	---	8	1918	57,000.0	40.62
01 Jan 1892	---	9	1922	54,100.0	46.56
01 Jan 1893	---	10	1923	51,100.0	52.50
01 Jan 1894	---	11	1916	39,600.0	58.44
01 Jan 1895	---	12	1911	38,800.0	64.38
01 Jan 1896	---	13	1910	34,100.0	70.31
01 Jan 1897	---	14	1919	32,200.0	76.25
01 Jan 1898	---	15	1915	27,600.0	82.19
01 Jan 1899	---	16	1913	27,600.0	88.12
01 Jan 1900	---	17	1908	27,300.0	94.06
01 Jan 1901	---	18	1907	---*	---
01 Jan 1902	---	19	1906	---*	---
01 Jan 1903	---	20	1905	---*	---
01 Jan 1904	---	21	1904	---*	---
01 Jan 1905	---	22	1903	---*	---
01 Jan 1906	---	23	1902	---*	---
01 Jan 1907	---	24	1901	---*	---
13 Jun 1908	27,300.0	25	1900	---*	---
09 Jun 1909	64,000.0	26	1899	---*	---
04 Jun 1910	34,100.0	27	1898	---*	---
10 Jun 1911	38,800.0	28	1897	---*	---
07 Jun 1912	59,600.0	29	1896	---*	---
28 May 1913	27,600.0	30	1895	---*	---
03 Jun 1914	59,600.0	31	1894	---*	---
12 Jun 1915	27,600.0	32	1893	---*	---
14 Jun 1916	39,600.0	33	1892	---*	---
20 Jun 1917	64,000.0	34	1891	---*	---
14 Jun 1918	57,000.0	35	1890	---*	---
29 May 1919	32,200.0	36	1889	---*	---
23 May 1920	79,100.0	37	1888	---*	---
16 Jun 1921	81,100.0	38	1887	---*	---
29 May 1922	54,100.0	39	1886	---*	---
29 May 1923	51,100.0	40	1885	---*	---

* Low outlier plotting positions are computed using Median parameters.

<< Frequency Curve >>
Colorado River-FRUITA, CO.-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Variance Log(EMA)	Percent Chance Exceedance	Confidence Limits 0.16 FLOW, CFS	0.84

132,122.4	0.00951	0.200	178,150.2	111,638.6
118,332.6	0.00644	0.500	150,561.8	102,665.1
108,032.4	0.00463	1.000	131,838.1	95,432.7
97,789.1	0.00324	2.000	114,754.9	87,707.0
87,525.1	0.00226	4.000	99,156.7	79,383.8
73,699.0	0.00153	10.000	80,713.6	67,369.3
62,705.2	0.00136	20.000	67,999.6	57,390.6
45,995.6	0.00149	50.000	50,134.2	41,855.6
33,701.2	0.00189	80.000	37,175.0	30,074.9
28,631.8	0.00248	90.000	31,907.3	24,847.7
25,019.8	0.00343	95.000	28,252.9	20,954.5
19,417.0	0.00725	99.000	22,910.2	14,785.1

<< Systematic Statistics >>
Colorado River-FRUITA, CO.-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.662	Historic Events	1
Standard Dev	0.160	High Outliers	0
Station Skew	-0.013	Low Outliers	0
Regional Skew	0.000	Zero Events	0
Weighted Skew	---	Missing Events	23
Adopted Skew	-0.013	Systematic Events	16
		Historic Period	40

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis
02 Nov 2017   02:06 PM

--- Input Data ---

Analysis Name: @State Line - 17C
Description:

Data Set Name: COLORADO RIVER-COLORADO-UTAH STATE LINE-FLOW-ANNUAL PEAK
DSS File Name: \\den-fs1\DVOFFICE\PUBLIC\P_Drive\3279 Project files- Water Group\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss
DSS Pathname: /COLORADO RIVER/COLORADO-UTAH STATE LINE/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: \\den-fs1\DVOFFICE\PUBLIC\P_Drive\3279 Project files- Water Group\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@State_Line_-_17C\@State_Line_-_17C.rpt
XML File Name: \\den-fs1\DVOFFICE\PUBLIC\P_Drive\3279 Project files- Water Group\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@State_Line_-_17C\@State_Line_-_17C.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.16
Lower Confidence Level: 0.84

Use non-standard frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 5.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

<< EMA Representation of Data >>
COLORADO RIVER-COLORADO-UTAH STATE LINE-FLOW-ANNUAL PEAK

		Value		Threshold		
Year	Peak	Low	High	Low	High	Type

1884	128,753.0	96,564.7	160,941.0	9,450.0	1.0E99	Hist
1885	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1886	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1887	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1888	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1889	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1890	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1891	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1892	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1893	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1894	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1895	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1896	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1897	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1898	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1899	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1900	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1901	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1902	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1903	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1904	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1905	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1906	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1907	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1908	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1909	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1910	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1911	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1912	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1913	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1914	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1915	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1916	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1917	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1918	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1919	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1920	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1921	83,535.0	62,651.0	104,419.0	9,450.0	1.0E99	Hist
1922	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1923	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1924	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1925	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1926	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1927	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1928	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1929	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1930	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1931	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1932	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1933	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1934	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1935	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1936	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1937	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1938	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1939	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1940	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1941	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1942	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1943	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1944	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1945	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1946	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens

1947	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1948	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1949	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1950	---	1.0E-99	62,100.0	62,100.0	1.0E99	Cens
1951	30,200.0	30,200.0	30,200.0	9,450.0	1.0E99	Syst
1952	52,000.0	52,000.0	52,000.0	9,450.0	1.0E99	Syst
1953	37,300.0	37,300.0	37,300.0	9,450.0	1.0E99	Syst
1954	11,600.0	11,600.0	11,600.0	9,450.0	1.0E99	Syst
1955	17,100.0	17,100.0	17,100.0	9,450.0	1.0E99	Syst
1956	28,900.0	28,900.0	28,900.0	9,450.0	1.0E99	Syst
1957	56,800.0	56,800.0	56,800.0	9,450.0	1.0E99	Syst
1958	45,000.0	45,000.0	45,000.0	9,450.0	1.0E99	Syst
1959	23,200.0	23,200.0	23,200.0	9,450.0	1.0E99	Syst
1960	24,700.0	24,700.0	24,700.0	9,450.0	1.0E99	Syst
1961	19,300.0	19,300.0	19,300.0	9,450.0	1.0E99	Syst
1962	40,500.0	40,500.0	40,500.0	9,450.0	1.0E99	Syst
1963	11,300.0	11,300.0	11,300.0	9,450.0	1.0E99	Syst
1964	27,300.0	27,300.0	27,300.0	9,450.0	1.0E99	Syst
1965	36,400.0	36,400.0	36,400.0	9,450.0	1.0E99	Syst
1966	14,400.0	14,400.0	14,400.0	9,450.0	1.0E99	Syst
1967	19,400.0	19,400.0	19,400.0	9,450.0	1.0E99	Syst
1968	26,600.0	26,600.0	26,600.0	9,450.0	1.0E99	Syst
1969	20,400.0	20,400.0	20,400.0	9,450.0	1.0E99	Syst
1970	33,000.0	33,000.0	33,000.0	9,450.0	1.0E99	Syst
1971	22,200.0	22,200.0	22,200.0	9,450.0	1.0E99	Syst
1972	18,400.0	18,400.0	18,400.0	9,450.0	1.0E99	Syst
1973	35,000.0	35,000.0	35,000.0	9,450.0	1.0E99	Syst
1974	22,800.0	22,800.0	22,800.0	9,450.0	1.0E99	Syst
1975	26,300.0	26,300.0	26,300.0	9,450.0	1.0E99	Syst
1976	14,400.0	14,400.0	14,400.0	9,450.0	1.0E99	Syst
1977	5,080.0	1.0E-6	9,450.0	9,450.0	1.0E99	Syst
1978	27,800.0	27,800.0	27,800.0	9,450.0	1.0E99	Syst
1979	36,000.0	36,000.0	36,000.0	9,450.0	1.0E99	Syst
1980	32,100.0	32,100.0	32,100.0	9,450.0	1.0E99	Syst
1981	12,100.0	12,100.0	12,100.0	9,450.0	1.0E99	Syst
1982	19,300.0	19,300.0	19,300.0	9,450.0	1.0E99	Syst
1983	62,100.0	62,100.0	62,100.0	9,450.0	1.0E99	Syst
1984	69,800.0	69,800.0	69,800.0	9,450.0	1.0E99	Syst
1985	39,300.0	39,300.0	39,300.0	9,450.0	1.0E99	Syst
1986	33,800.0	33,800.0	33,800.0	9,450.0	1.0E99	Syst
1987	22,500.0	22,500.0	22,500.0	9,450.0	1.0E99	Syst
1988	15,400.0	15,400.0	15,400.0	9,450.0	1.0E99	Syst
1989	9,970.0	9,970.0	9,970.0	9,450.0	1.0E99	Syst
1990	12,600.0	12,600.0	12,600.0	9,450.0	1.0E99	Syst
1991	19,800.0	19,800.0	19,800.0	9,450.0	1.0E99	Syst
1992	16,500.0	16,500.0	16,500.0	9,450.0	1.0E99	Syst
1993	44,300.0	44,300.0	44,300.0	9,450.0	1.0E99	Syst
1994	13,600.0	13,600.0	13,600.0	9,450.0	1.0E99	Syst
1995	49,300.0	49,300.0	49,300.0	9,450.0	1.0E99	Syst
1996	29,100.0	29,100.0	29,100.0	9,450.0	1.0E99	Syst
1997	37,500.0	37,500.0	37,500.0	9,450.0	1.0E99	Syst
1998	26,100.0	26,100.0	26,100.0	9,450.0	1.0E99	Syst
1999	17,900.0	17,900.0	17,900.0	9,450.0	1.0E99	Syst
2000	17,900.0	17,900.0	17,900.0	9,450.0	1.0E99	Syst
2001	13,200.0	13,200.0	13,200.0	9,450.0	1.0E99	Syst
2002	5,520.0	1.0E-6	9,450.0	9,450.0	1.0E99	Syst
2003	26,100.0	26,100.0	26,100.0	9,450.0	1.0E99	Syst
2004	9,450.0	9,450.0	9,450.0	9,450.0	1.0E99	Syst
2005	31,000.0	31,000.0	31,000.0	9,450.0	1.0E99	Syst
2006	21,700.0	21,700.0	21,700.0	9,450.0	1.0E99	Syst
2007	14,700.0	14,700.0	14,700.0	9,450.0	1.0E99	Syst
2008	39,600.0	39,600.0	39,600.0	9,450.0	1.0E99	Syst
2009	29,000.0	29,000.0	29,000.0	9,450.0	1.0E99	Syst

2010	30,300.0	30,300.0	30,300.0	9,450.0	1.0E99	Syst
2011	47,700.0	47,700.0	47,700.0	9,450.0	1.0E99	Syst
2012	5,960.0	1.0E-6	9,450.0	9,450.0	1.0E99	Syst
2013	13,100.0	13,100.0	13,100.0	9,450.0	1.0E99	Syst
2014	38,000.0	38,000.0	38,000.0	9,450.0	1.0E99	Syst
2015	31,400.0	31,400.0	31,400.0	9,450.0	1.0E99	Syst
2016	24,500.0	24,500.0	24,500.0	9,450.0	1.0E99	Syst

Fitted log10 Moments	Mean	Variance	Std Dev	Skew
EMA at-site data w/o regional info	4.373220	0.055543	0.235675	-0.164493
EMA w/ regional info and B17b MSE(G)	4.373220	0.055543	0.235675	-0.164493
EMA w/ regional info and specified MSE(G)	4.373220	0.055543	0.235675	-0.164493

EMA Estimate of MSE[G at-site]	0.047294
MSE[G at-site systematic]	0.088683
Effective Record Length [G at-site]	123.759475
Grubbs-Beck Critical Value	9,450.000000

--- Final Results ---

<< Plotting Positions >>
COLORADO RIVER-COLORADO-UTAH STATE LINE-FLOW-ANNUAL PEAK

Events Analyzed Day Mon Year	FLOW CFS	Ordered Events Rank	Water Year	FLOW CFS	H-S Plot Pos
23 Jun 1884	128,753.0	1	1884	128,753.0	0.60
23 Jun 1885	---	2	1921	83,535.0	1.20
23 Jun 1886	---	3	1984	69,800.0	1.80
23 Jun 1887	---	4	1983	62,100.0	2.41
23 Jun 1888	---	5	1957	56,800.0	4.50
23 Jun 1889	---	6	1952	52,000.0	5.99
23 Jun 1890	---	7	1995	49,300.0	7.48
23 Jun 1891	---	8	2011	47,700.0	8.97
23 Jun 1892	---	9	1958	45,000.0	10.46
23 Jun 1893	---	10	1993	44,300.0	11.95
23 Jun 1894	---	11	1962	40,500.0	13.44
23 Jun 1895	---	12	2008	39,600.0	14.94
23 Jun 1896	---	13	1985	39,300.0	16.43
23 Jun 1897	---	14	2014	38,000.0	17.92
23 Jun 1898	---	15	1997	37,500.0	19.41
23 Jun 1899	---	16	1953	37,300.0	20.90
23 Jun 1900	---	17	1965	36,400.0	22.39
23 Jun 1901	---	18	1979	36,000.0	23.88
23 Jun 1902	---	19	1973	35,000.0	25.37
23 Jun 1903	---	20	1986	33,800.0	26.86
23 Jun 1904	---	21	1970	33,000.0	28.36

23 Jun 1905	---	22	1980	32,100.0	29.85	
23 Jun 1906	---	23	2015	31,400.0	31.34	
23 Jun 1907	---	24	2005	31,000.0	32.83	
23 Jun 1908	---	25	2010	30,300.0	34.32	
23 Jun 1909	---	26	1951	30,200.0	35.81	
23 Jun 1910	---	27	1996	29,100.0	37.30	
23 Jun 1911	---	28	2009	29,000.0	38.79	
23 Jun 1912	---	29	1956	28,900.0	40.28	
23 Jun 1913	---	30	1978	27,800.0	41.78	
23 Jun 1914	---	31	1964	27,300.0	43.27	
23 Jun 1915	---	32	1968	26,600.0	44.76	
23 Jun 1916	---	33	1975	26,300.0	46.25	
23 Jun 1917	---	34	2003	26,100.0	47.74	
23 Jun 1918	---	35	1998	26,100.0	49.23	
23 Jun 1919	---	36	1960	24,700.0	50.72	
23 Jun 1920	---	37	2016	24,500.0	52.21	
23 Jun 1921	83,535.0	38	1959	23,200.0	53.70	
23 Jun 1922	---	39	1974	22,800.0	55.19	
23 Jun 1923	---	40	1987	22,500.0	56.69	
23 Jun 1924	---	41	1971	22,200.0	58.18	
23 Jun 1925	---	42	2006	21,700.0	59.67	
23 Jun 1926	---	43	1969	20,400.0	61.16	
23 Jun 1927	---	44	1991	19,800.0	62.65	
23 Jun 1928	---	45	1967	19,400.0	64.14	
23 Jun 1929	---	46	1982	19,300.0	65.63	
23 Jun 1930	---	47	1961	19,300.0	67.12	
23 Jun 1931	---	48	1972	18,400.0	68.61	
23 Jun 1932	---	49	2000	17,900.0	70.11	
23 Jun 1933	---	50	1999	17,900.0	71.60	
23 Jun 1934	---	51	1955	17,100.0	73.09	
23 Jun 1935	---	52	1992	16,500.0	74.58	
23 Jun 1936	---	53	1988	15,400.0	76.07	
23 Jun 1937	---	54	2007	14,700.0	77.56	
23 Jun 1938	---	55	1976	14,400.0	79.05	
23 Jun 1939	---	56	1966	14,400.0	80.54	
23 Jun 1940	---	57	1994	13,600.0	82.03	
23 Jun 1941	---	58	2001	13,200.0	83.52	
23 Jun 1942	---	59	2013	13,100.0	85.02	
23 Jun 1943	---	60	1990	12,600.0	86.51	
23 Jun 1944	---	61	1981	12,100.0	88.00	
23 Jun 1945	---	62	1954	11,600.0	89.49	
23 Jun 1946	---	63	1963	11,300.0	90.98	
23 Jun 1947	---	64	1989	9,970.0	92.47	
23 Jun 1948	---	65	2004	9,450.0*	93.96	
23 Jun 1949	---	66	2012	5,960.0*	96.05	
23 Jun 1950	---	67	2002	5,520.0*	97.51	
23 Jun 1951	30,200.0	68	1977	5,080.0*	98.98	
09 Jun 1952	52,000.0	69	1950	---*	---	
15 Jun 1953	37,300.0	70	1949	---*	---	
23 May 1954	11,600.0	71	1948	---*	---	
10 Jun 1955	17,100.0	72	1947	---*	---	
04 Jun 1956	28,900.0	73	1946	---*	---	
09 Jun 1957	56,800.0	74	1945	---*	---	
31 May 1958	45,000.0	75	1944	---*	---	
11 Jun 1959	23,200.0	76	1943	---*	---	
05 Jun 1960	24,700.0	77	1942	---*	---	
31 May 1961	19,300.0	78	1941	---*	---	
14 May 1962	40,500.0	79	1940	---*	---	
20 May 1963	11,300.0	80	1939	---*	---	
27 May 1964	27,300.0	81	1938	---*	---	
20 Jun 1965	36,400.0	82	1937	---*	---	
11 May 1966	14,400.0	83	1936	---*	---	
27 May 1967	19,400.0	84	1935	---*	---	

07 Jun 1968	26,600.0	85	1934	---*	---
26 Jun 1969	20,400.0	86	1933	---*	---
24 May 1970	33,000.0	87	1932	---*	---
19 Jun 1971	22,200.0	88	1931	---*	---
09 Jun 1972	18,400.0	89	1930	---*	---
16 Jun 1973	35,000.0	90	1929	---*	---
11 May 1974	22,800.0	91	1928	---*	---
09 Jun 1975	26,300.0	92	1927	---*	---
07 Jun 1976	14,400.0	93	1926	---*	---
10 Jun 1977	5,080.0	94	1925	---*	---
17 Jun 1978	27,800.0	95	1924	---*	---
30 May 1979	36,000.0	96	1923	---*	---
24 May 1980	32,100.0	97	1922	---*	---
09 Jun 1981	12,100.0	98	1920	---*	---
20 Jun 1982	19,300.0	99	1919	---*	---
27 Jun 1983	62,100.0	100	1918	---*	---
27 May 1984	69,800.0	101	1917	---*	---
05 May 1985	39,300.0	102	1916	---*	---
08 Jun 1986	33,800.0	103	1915	---*	---
18 May 1987	22,500.0	104	1914	---*	---
19 May 1988	15,400.0	105	1913	---*	---
31 May 1989	9,970.0	106	1912	---*	---
12 Jun 1990	12,600.0	107	1911	---*	---
16 Jun 1991	19,800.0	108	1910	---*	---
28 May 1992	16,500.0	109	1909	---*	---
28 May 1993	44,300.0	110	1908	---*	---
19 May 1994	13,600.0	111	1907	---*	---
19 Jun 1995	49,300.0	112	1906	---*	---
20 May 1996	29,100.0	113	1905	---*	---
10 Jun 1997	37,500.0	114	1904	---*	---
22 May 1998	26,100.0	115	1903	---*	---
01 Jun 1999	17,900.0	116	1902	---*	---
31 May 2000	17,900.0	117	1901	---*	---
18 May 2001	13,200.0	118	1900	---*	---
12 Sep 2002	5,520.0	119	1899	---*	---
02 Jun 2003	26,100.0	120	1898	---*	---
12 May 2004	9,450.0	121	1897	---*	---
25 May 2005	31,000.0	122	1896	---*	---
24 May 2006	21,700.0	123	1895	---*	---
23 May 2007	14,700.0	124	1894	---*	---
04 Jun 2008	39,600.0	125	1893	---*	---
25 May 2009	29,000.0	126	1892	---*	---
09 Jun 2010	30,300.0	127	1891	---*	---
09 Jun 2011	47,700.0	128	1890	---*	---
07 Oct 2011	5,960.0	129	1889	---*	---
19 May 2013	13,100.0	130	1888	---*	---
03 Jun 2014	38,000.0	131	1887	---*	---
13 Jun 2015	31,400.0	132	1886	---*	---
08 Jun 2016	24,500.0	133	1885	---*	---

* Outlier

* Low outlier plotting positions are computed using Median parameters.

<< Frequency Curve >>
COLORADO RIVER-COLORADO-UTAH STATE LINE-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Variance Log(EMA)	Percent Chance Exceedance	Confidence Limits 0.16 FLOW, CFS	0.84
101,082.5	0.00529	0.200	123,241.7	87,435.7

87,873.5	0.00352	0.500	103,104.1	77,935.5
78,132.6	0.00250	1.000	89,211.5	70,481.3
68,581.3	0.00175	2.000	76,378.9	62,760.5
56,175.1	0.00112	5.000	60,921.9	52,110.3
46,859.4	0.00090	10.000	50,228.8	43,716.4
37,429.9	0.00085	20.000	39,993.8	34,981.9
23,970.6	0.00091	50.000	25,673.8	22,349.1
15,031.0	0.00126	80.000	16,232.0	13,745.5
11,677.3	0.00199	90.000	12,781.8	10,335.1
9,437.7	0.00321	95.000	10,534.0	8,020.7
6,260.8	0.00815	99.000	7,414.0	4,791.5

<< Systematic Statistics >>
COLORADO RIVER-COLORADO-UTAH STATE LINE-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.373	Historic Events	2
Standard Dev	0.236	High Outliers	0
Station Skew	-0.164	Low Outliers	3
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	65
Adopted Skew	-0.164	Systematic Events	66
		Historic Period	133

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis
27 Oct 2017   11:06 AM

--- Input Data ---

Analysis Name: @Cisco - 17C
Description:

Data Set Name: COLORADO RIVER-CISCO, UT-FLOW-ANNUAL PEAK
DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss
DSS Pathname: /COLORADO RIVER/CISCO, UT/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Cisco_-_17C\@Cisco_-_17C.rpt
XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Cisco_-_17C\@Cisco_-_17C.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.16
Lower Confidence Level: 0.84

Use non-standard frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 4.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

<< EMA Representation of Data >>
COLORADO RIVER-CISCO, UT-FLOW-ANNUAL PEAK

Year	Peak	Value Low	Value High	Threshold Low	Threshold High	Type
1884	155,700.0	116,775.0	194,625.0	31,600.0	1.0E99	Hist
1885	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1886	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1887	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens

1888	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1889	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1890	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1891	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1892	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1893	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1894	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1895	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1896	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1897	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1898	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1899	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1900	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1901	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1902	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1903	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1904	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1905	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1906	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1907	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1908	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1909	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1910	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1911	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1912	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1913	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1914	66,100.0	66,100.0	66,100.0	31,600.0	1.0E99	Syst
1915	35,500.0	35,500.0	35,500.0	31,600.0	1.0E99	Syst
1916	47,800.0	47,800.0	47,800.0	31,600.0	1.0E99	Syst
1917	76,800.0	76,800.0	76,800.0	31,600.0	1.0E99	Syst
1918	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1919	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1920	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1921	101,000.0	75,750.0	126,250.0	31,600.0	1.0E99	Syst
1922	---	1.0E-99	70,300.0	70,300.0	1.0E99	Cens
1923	47,500.0	47,500.0	47,500.0	31,600.0	1.0E99	Syst
1924	51,300.0	51,300.0	51,300.0	31,600.0	1.0E99	Syst
1925	28,200.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1926	52,400.0	52,400.0	52,400.0	31,600.0	1.0E99	Syst
1927	49,000.0	49,000.0	49,000.0	31,600.0	1.0E99	Syst
1928	65,000.0	65,000.0	65,000.0	31,600.0	1.0E99	Syst
1929	59,600.0	59,600.0	59,600.0	31,600.0	1.0E99	Syst
1930	41,000.0	41,000.0	41,000.0	31,600.0	1.0E99	Syst
1931	18,700.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1932	50,100.0	50,100.0	50,100.0	31,600.0	1.0E99	Syst
1933	50,600.0	50,600.0	50,600.0	31,600.0	1.0E99	Syst
1934	17,300.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1935	54,600.0	54,600.0	54,600.0	31,600.0	1.0E99	Syst
1936	39,200.0	39,200.0	39,200.0	31,600.0	1.0E99	Syst
1937	40,100.0	40,100.0	40,100.0	31,600.0	1.0E99	Syst
1938	53,700.0	53,700.0	53,700.0	31,600.0	1.0E99	Syst
1939	25,400.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1940	25,390.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1941	64,400.0	64,400.0	64,400.0	31,600.0	1.0E99	Syst
1942	51,500.0	51,500.0	51,500.0	31,600.0	1.0E99	Syst
1943	36,600.0	36,600.0	36,600.0	31,600.0	1.0E99	Syst
1944	53,600.0	53,600.0	53,600.0	31,600.0	1.0E99	Syst
1945	33,400.0	33,400.0	33,400.0	31,600.0	1.0E99	Syst
1946	27,800.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1947	40,300.0	40,300.0	40,300.0	31,600.0	1.0E99	Syst
1948	51,900.0	51,900.0	51,900.0	31,600.0	1.0E99	Syst
1949	53,800.0	53,800.0	53,800.0	31,600.0	1.0E99	Syst
1950	24,200.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst

1951	29,800.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1952	57,200.0	57,200.0	57,200.0	31,600.0	1.0E99	Syst
1953	38,900.0	38,900.0	38,900.0	31,600.0	1.0E99	Syst
1954	12,900.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1955	18,100.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1956	30,900.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1957	64,200.0	64,200.0	64,200.0	31,600.0	1.0E99	Syst
1958	49,700.0	49,700.0	49,700.0	31,600.0	1.0E99	Syst
1959	22,300.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1960	26,100.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1961	21,100.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1962	44,400.0	44,400.0	44,400.0	31,600.0	1.0E99	Syst
1963	12,500.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1964	29,200.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1965	38,200.0	38,200.0	38,200.0	31,600.0	1.0E99	Syst
1966	17,800.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1967	21,600.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1968	31,900.0	31,900.0	31,900.0	31,600.0	1.0E99	Syst
1969	24,000.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1970	36,100.0	36,100.0	36,100.0	31,600.0	1.0E99	Syst
1971	23,500.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1972	19,600.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1973	42,800.0	42,800.0	42,800.0	31,600.0	1.0E99	Syst
1974	25,100.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1975	30,000.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1976	16,200.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1977	8,010.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1978	31,600.0	31,600.0	31,600.0	31,600.0	1.0E99	Syst
1979	45,400.0	45,400.0	45,400.0	31,600.0	1.0E99	Syst
1980	39,200.0	39,200.0	39,200.0	31,600.0	1.0E99	Syst
1981	12,800.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1982	22,700.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1983	61,900.0	61,900.0	61,900.0	31,600.0	1.0E99	Syst
1984	70,300.0	70,300.0	70,300.0	31,600.0	1.0E99	Syst
1985	43,900.0	43,900.0	43,900.0	31,600.0	1.0E99	Syst
1986	34,700.0	34,700.0	34,700.0	31,600.0	1.0E99	Syst
1987	30,800.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1988	14,800.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1989	10,200.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1990	12,900.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1991	19,100.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1992	18,100.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1993	49,300.0	49,300.0	49,300.0	31,600.0	1.0E99	Syst
1994	15,300.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1995	51,900.0	51,900.0	51,900.0	31,600.0	1.0E99	Syst
1996	29,400.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1997	41,200.0	41,200.0	41,200.0	31,600.0	1.0E99	Syst
1998	29,400.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
1999	20,600.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
2000	18,500.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
2001	14,000.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
2002	6,540.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
2003	27,500.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
2004	10,600.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
2005	40,200.0	40,200.0	40,200.0	31,600.0	1.0E99	Syst
2006	21,700.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
2007	20,400.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
2008	41,500.0	41,500.0	41,500.0	31,600.0	1.0E99	Syst
2009	31,200.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
2010	30,600.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
2011	49,000.0	49,000.0	49,000.0	31,600.0	1.0E99	Syst
2012	6,330.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst
2013	12,800.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst

2014	37,500.0	37,500.0	37,500.0	31,600.0	1.0E99	Syst
2015	31,800.0	31,800.0	31,800.0	31,600.0	1.0E99	Syst
2016	25,100.0	1.0E-6	31,600.0	31,600.0	1.0E99	Syst

Fitted log10 Moments	Mean	Variance	Std Dev	Skew
EMA at-site data w/o regional info	4.479736	0.060468	0.245902	-0.561291
EMA w/ regional info and B17b MSE(G)	4.479736	0.060468	0.245902	-0.561291
EMA w/ regional info and specified MSE(G)	4.479736	0.060468	0.245902	-0.561291

EMA Estimate of MSE[G at-site]	0.066450
MSE[G at-site systematic]	0.084685
Effective Record Length [G at-site]	124.893344
Grubbs-Beck Critical Value	31,600.000000

--- Final Results ---

<< Plotting Positions >>
COLORADO RIVER-CISCO, UT-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
Day Mon Year	FLOW CFS	Rank	Water Year	FLOW CFS	H-S Plot Pos
04 Jul 1884	155,700.0	1	1884	155,700.0	0.60
01 Jan 1885	---	2	1921	101,000.0	1.20
01 Jan 1886	---	3	1917	76,800.0	1.80
01 Jan 1887	---	4	1984	70,300.0	2.41
01 Jan 1888	---	5	1914	66,100.0	4.00
01 Jan 1889	---	6	1928	65,000.0	4.99
01 Jan 1890	---	7	1941	64,400.0	5.98
01 Jan 1891	---	8	1957	64,200.0	6.96
01 Jan 1892	---	9	1983	61,900.0	7.95
01 Jan 1893	---	10	1929	59,600.0	8.94
01 Jan 1894	---	11	1952	57,200.0	9.93
01 Jan 1895	---	12	1935	54,600.0	10.92
01 Jan 1896	---	13	1949	53,800.0	11.91
01 Jan 1897	---	14	1938	53,700.0	12.90
01 Jan 1898	---	15	1944	53,600.0	13.89
01 Jan 1899	---	16	1926	52,400.0	14.88
01 Jan 1900	---	17	1995	51,900.0	15.87
01 Jan 1901	---	18	1948	51,900.0	16.86
01 Jan 1902	---	19	1942	51,500.0	17.85
01 Jan 1903	---	20	1924	51,300.0	18.84
01 Jan 1904	---	21	1933	50,600.0	19.83
01 Jan 1905	---	22	1932	50,100.0	20.81
01 Jan 1906	---	23	1958	49,700.0	21.80
01 Jan 1907	---	24	1993	49,300.0	22.79
01 Jan 1908	---	25	2011	49,000.0	23.78

01 Jan 1909	---	26	1927	49,000.0	24.77
01 Jan 1910	---	27	1916	47,800.0	25.76
01 Jan 1911	---	28	1923	47,500.0	26.75
01 Jan 1912	---	29	1979	45,400.0	27.74
01 Jan 1913	---	30	1962	44,400.0	28.73
03 Jun 1914	66,100.0	31	1985	43,900.0	29.72
13 Jun 1915	35,500.0	32	1973	42,800.0	30.71
11 May 1916	47,800.0	33	2008	41,500.0	31.70
19 Jun 1917	76,800.0	34	1997	41,200.0	32.69
01 Jan 1918	---	35	1930	41,000.0	33.68
01 Jan 1919	---	36	1947	40,300.0	34.66
01 Jan 1920	---	37	2005	40,200.0	35.65
01 Jan 1921	101,000.0	38	1937	40,100.0	36.64
01 Jan 1922	---	39	1980	39,200.0	37.63
29 May 1923	47,500.0	40	1936	39,200.0	38.62
16 Jun 1924	51,300.0	41	1953	38,900.0	39.61
01 Jun 1925	28,200.0	42	1965	38,200.0	40.60
27 May 1926	52,400.0	43	2014	37,500.0	41.59
20 May 1927	49,000.0	44	1943	36,600.0	42.58
01 Jun 1928	65,000.0	45	1970	36,100.0	43.57
27 May 1929	59,600.0	46	1915	35,500.0	44.56
01 Jun 1930	41,000.0	47	1986	34,700.0	45.55
09 Jun 1931	18,700.0	48	1945	33,400.0	46.54
24 May 1932	50,100.0	49	1968	31,900.0	47.53
03 Jun 1933	50,600.0	50	2015	31,800.0	48.51
13 May 1934	17,300.0	51	1978	31,600.0	49.50
16 Jun 1935	54,600.0	52	2009	31,200.0*	51.49
07 May 1936	39,200.0	53	1956	30,900.0*	52.49
17 May 1937	40,100.0	54	1987	30,800.0*	53.49
05 Jun 1938	53,700.0	55	2010	30,600.0*	54.48
24 May 1939	25,400.0	56	1975	30,000.0*	55.48
14 May 1940	25,390.0	57	1951	29,800.0*	56.47
15 May 1941	64,400.0	58	1998	29,400.0*	57.47
28 May 1942	51,500.0	59	1996	29,400.0*	58.47
03 Jun 1943	36,600.0	60	1964	29,200.0*	59.46
17 May 1944	53,600.0	61	1925	28,200.0*	60.46
13 May 1945	33,400.0	62	1946	27,800.0*	61.45
19 Jun 1946	27,800.0	63	2003	27,500.0*	62.45
22 Jun 1947	40,300.0	64	1960	26,100.0*	63.45
23 May 1948	51,900.0	65	1939	25,400.0*	64.44
20 Jun 1949	53,800.0	66	1940	25,390.0*	65.44
04 Jun 1950	24,200.0	67	2016	25,100.0*	66.43
23 Jun 1951	29,800.0	68	1974	25,100.0*	67.43
09 Jun 1952	57,200.0	69	1950	24,200.0*	68.43
15 Jun 1953	38,900.0	70	1969	24,000.0*	69.42
23 May 1954	12,900.0	71	1971	23,500.0*	70.42
10 Jun 1955	18,100.0	72	1982	22,700.0*	71.41
04 Jun 1956	30,900.0	73	1959	22,300.0*	72.41
09 Jun 1957	64,200.0	74	2006	21,700.0*	73.41
31 May 1958	49,700.0	75	1967	21,600.0*	74.40
19 Jun 1959	22,300.0	76	1961	21,100.0*	75.40
05 Jun 1960	26,100.0	77	1999	20,600.0*	76.39
31 May 1961	21,100.0	78	2007	20,400.0*	77.39
14 May 1962	44,400.0	79	1972	19,600.0*	78.39
20 May 1963	12,500.0	80	1991	19,100.0*	79.38
28 May 1964	29,200.0	81	1931	18,700.0*	80.38
20 Jun 1965	38,200.0	82	2000	18,500.0*	81.37
11 May 1966	17,800.0	83	1992	18,100.0*	82.37
27 May 1967	21,600.0	84	1955	18,100.0*	83.37
07 Jun 1968	31,900.0	85	1966	17,800.0*	84.36
25 Apr 1969	24,000.0	86	1934	17,300.0*	85.36
24 May 1970	36,100.0	87	1976	16,200.0*	86.35
19 Jun 1971	23,500.0	88	1994	15,300.0*	87.35

10 Jun 1972	19,600.0	89	1988	14,800.0*	88.35
15 Jun 1973	42,800.0	90	2001	14,000.0*	89.34
12 May 1974	25,100.0	91	1990	12,900.0*	90.34
09 Jun 1975	30,000.0	92	1954	12,900.0*	91.33
07 Jun 1976	16,200.0	93	2013	12,800.0*	92.33
24 Jul 1977	8,010.0	94	1981	12,800.0*	93.33
17 Jun 1978	31,600.0	95	1963	12,500.0*	94.32
29 May 1979	45,400.0	96	2004	10,600.0*	95.32
25 May 1980	39,200.0	97	1989	10,200.0*	96.31
09 Jun 1981	12,800.0	98	1977	8,010.0*	97.31
06 May 1982	22,700.0	99	2002	6,540.0*	98.31
27 Jun 1983	61,900.0	100	2012	6,330.0*	99.30
27 May 1984	70,300.0	101	1922	---*	---
06 May 1985	43,900.0	102	1920	---*	---
08 Jun 1986	34,700.0	103	1919	---*	---
18 May 1987	30,800.0	104	1918	---*	---
19 May 1988	14,800.0	105	1913	---*	---
31 May 1989	10,200.0	106	1912	---*	---
12 Jun 1990	12,900.0	107	1911	---*	---
16 Jun 1991	19,100.0	108	1910	---*	---
28 May 1992	18,100.0	109	1909	---*	---
29 May 1993	49,300.0	110	1908	---*	---
21 May 1994	15,300.0	111	1907	---*	---
18 Jun 1995	51,900.0	112	1906	---*	---
20 May 1996	29,400.0	113	1905	---*	---
03 Jun 1997	41,200.0	114	1904	---*	---
23 May 1998	29,400.0	115	1903	---*	---
26 May 1999	20,600.0	116	1902	---*	---
31 May 2000	18,500.0	117	1901	---*	---
19 May 2001	14,000.0	118	1900	---*	---
30 Sep 2002	6,540.0	119	1899	---*	---
03 Jun 2003	27,500.0	120	1898	---*	---
12 May 2004	10,600.0	121	1897	---*	---
25 May 2005	40,200.0	122	1896	---*	---
24 May 2006	21,700.0	123	1895	---*	---
07 Oct 2006	20,400.0	124	1894	---*	---
23 May 2008	41,500.0	125	1893	---*	---
26 May 2009	31,200.0	126	1892	---*	---
09 Jun 2010	30,600.0	127	1891	---*	---
09 Jun 2011	49,000.0	128	1890	---*	---
08 Oct 2011	6,330.0	129	1889	---*	---
19 May 2013	12,800.0	130	1888	---*	---
03 Jun 2014	37,500.0	131	1887	---*	---
13 Jun 2015	31,800.0	132	1886	---*	---
09 Jun 2016	25,100.0	133	1885	---*	---

* Outlier

* Low outlier plotting positions are computed using Median parameters.

<< Frequency Curve >>

COLORADO RIVER-CISCO, UT-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Variance Log(EMA)	Percent Chance Exceedance	Confidence Limits 0.16 FLOW, CFS	Confidence Limits 0.84 FLOW, CFS
105,650.1	0.00256	0.200	122,702.0	95,490.9
96,447.7	0.00201	0.500	110,141.4	88,113.5
88,956.8	0.00165	1.000	100,185.7	81,899.7
80,944.5	0.00132	2.000	89,775.4	75,076.7
72,325.3	0.00103	4.000	78,885.0	67,572.1

59,762.4	0.00069	10.000	63,783.3	56,390.7
49,032.0	0.00054	20.000	51,789.5	46,476.8
31,814.8	0.00126	50.000	33,892.5	28,110.6
19,154.9	0.00550	80.000	21,720.9	14,735.9
14,241.0	0.01062	90.000	17,015.4	10,030.0
10,964.3	0.01725	95.000	13,806.0	7,106.3
6,439.0	0.03816	99.000	9,150.4	3,472.8

<< Systematic Statistics >>
COLORADO RIVER-CISCO, UT-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.480	Historic Events	1
Standard Dev	0.246	High Outliers	0
Station Skew	-0.561	Low Outliers	49
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	33
Adopted Skew	-0.561	Systematic Events	99
		Historic Period	133

--- End of Analytical Frequency Curve ---

HEC-SSP Bulletin 17B Analysis

Bulletin 17B Frequency Analysis

22 Aug 2017 10:21 AM

--- Input Data ---

Analysis Name: @Granby Below Lake 17B

Description:

Data Set Name: Colorado River-LAKE GRANBY, CO.-FLOW-ANNUAL PEAK

DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss

DSS Pathname: /COLORADO RIVER/LAKE GRANBY, CO./FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Granby_Below_Lake_17B\@Granby_Below_Lake_17B.rpt

XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Granby_Below_Lake_17B\@Granby_Below_Lake_17B.xml

Start Date:

End Date:

Skew Option: Use Weighted Skew

Regional Skew: -0.18

Regional Skew MSE: 0.302

Plotting Position Type: Median

Upper Confidence Level: 0.05

Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

<< High Outlier Test >>

Based on 32 events, 10 percent outlier test deviate K(N) = 2.591

Computed high outlier test value = 1,758.76

0 high outlier(s) identified above test value of 1,758.76

<< Low Outlier Test >>

Based on 32 events, 10 percent outlier test deviate K(N) = 2.591

Computed low outlier test value = 13.2

0 low outlier(s) identified below test value of 13.2

--- Final Results ---

<< Plotting Positions >>

Colorado River-LAKE GRANBY, CO.-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
	FLOW		Water	FLOW	Median
Day Mon Year	CFS	Rank	Year	CFS	Plot Pos
13 Jun 1951	73.0	1	1971	1,520.0	2.16
20 Jun 1952	437.0	2	1974	1,470.0	5.25
04 Oct 1952	102.0	3	1973	1,440.0	8.33
01 May 1954	94.0	4	1962	1,400.0	11.42
29 Jun 1955	79.0	5	1952	437.0	14.51
29 May 1956	79.0	6	1963	237.0	17.59
02 May 1957	217.0	7	1957	217.0	20.68
25 Mar 1958	172.0	8	1972	174.0	23.77
05 Jul 1959	79.0	9	1958	172.0	26.85
02 May 1960	84.0	10	1980	114.0	29.94
12 Jun 1961	96.0	11	1969	110.0	33.02
03 Jul 1962	1,400.0	12	1965	109.0	36.11
24 Jul 1963	237.0	13	1970	107.0	39.20
01 Jul 1964	96.0	14	1976	105.0	42.28
18 Jul 1965	109.0	15	1968	105.0	45.37
18 Jul 1966	86.0	16	1978	103.0	48.46
07 Jul 1967	103.0	17	1967	103.0	51.54
15 Jul 1968	105.0	18	1982	102.0	54.63
17 Sep 1969	110.0	19	1953	102.0	57.72

17 Jun 1970	107.0	20	1975	97.0	60.80
27 Jun 1971	1,520.0	21	1964	96.0	63.89
12 Sep 1972	174.0	22	1961	96.0	66.98
03 Jul 1973	1,440.0	23	1954	94.0	70.06
20 Jun 1974	1,470.0	24	1979	93.0	73.15
16 Jun 1975	97.0	25	1966	86.0	76.23
17 Jul 1976	105.0	26	1960	84.0	79.32
05 Jul 1977	83.0	27	1977	83.0	82.41
23 Jul 1978	103.0	28	1959	79.0	85.49
30 Jul 1979	93.0	29	1956	79.0	88.58
14 Jul 1980	114.0	30	1955	79.0	91.67
04 May 1981	78.0	31	1981	78.0	94.75
01 Jun 1982	102.0	32	1951	73.0	97.84

<< Skew Weighting >>

Based on 32 events, mean-square error of station skew = 0.555

Mean-square error of regional skew = 0.302

<< Frequency Curve >>

Colorado River-LAKE GRANBY, CO.-FLOW-ANNUAL PEAK

Computed Curve	Expected Probability	Percent Chance	Confidence Limits 0.05	0.95

FLOW, CFS		Exceedance	FLOW, CFS	
4,195.7	6,328.6	0.2	10,612.9	2,244.8
2,737.1	3,686.5	0.5	6,229.3	1,565.4
1,948.9	2,438.1	1.0	4,084.1	1,173.6
1,362.6	1,602.1	2.0	2,622.6	864.6
817.0	897.7	5.0	1,399.9	555.8
531.8	563.0	10.0	833.0	380.6
326.2	335.4	20.0	468.1	243.7
140.4	140.4	50.0	185.3	105.6
67.9	66.6	80.0	91.1	46.9
48.5	46.9	90.0	67.0	31.6
37.5	35.6	95.0	53.3	23.2
24.4	22.2	99.0	36.6	13.8

<< Systematic Statistics >>

Colorado River-LAKE GRANBY, CO.-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	2.183	Historic Events	0
Standard Dev	0.410	High Outliers	0
Station Skew	1.807	Low Outliers	0
Regional Skew	-0.180	Zero Events	0
Weighted Skew	0.520	Missing Events	0
Adopted Skew	0.520	Systematic Events	32

|------------------------------|-------------------------------|

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis

22 Aug 2017 11:19 AM

--- Input Data ---

Analysis Name: @Granby - 17B

Description:

Data Set Name: Colorado River-GRANBY, CO-FLOW-ANNUAL PEAK

DSS File Name: L:\PUBLIC\P_Drive\3279 Project files- Water Group\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss

DSS Pathname: /COLORADO RIVER/GRANBY, CO/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: L:\PUBLIC\P_Drive\3279 Project files- Water Group\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Granby_-_17B\@Granby_-_17B.rpt

XML File Name: L:\PUBLIC\P_Drive\3279 Project files- Water Group\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Granby_-_17B\@Granby_-_17B.xml

Start Date:

End Date:

Skew Option: Use Station Skew

Regional Skew: -0.18

Regional Skew MSE: 0.302

Plotting Position Type: Median

Upper Confidence Level: 0.05

Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

<< Low Outlier Test >>

Based on 79 events, 10 percent outlier test deviate K(N) = 2.935

Computed low outlier test value = 6.16

0 low outlier(s) identified below test value of 6.16

<< High Outlier Test >>

Based on 79 events, 10 percent outlier test deviate K(N) = 2.935

Computed high outlier test value = 29,603.6

0 high outlier(s) identified above test value of 29,603.6

--- Final Results ---

<< Plotting Positions >>

Colorado River-GRANBY, CO-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
	FLOW		Water	FLOW	Median
Day Mon Year	CFS	Rank	Year	CFS	Plot Pos
17 Jun 1908	1,480.0	1	1909	4,100.0	0.88
20 Jun 1909	4,100.0	2	1935	3,370.0	2.14
01 Jun 1910	2,320.0	3	1938	3,010.0	3.40
16 Jun 1911	2,800.0	4	1949	2,960.0	4.66
12 May 1934	1,240.0	5	1947	2,830.0	5.92
16 Jun 1935	3,370.0	6	1911	2,800.0	7.18
01 Jun 1936	2,640.0	7	1936	2,640.0	8.44
26 Jun 1937	1,590.0	8	1996	2,520.0	9.70
22 Jun 1938	3,010.0	9	1983	2,510.0	10.96
01 Jun 1939	2,070.0	10	2015	2,480.0	12.22
02 Jun 1940	1,860.0	11	1948	2,390.0	13.48
14 May 1941	2,070.0	12	1910	2,320.0	14.74
12 Jun 1942	2,260.0	13	2011	2,290.0	15.99
23 Jun 1943	1,870.0	14	1942	2,260.0	17.25
11 Jun 1944	1,950.0	15	1945	2,240.0	18.51
25 May 1945	2,240.0	16	1984	2,140.0	19.77
08 Jun 1946	2,070.0	17	1946	2,070.0	21.03
10 Jun 1947	2,830.0	18	1941	2,070.0	22.29

22 May 1948	2,390.0	19	1939	2,070.0	23.55	
18 Jun 1949	2,960.0	20	1997	1,980.0	24.81	
23 Jul 1950	59.0	21	1944	1,950.0	26.07	
14 Jun 1951	80.0	22	1943	1,870.0	27.33	
23 Jun 1952	435.0	23	1940	1,860.0	28.59	
19 Jun 1953	112.0	24	1937	1,590.0	29.85	
09 Jun 1961	90.0	25	1908	1,480.0	31.11	
03 Jul 1962	1,420.0	26	1973	1,460.0	32.37	
24 Jul 1963	104.0	27	1971	1,450.0	33.63	
21 May 1964	95.0	28	1962	1,420.0	34.89	
01 May 1965	121.0	29	1974	1,370.0	36.15	
26 Jul 1966	80.0	30	1999	1,260.0	37.41	
07 Jul 1967	118.0	31	1934	1,240.0	38.66	
12 Jul 1968	86.0	32	1998	1,200.0	39.92	
14 Jun 1969	120.0	33	2016	1,190.0	41.18	
03 May 1970	154.0	34	2000	1,030.0	42.44	
25 Jun 1971	1,450.0	35	1995	887.0	43.70	
22 May 1972	112.0	36	1993	857.0	44.96	
01 Jul 1973	1,460.0	37	2014	716.0	46.22	
21 Jun 1974	1,370.0	38	1986	460.0	47.48	
16 Jul 1975	133.0	39	1952	435.0	48.74	
17 Jun 1976	117.0	40	1985	305.0	50.00	
16 Mar 1977	83.0	41	2006	183.0	51.26	
18 May 1978	99.0	42	2012	176.0	52.52	
07 Jun 1979	112.0	43	2008	173.0	53.78	
01 Jun 1980	100.0	44	1970	154.0	55.04	
14 Jul 1981	81.0	45	1991	153.0	56.30	
18 Jun 1982	102.0	46	1975	133.0	57.56	
11 Jul 1983	2,510.0	47	2010	125.0	58.82	

01 Jul 1984	2,140.0	48	2009	123.0	60.08
02 May 1985	305.0	49	2007	123.0	61.34
02 Jul 1986	460.0	50	1965	121.0	62.59
23 Jun 1987	91.0	51	1969	120.0	63.85
21 Jul 1989	100.0	52	1967	118.0	65.11
29 May 1990	108.0	53	1976	117.0	66.37
01 Jun 1991	153.0	54	2003	115.0	67.63
26 May 1992	91.0	55	1979	112.0	68.89
26 Aug 1993	857.0	56	1972	112.0	70.15
19 Jun 1994	101.0	57	1953	112.0	71.41
24 Jul 1995	887.0	58	1990	108.0	72.67
22 Jun 1996	2,520.0	59	2013	105.0	73.93
12 Jun 1997	1,980.0	60	1963	104.0	75.19
01 Jul 1998	1,200.0	61	1982	102.0	76.45
01 Jul 1999	1,260.0	62	1994	101.0	77.71
01 Jun 2000	1,030.0	63	2005	100.0	78.97
17 May 2001	90.0	64	1989	100.0	80.23
20 Jun 2002	92.0	65	1980	100.0	81.49
12 Jun 2003	115.0	66	1978	99.0	82.75
21 Jul 2004	82.0	67	1964	95.0	84.01
25 Jul 2005	100.0	68	2002	92.0	85.26
28 Jun 2006	183.0	69	1992	91.0	86.52
03 Jul 2007	123.0	70	1987	91.0	87.78
16 Jul 2008	173.0	71	2001	90.0	89.04
02 May 2009	123.0	72	1961	90.0	90.30
15 Jun 2010	125.0	73	1968	86.0	91.56
25 Jun 2011	2,290.0	74	1977	83.0	92.82
05 Jul 2012	176.0	75	2004	82.0	94.08
01 May 2013	105.0	76	1981	81.0	95.34

01 Aug 2014	716.0	77	1966	80.0	96.60
18 Jun 2015	2,480.0	78	1951	80.0	97.86
22 Jun 2016	1,190.0	79	1950	59.0	99.12

<< Skew Weighting >>

Based on 79 events, mean-square error of station skew = 0.074

Mean-square error of regional skew = 0.302

<< Frequency Curve >>

Colorado River-GRANBY, CO-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
34,146.7	40,643.3	0.2	70,391.9	19,334.7
20,957.2	23,892.1	0.5	40,384.8	12,477.5
14,070.4	15,578.3	1.0	25,691.0	8,717.8
9,145.8	9,868.0	2.0	15,777.2	5,907.2
4,835.7	5,067.9	5.0	7,700.4	3,308.3
2,769.6	2,851.9	10.0	4,135.9	1,981.1
1,426.1	1,447.7	20.0	1,994.7	1,063.9
414.3	414.3	50.0	542.2	316.2

125.7	124.0	80.0	168.7	89.7
68.6	66.8	90.0	95.6	46.1
41.9	40.3	95.0	60.7	26.7
17.0	15.7	99.0	26.8	9.7

<< Systematic Statistics >>

Colorado River-GRANBY, CO-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	2.631	Historic Events	0
Standard Dev	0.627	High Outliers	0
Station Skew	0.128	Low Outliers	0
Regional Skew	-0.180	Zero Events	0
Weighted Skew	0.068	Missing Events	0
Adopted Skew	0.128	Systematic Events	79

--- End of Analytical Frequency Curve ---

```
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Bulletin 17B Frequency Analysis
    12 Dec 2017   11:08 AM
-------------------------------


--- Input Data ---

Analysis Name: @HSS-Windy Gap - 17B
Description:

Data Set Name: HSS-Windy Gap Combined Data
DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4
HH2\HEC-SSP\Post\HSS-Windy Gap Combo\HSS-Windy_Gap_Combo\HSS-Windy_Gap_Combo.dss
DSS Pathname: ////01jan1900/IR-CENTURY//

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4
HH2\HEC-SSP\Post\HSS-Windy Gap
Combo\HSS-Windy_Gap_Combo\Bulletin17Results\@HSS-Windy_Gap_-_17B\@HSS-Windy_Gap_-_17
B.rpt
XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4
HH2\HEC-SSP\Post\HSS-Windy Gap
Combo\HSS-Windy_Gap_Combo\Bulletin17Results\@HSS-Windy_Gap_-_17B\@HSS-Windy_Gap_-_17
B.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Median

Upper Confidence Level: 0.05
Lower Confidence Level: 0.95

Display ordinate values using 3 digits in fraction part of value

--- End of Input Data ---



----------------------
<< Low Outlier Test >>
----------------------
  Based on 64 events, 10 percent outlier test deviate K(N) = 2.86
                      Computed low outlier test value = 135.0942

         0 low outlier(s) identified below test value of 135.0942



-----------------------
<< High Outlier Test >>
-----------------------
  Based on 64 events, 10 percent outlier test deviate K(N) = 2.86
                   Computed high outlier test value = 12,663.172

      0 high outlier(s) identified above test value of 12,663.172
```

--- Final Results ---

<< Plotting Positions >>
HSS-Windy Gap Combined Data

Events Analyzed Day Mon Year	FLOW CFS	Rank	Water Year	FLOW CFS	Median Plot Pos
20 Jun 1953	1,930.000	1	1984	5,720.000	1.09
23 May 1954	358.000	2	2011	5,264.000	2.64
16 May 1955	485.000	3	1996	4,800.000	4.19
23 May 1956	2,220.000	4	1983	4,620.000	5.75
08 Jun 1957	3,430.000	5	1997	4,614.000	7.30
27 May 1958	2,830.000	6	2015	4,438.000	8.85
28 Jun 1959	832.000	7	2014	3,613.000	10.40
18 Jun 1960	1,220.000	8	1957	3,430.000	11.96
29 Sep 1961	638.000	9	1971	2,880.000	13.51
13 May 1962	2,720.000	10	1958	2,830.000	15.06
08 Apr 1963	562.000	11	1974	2,820.000	16.61
27 May 1964	768.000	12	1995	2,787.000	18.17
18 Jun 1965	1,760.000	13	1962	2,720.000	19.72
10 May 1966	424.000	14	2016	2,549.000	21.27
23 Jun 1967	876.000	15	1970	2,500.000	22.83
06 Jun 1968	760.000	16	2010	2,415.000	24.38
18 Jun 1969	1,510.000	17	2000	2,405.000	25.93
23 May 1970	2,500.000	18	1956	2,220.000	27.48
26 Jun 1971	2,880.000	19	1973	2,200.000	29.04
09 Jun 1972	1,150.000	20	2008	2,095.000	30.59
14 Jun 1973	2,200.000	21	1999	2,064.000	32.14
19 Jun 1974	2,820.000	22	2003	2,044.000	33.70
09 Jul 1975	970.000	23	1953	1,930.000	35.25
17 Jun 1976	424.000	24	1993	1,910.000	36.80
07 Jun 1977	351.000	25	1985	1,890.000	38.35
26 May 1978	1,200.000	26	1980	1,810.000	39.91
15 Jun 1979	1,580.000	27	1965	1,760.000	41.46
12 Jun 1980	1,810.000	28	1986	1,740.000	43.01
29 May 1981	595.000	29	2009	1,590.000	44.57
03 Jul 1982	1,100.000	30	1979	1,580.000	46.12
11 Jul 1983	4,620.000	31	1988	1,550.000	47.67
25 May 1984	5,720.000	32	1969	1,510.000	49.22
10 Jun 1985	1,890.000	33	1998	1,497.000	50.78
20 Jun 1986	1,740.000	34	1960	1,220.000	52.33
10 Jun 1987	983.000	35	1978	1,200.000	53.88
20 May 1988	1,550.000	36	1972	1,150.000	55.43
12 May 1989	393.000	37	1982	1,100.000	56.99
08 Jul 1990	474.000	38	2013	1,073.000	58.54
16 Jun 1991	873.000	39	2005	997.000	60.09
15 Jun 1992	439.000	40	1987	983.000	61.65
29 May 1993	1,910.000	41	1975	970.000	63.20
01 Jun 1994	795.000	42	2007	951.000	64.75
18 Jun 1995	2,787.000	43	2006	889.000	66.30
23 Jun 1996	4,800.000	44	1967	876.000	67.86
09 Jun 1997	4,614.000	45	1991	873.000	69.41
02 Jul 1998	1,497.000	46	1959	832.000	70.96
26 Jun 1999	2,064.000	47	1994	795.000	72.52
01 Jun 2000	2,405.000	48	1964	768.000	74.07
13 Jul 2001	436.000	49	1968	760.000	75.62
05 Jun 2002	310.000	50	1961	638.000	77.17
30 May 2003	2,044.000	51	1981	595.000	78.73
30 Jun 2004	436.000	52	1963	562.000	80.28
20 Jun 2005	997.000	53	1955	485.000	81.83
14 Apr 2006	889.000	54	1990	474.000	83.39

18 Jun 2007	951.000	55	1992	439.000	84.94
22 May 2008	2,095.000	56	2004	436.000	86.49
27 Jun 2009	1,590.000	57	2001	436.000	88.04
08 Jun 2010	2,415.000	58	1976	424.000	89.60
25 Jun 2011	5,264.000	59	1966	424.000	91.15
05 Jul 2012	340.000	60	1989	393.000	92.70
16 May 2013	1,073.000	61	1954	358.000	94.25
31 May 2014	3,613.000	62	1977	351.000	95.81
14 Jun 2015	4,438.000	63	2012	340.000	97.36
23 Jun 2016	2,549.000	64	2002	310.000	98.91

<< Skew Weighting >>

Based on 64 events, mean-square error of station skew = 0.087
Mean-square error of regional skew = -?

<< Frequency Curve >>
HSS-Windy Gap Combined Data

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
11,780.893	12,971.091	0.2	17,866.065	8,555.039
9,448.978	10,171.434	0.5	13,849.996	7,030.892
7,864.152	8,336.339	1.0	11,211.406	5,968.083
6,424.106	6,715.147	2.0	8,889.412	4,978.384
4,727.724	4,863.341	5.0	6,265.868	3,774.113
3,588.529	3,653.548	10.0	4,588.910	2,933.327
2,559.317	2,583.691	20.0	3,150.851	2,140.992
1,323.589	1,323.589	50.0	1,561.438	1,122.557
673.093	666.327	80.0	804.296	547.107
469.473	460.357	90.0	575.038	366.434
347.427	336.715	95.0	436.852	260.691
195.815	183.021	99.0	260.936	135.195

<< Systematic Statistics >>
HSS-Windy Gap Combined Data

Log Transform: FLOW, CFS		Number of Events	
Mean	3.117	Historic Events	0
Standard Dev	0.345	High Outliers	0
Station Skew	-0.090	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-0.090	Systematic Events	64

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis

22 Aug 2017   10:36 AM

--- Input Data ---

Analysis Name: @Kremmling Post 17B

Description:

Data Set Name: Kremmling no Historical

DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH2\HEC-SSP\Post\@Kremmling_no_Historical\Kremmling_no_Historical.dss

DSS Pathname: ////01jan1900/IR-CENTURY//

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH2\HEC-SSP\Post\@Kremmling_no_Historical\Bulletin17Results\@Kremmling_Post_17B\@Kremmling_Post_17B.rpt

XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH2\HEC-SSP\Post\@Kremmling_no_Historical\Bulletin17Results\@Kremmling_Post_17B\@Kremmling_Post_17B.xml

Start Date:

End Date:

Skew Option: Use Station Skew

Regional Skew: -0.28

Regional Skew MSE: 0.302

Plotting Position Type: Median

Upper Confidence Level: 0.05

Lower Confidence Level: 0.95

Display ordinate values using 3 digits in fraction part of value

--- End of Input Data ---

<< Low Outlier Test >>

Based on 54 events, 10 percent outlier test deviate K(N) = 2.798

Computed low outlier test value = 505.6778

0 low outlier(s) identified below test value of 505.6778

<< High Outlier Test >>

Based on 54 events, 10 percent outlier test deviate K(N) = 2.798

Computed high outlier test value = 19,856.2116

0 high outlier(s) identified above test value of 19,856.2116

--- Final Results ---

<< Plotting Positions >>

Kremmling no Historical

Events Analyzed		Ordered Events			
	FLOW		Water	FLOW	Median
Day Mon Year	CFS	Rank	Year	CFS	Plot Pos
13 May 1962	6,310.000	1	1984	13,600.000	1.29
02 Nov 1962	1,860.000	2	1983	10,100.000	3.12
22 May 1964	1,630.000	3	2011	9,540.000	4.96
24 May 1965	3,100.000	4	1996	8,450.000	6.80
04 Apr 1966	1,700.000	5	1997	8,340.000	8.64
10 Apr 1967	1,890.000	6	2015	7,860.000	10.48
07 Jun 1968	2,050.000	7	2014	7,830.000	12.32
25 Jun 1969	3,540.000	8	1995	7,080.000	14.15
23 May 1970	6,220.000	9	1962	6,310.000	15.99
10 Jun 1972	2,910.000	10	2008	6,230.000	17.83
15 Jun 1973	4,370.000	11	1970	6,220.000	19.67
11 May 1974	4,960.000	12	2010	6,080.000	21.51
10 Jun 1975	2,940.000	13	2009	5,380.000	23.35
23 May 1976	1,840.000	14	1974	4,960.000	25.18
23 Jul 1977	1,240.000	15	2016	4,830.000	27.02
25 May 1978	3,100.000	16	1986	4,530.000	28.86
30 May 1979	4,120.000	17	1973	4,370.000	30.70
25 May 1980	4,200.000	18	1980	4,200.000	32.54

30 May 1981	1,110.000	19	1993	4,190.000	34.37
03 Jul 1982	2,080.000	20	1999	4,170.000	36.21
12 Jul 1983	10,100.000	21	2007	4,140.000	38.05
26 May 1984	13,600.000	22	1979	4,120.000	39.89
11 May 1985	3,620.000	23	1985	3,620.000	41.73
09 Jun 1986	4,530.000	24	1969	3,540.000	43.57
10 Jun 1987	1,940.000	25	1988	3,280.000	45.40
20 May 1988	3,280.000	26	1998	3,270.000	47.24
25 Apr 1989	1,530.000	27	2000	3,110.000	49.08
04 Sep 1990	1,490.000	28	1978	3,100.000	50.92
07 Jun 1991	2,180.000	29	1965	3,100.000	52.76
01 May 1992	1,250.000	30	1975	2,940.000	54.60
30 May 1993	4,190.000	31	1972	2,910.000	56.43
21 May 1994	1,630.000	32	2006	2,760.000	58.27
13 Jul 1995	7,080.000	33	2003	2,620.000	60.11
23 Jun 1996	8,450.000	34	2005	2,600.000	61.95
12 Jun 1997	8,340.000	35	1991	2,180.000	63.79
31 May 1998	3,270.000	36	1982	2,080.000	65.62
05 Jun 1999	4,170.000	37	1968	2,050.000	67.46
01 Jun 2000	3,110.000	38	1987	1,940.000	69.30
31 Aug 2001	1,530.000	39	1967	1,890.000	71.14
01 Oct 2001	991.000	40	1963	1,860.000	72.98
01 Jun 2003	2,620.000	41	1976	1,840.000	74.82
06 Oct 2003	1,260.000	42	2013	1,750.000	76.65
28 Jun 2005	2,600.000	43	1966	1,700.000	78.49
22 May 2006	2,760.000	44	1994	1,630.000	80.33
18 Jun 2007	4,140.000	45	1964	1,630.000	82.17
23 May 2008	6,230.000	46	2001	1,530.000	84.01
27 Jun 2009	5,380.000	47	1989	1,530.000	85.85

13 Jun 2010	6,080.000	48	1990	1,490.000	87.68
26 Jun 2011	9,540.000	49	2012	1,280.000	89.52
06 Oct 2011	1,280.000	50	2004	1,260.000	91.36
18 May 2013	1,750.000	51	1992	1,250.000	93.20
31 May 2014	7,830.000	52	1977	1,240.000	95.04
19 Jun 2015	7,860.000	53	1981	1,110.000	96.87
09 Jun 2016	4,830.000	54	2002	991.000	98.71

<< Skew Weighting >>

Based on 54 events, mean-square error of station skew = 0.107

Mean-square error of regional skew = 0.302

<< Frequency Curve >>

Kremmling no Historical

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
24,233.784	27,428.655	0.2	36,826.801	17,740.366
19,214.447	21,078.540	0.5	28,041.159	14,469.845
15,911.982	17,090.902	1.0	22,484.908	12,253.805
12,987.823	13,695.166	2.0	17,741.908	10,236.845

9,633.747	9,950.665	5.0	12,549.311	7,839.130
7,431.189	7,582.113	10.0	9,319.274	6,196.210
5,466.556	5,522.754	20.0	6,595.967	4,661.819
3,105.908	3,105.908	50.0	3,602.184	2,675.196
1,815.418	1,799.190	80.0	2,130.268	1,502.611
1,386.467	1,363.367	90.0	1,659.160	1,109.497
1,116.092	1,087.142	95.0	1,362.317	865.729
753.203	714.400	99.0	958.410	549.018

<< Systematic Statistics >>

Kremmling no Historical

Log Transform: FLOW, CFS		Number of Events	
Mean	3.501	Historic Events	0
Standard Dev	0.285	High Outliers	0
Station Skew	0.184	Low Outliers	0
Regional Skew	-0.280	Zero Events	0
Weighted Skew	0.062	Missing Events	0
Adopted Skew	0.184	Systematic Events	54

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis

22 Aug 2017   10:34 AM

--- Input Data ---

Analysis Name: @Dotsero Post 1968 - 17B

Description:

Data Set Name: Dotsero Post 1968

DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH2\HEC-SSP\Post\@Dotsero_Post_68\Dotsero_Post_68.dss

DSS Pathname: ////01jan1900/IR-CENTURY//

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH2\HEC-SSP\Post\@Dotsero_Post_68\Bulletin17Results\@Dotsero_Post_1968_-_17B\@Dotsero_Post_1968_-_17B.rpt

XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH2\HEC-SSP\Post\@Dotsero_Post_68\Bulletin17Results\@Dotsero_Post_1968_-_17B\@Dotsero_Post_1968_-_17B.xml

Start Date:

End Date:

Skew Option: Use Station Skew

Regional Skew: -Infinity

Regional Skew MSE: -Infinity

Plotting Position Type: Median

Upper Confidence Level: 0.05

Lower Confidence Level: 0.95

Display ordinate values using 3 digits in fraction part of value

--- End of Input Data ---

--- Preliminary Results ---

<< Skew Weighting >>

Based on 49 events, mean-square error of station skew = 0.152

Mean-square error of regional skew = -?

<< Frequency Curve >>

Dotsero Post 1968

Computed	Expected	Percent	Confidence Limits	
Curve	Probability	Chance	0.05	0.95
FLOW, CFS		Exceedance	FLOW, CFS	
26,142.284	27,248.280	0.2	33,972.770	21,464.004
24,203.790	25,042.058	0.5	31,037.807	20,048.861

22,587.881	23,252.244	1.0	28,628.338	18,855.078
20,820.944	21,316.737	2.0	26,035.164	17,533.244
18,203.652	18,513.869	5.0	22,281.450	15,538.586
15,949.992	16,131.353	10.0	19,143.675	13,778.580
13,363.445	13,450.657	20.0	15,669.482	11,695.915
9,020.360	9,020.360	50.0	10,232.892	7,976.292
5,641.953	5,584.737	80.0	6,434.364	4,829.309
4,275.843	4,186.766	90.0	4,979.786	3,526.800
3,343.066	3,228.593	95.0	3,990.673	2,652.117
2,018.413	1,856.711	99.0	2,557.520	1,465.009

<< Systematic Statistics >>

Dotsero Post 1968

Log Transform: FLOW, CFS		Number of Events	
Mean	3.932	Historic Events	0
Standard Dev	0.226	High Outliers	0
Station Skew	-0.622	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-0.622	Systematic Events	49

--- End of Preliminary Results ---

<< Low Outlier Test >>

Based on 49 events, 10 percent outlier test deviate K(N) = 2.76

Computed low outlier test value = 2,028.8318

1 low outlier(s) identified below test value of 2,028.8318

Statistics and frequency curve adjusted for 1 low outlier(s)

<< Systematic Statistics >>

Dotsero Post 1968

Log Transform: FLOW, CFS		Number of Events	
Mean	3.945	Historic Events	0
Standard Dev	0.209	High Outliers	0
Station Skew	-0.403	Low Outliers	1
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-0.622	Systematic Events	49

<< High Outlier Test >>

Based on 48 events, 10 percent outlier test deviate K(N) = 2.753

Computed high outlier test value = 33,193.8915

0 high outlier(s) identified above test value of 33,193.8915

Note: Statistics and frequency curve were modified

using conditional probablity adjustment.

--- Final Results ---

<< Plotting Positions >>

Dotsero Post 1968

Events Analyzed		Ordered Events			
Day Mon Year	FLOW CFS	Rank	Water Year	FLOW CFS	Median Plot Pos
06 Jun 1968	9,270.000	1	1984	22,200.000	1.42
25 Jun 1969	6,730.000	2	2011	18,500.000	3.44
22 May 1970	13,900.000	3	1983	17,700.000	5.47
25 Jun 1971	10,300.000	4	2014	17,200.000	7.49

07 Jun 1972	8,420.000	5	1997	16,100.000	9.51
15 Jun 1973	11,300.000	6	1995	15,400.000	11.54
10 May 1974	11,200.000	7	2010	14,600.000	13.56
09 Jun 1975	9,410.000	8	1970	13,900.000	15.59
12 Jul 1976	7,310.000	9	1996	13,800.000	17.61
07 Jun 1977	2,800.000	10	2015	13,000.000	19.64
16 Jun 1978	11,600.000	11	2008	13,000.000	21.66
29 May 1979	11,800.000	12	1979	11,800.000	23.68
12 Jun 1980	10,700.000	13	2016	11,700.000	25.71
09 Jun 1981	4,900.000	14	2003	11,700.000	27.73
29 Jun 1982	6,820.000	15	1985	11,600.000	29.76
27 Jun 1983	17,700.000	16	1978	11,600.000	31.78
25 May 1984	22,200.000	17	1993	11,500.000	33.81
09 Jun 1985	11,600.000	18	1973	11,300.000	35.83
07 Jun 1986	11,100.000	19	1974	11,200.000	37.85
17 May 1987	5,840.000	20	1986	11,100.000	39.88
07 Jun 1988	6,300.000	21	1980	10,700.000	41.90
24 May 1989	4,420.000	22	2009	10,400.000	43.93
08 Jun 1990	5,060.000	23	1971	10,300.000	45.95
15 Jun 1991	7,200.000	24	2006	9,600.000	47.98
27 May 1992	3,700.000	25	1975	9,410.000	50.00
29 May 1993	11,500.000	26	1968	9,270.000	52.02
02 Jun 1994	4,630.000	27	2000	8,790.000	54.05
18 Jun 1995	15,400.000	28	1972	8,420.000	56.07
20 May 1996	13,800.000	29	1999	8,310.000	58.10
04 Jun 1997	16,100.000	30	1998	7,550.000	60.12
02 Jun 1998	7,550.000	31	2005	7,390.000	62.15
09 Jun 1999	8,310.000	32	1976	7,310.000	64.17
30 May 2000	8,790.000	33	1991	7,200.000	66.19

20 May 2001	4,400.000	34	1982	6,820.000	68.22
01 Jun 2002	2,020.000	35	1969	6,730.000	70.24
02 Jun 2003	11,700.000	36	2007	6,720.000	72.27
08 Jun 2004	3,240.000	37	1988	6,300.000	74.29
24 May 2005	7,390.000	38	2013	5,990.000	76.32
23 May 2006	9,600.000	39	1987	5,840.000	78.34
19 Jun 2007	6,720.000	40	1990	5,060.000	80.36
22 May 2008	13,000.000	41	2012	5,020.000	82.39
21 May 2009	10,400.000	42	1981	4,900.000	84.41
08 Jun 2010	14,600.000	43	1994	4,630.000	86.44
07 Jun 2011	18,500.000	44	1989	4,420.000	88.46
24 Jul 2012	5,020.000	45	2001	4,400.000	90.49
18 May 2013	5,990.000	46	1992	3,700.000	92.51
01 Jun 2014	17,200.000	47	2004	3,240.000	94.53
18 Jun 2015	13,000.000	48	1977	2,800.000	96.56
10 Jun 2016	11,700.000	49	2002	2,020.000*	98.58

* Outlier

<< Skew Weighting >>

Based on 49 events, mean-square error of station skew = 0.132

Mean-square error of regional skew = -?

<< Frequency Curve >>

Dotsero Post 1968

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
27,991.856	29,565.692	0.2	36,518.570	22,958.623
25,383.685	26,504.890	0.5	32,546.211	21,064.029
23,330.972	24,171.133	1.0	29,478.686	19,550.868
21,196.322	21,792.155	2.0	26,348.739	17,953.647
18,215.450	18,559.738	5.0	22,092.252	15,675.223
15,796.046	15,989.803	10.0	18,749.956	13,774.654
13,158.166	13,246.854	20.0	15,244.242	11,632.325
8,985.073	8,985.073	50.0	10,089.742	8,015.594
5,874.333	5,822.724	80.0	6,637.709	5,081.206
4,620.802	4,539.425	90.0	5,317.364	3,870.439
3,754.194	3,646.885	95.0	4,409.865	3,043.676
2,483.610	2,323.283	99.0	3,060.941	1,873.678

<< Synthetic Statistics >>

Dotsero Post 1968

Log Transform: FLOW, CFS		Number of Events	
Mean	3.940	Historic Events	0
Standard Dev	0.209	High Outliers	0

```
|  Station Skew       -0.382  |  Low Outliers          1     |
|  Regional Skew         ---  |  Zero Events           0     |
|  Weighted Skew         ---  |  Missing Events        0     |
|  Adopted Skew       -0.382  |  Systematic Events    49     |
|-----------------------------|------------------------------|
```

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis

22 Aug 2017 10:22 AM

--- Input Data ---

Analysis Name: @At Glenwood - 17B

Description:

Data Set Name: Colorado River-GLENWOOD SPRINGS, CO.-FLOW-ANNUAL PEAK

DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss

DSS Pathname: /COLORADO RIVER/GLENWOOD SPRINGS, CO./FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@At_Glenwood_-_17B\@At_Glenwood_-_17B.rpt

XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@At_Glenwood_-_17B\@At_Glenwood_-_17B.xml

Start Date:

End Date:

Skew Option: Use Station Skew

Regional Skew: -0.1

Regional Skew MSE: 0.302

Plotting Position Type: Median

Upper Confidence Level: 0.05

Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

--- Preliminary Results ---

<< Skew Weighting >>

Based on 67 events, mean-square error of station skew = 0.126

Mean-square error of regional skew = 0.302

<< Frequency Curve >>

Colorado River-GLENWOOD SPRINGS, CO.-FLOW-ANNUAL PEAK

Computed Curve	Expected Probability	Percent Chance	Confidence Limits 0.05	Confidence Limits 0.95
FLOW, CFS		Exceedance	FLOW, CFS	
36,959.9	37,798.5	0.2	44,315.5	32,035.7
34,845.0	35,505.0	0.5	41,434.4	30,379.2
33,024.3	33,565.5	1.0	38,979.3	28,941.2

30,973.6	31,391.4	2.0	36,243.7	27,306.7
27,818.1	28,093.9	5.0	32,101.4	24,756.9
24,984.1	25,151.6	10.0	28,459.0	22,424.4
21,589.1	21,673.7	20.0	24,209.7	19,563.1
15,500.5	15,500.5	50.0	16,995.4	14,167.5
10,344.0	10,277.1	80.0	11,397.1	9,250.6
8,118.4	8,009.8	90.0	9,091.6	7,071.0
6,536.9	6,392.5	95.0	7,462.0	5,535.1
4,175.9	3,956.7	99.0	4,994.0	3,312.4

<< Systematic Statistics >>

Colorado River-GLENWOOD SPRINGS, CO.-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.168	Historic Events	0
Standard Dev	0.194	High Outliers	0
Station Skew	-0.697	Low Outliers	0
Regional Skew	-0.100	Zero Events	0
Weighted Skew	-0.521	Missing Events	0
Adopted Skew	-0.697	Systematic Events	67

--- End of Preliminary Results ---

<< Low Outlier Test >>

Based on 67 events, 10 percent outlier test deviate K(N) = 2.877

Computed low outlier test value = 4,073.2

1 low outlier(s) identified below test value of 4,073.2

Statistics and frequency curve adjusted for 1 low outlier(s)

<< Systematic Statistics >>

Colorado River-GLENWOOD SPRINGS, CO.-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.176	Historic Events	0
Standard Dev	0.183	High Outliers	0
Station Skew	-0.536	Low Outliers	1
Regional Skew	-0.100	Zero Events	0
Weighted Skew	-0.521	Missing Events	0
Adopted Skew	-0.697	Systematic Events	67

<< High Outlier Test >>

Based on 66 events, 10 percent outlier test deviate K(N) = 2.871

Computed high outlier test value = 50,176.62

0 high outlier(s) identified above test value of 50,176.62

Note: Statistics and frequency curve were modified

using conditional probablity adjustment.

--- Final Results ---

<< Plotting Positions >>

Colorado River-GLENWOOD SPRINGS, CO.-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
	FLOW		Water	FLOW	Median
Day Mon Year	CFS	Rank	Year	CFS	Plot Pos
30 May 1900	20,000.0	1	1918	30,100.0	1.04
22 May 1901	20,000.0	2	1917	29,400.0	2.52
16 May 1902	12,000.0	3	1921	29,000.0	4.01
18 Jun 1903	16,500.0	4	1914	28,100.0	5.49
25 May 1904	16,500.0	5	1909	27,900.0	6.97

06 Jun 1905	22,500.0	6	1912	27,700.0	8.46	
14 Jun 1906	22,100.0	7	1928	27,400.0	9.94	
17 Jun 1907	20,400.0	8	1924	24,500.0	11.42	
12 Jun 1908	11,500.0	9	1920	24,300.0	12.91	
21 Jun 1909	27,900.0	10	1926	23,000.0	14.39	
01 Jun 1910	14,600.0	11	1905	22,500.0	15.88	
09 Jun 1911	15,200.0	12	1906	22,100.0	17.36	
09 Jun 1912	27,700.0	13	1929	21,400.0	18.84	
01 Jun 1913	12,400.0	14	1935	21,300.0	20.33	
03 Jun 1914	28,100.0	15	1938	20,900.0	21.81	
21 Jun 1915	13,400.0	16	1952	20,800.0	23.29	
14 Jun 1916	14,800.0	17	1933	20,600.0	24.78	
19 Jun 1917	29,400.0	18	1923	20,400.0	26.26	
14 Jun 1918	30,100.0	19	1907	20,400.0	27.74	
29 May 1919	12,300.0	20	1901	20,000.0	29.23	
01 Jun 1920	24,300.0	21	1900	20,000.0	30.71	
15 Jun 1921	29,000.0	22	1957	18,900.0	32.20	
10 Jun 1922	16,100.0	23	1927	18,400.0	33.68	
17 Jun 1923	20,400.0	24	1932	17,300.0	35.16	
15 Jun 1924	24,500.0	25	1936	16,900.0	36.65	
31 May 1925	11,200.0	26	1942	16,800.0	38.13	
07 Jun 1926	23,000.0	27	1948	16,600.0	39.61	
22 May 1927	18,400.0	28	1904	16,500.0	41.10	
31 May 1928	27,400.0	29	1903	16,500.0	42.58	
10 Jun 1929	21,400.0	30	1949	16,300.0	44.07	
01 Jun 1930	15,500.0	31	1922	16,100.0	45.55	
08 Jun 1931	9,710.0	32	1958	16,000.0	47.03	
24 May 1932	17,300.0	33	1930	15,500.0	48.52	
13 Jun 1933	20,600.0	34	1911	15,200.0	50.00	

13 May 1934	8,140.0	35	1941	14,900.0	51.48	
16 Jun 1935	21,300.0	36	1916	14,800.0	52.97	
01 Jun 1936	16,900.0	37	1962	14,600.0	54.45	
17 May 1937	11,400.0	38	1910	14,600.0	55.93	
06 Jun 1938	20,900.0	39	1951	14,400.0	57.42	
23 May 1939	13,100.0	40	1947	14,200.0	58.90	
03 Jun 1940	11,100.0	41	1953	14,000.0	60.39	
15 May 1941	14,900.0	42	1915	13,400.0	61.87	
28 May 1942	16,800.0	43	1939	13,100.0	63.35	
02 Jun 1943	13,000.0	44	1943	13,000.0	64.84	
02 Jun 1944	10,600.0	45	1956	12,600.0	66.32	
29 May 1945	10,600.0	46	1913	12,400.0	67.80	
09 Jun 1946	9,720.0	47	1919	12,300.0	69.29	
21 Jun 1947	14,200.0	48	1902	12,000.0	70.77	
22 May 1948	16,600.0	49	1965	11,900.0	72.26	
18 Jun 1949	16,300.0	50	1908	11,500.0	73.74	
13 Jun 1950	10,100.0	51	1937	11,400.0	75.22	
21 Jun 1951	14,400.0	52	1925	11,200.0	76.71	
08 Jun 1952	20,800.0	53	1940	11,100.0	78.19	
14 Jun 1953	14,000.0	54	1945	10,600.0	79.67	
22 May 1954	4,060.0	55	1944	10,600.0	81.16	
24 May 1955	5,400.0	56	1950	10,100.0	82.64	
24 May 1956	12,600.0	57	1960	9,730.0	84.12	
08 Jun 1957	18,900.0	58	1946	9,720.0	85.61	
29 May 1958	16,000.0	59	1931	9,710.0	87.09	
10 Jun 1959	8,480.0	60	1959	8,480.0	88.58	
04 Jun 1960	9,730.0	61	1934	8,140.0	90.06	
31 May 1961	7,680.0	62	1961	7,680.0	91.54	
13 May 1962	14,600.0	63	1964	7,580.0	93.03	

07 May 1963	5,470.0	64	1963	5,470.0	94.51
25 May 1964	7,580.0	65	1955	5,400.0	95.99
18 Jun 1965	11,900.0	66	1966	4,840.0	97.48
08 May 1966	4,840.0	67	1954	4,060.0*	98.96

* Outlier

<< Skew Weighting >>

Based on 67 events, mean-square error of station skew = 0.111

Mean-square error of regional skew = 0.302

<< Frequency Curve >>

Colorado River-GLENWOOD SPRINGS, CO.-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
38,579.4	39,687.2	0.2	46,319.8	33,436.2
35,904.9	36,735.9	0.5	42,664.6	31,347.8
33,704.5	34,356.3	1.0	39,693.6	29,612.4
31,322.0	31,805.5	2.0	36,516.7	27,713.6
27,822.2	28,122.0	5.0	31,933.3	24,881.3
24,821.0	24,997.8	10.0	28,092.6	22,402.9

21,367.7	21,453.6	20.0	23,796.2	19,478.0
15,461.0	15,461.0	50.0	16,851.7	14,206.4
10,630.3	10,568.7	80.0	11,648.4	9,564.6
8,556.3	8,455.5	90.0	9,514.0	7,518.1
7,071.7	6,935.5	95.0	7,995.7	6,062.2
4,808.4	4,593.9	99.0	5,656.4	3,898.4

<< Synthetic Statistics >>

Colorado River-GLENWOOD SPRINGS, CO.-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.174	Historic Events	0
Standard Dev	0.182	High Outliers	0
Station Skew	-0.516	Low Outliers	1
Regional Skew	-0.100	Zero Events	0
Weighted Skew	-0.404	Missing Events	0
Adopted Skew	-0.516	Systematic Events	67

--- End of Analytical Frequency Curve ---

```
------------------------------
Bulletin 17B Frequency Analysis
    13 Dec 2017   08:36 AM
------------------------------


--- Input Data ---

Analysis Name: @Below Glenwood - RF - 17B
Description:

Data Set Name: Below Glenwood - RF
DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4
HH2\HEC-SSP\Post\@Below_Glenwood_-_No_RF\@Below_Glenwood_-_No_RF.dss
DSS Pathname: ////01jan1900/IR-CENTURY//

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4
HH2\HEC-SSP\Post\@Below_Glenwood_-_No_RF\Bulletin17Results\@Below_Glenwood_-_RF_-_17
B\@Below_Glenwood_-_RF_-_17B.rpt
XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4
HH2\HEC-SSP\Post\@Below_Glenwood_-_No_RF\Bulletin17Results\@Below_Glenwood_-_RF_-_17
B\@Below_Glenwood_-_RF_-_17B.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Median

Upper Confidence Level: 0.05
Lower Confidence Level: 0.95

Display ordinate values using 3 digits in fraction part of value

--- End of Input Data ---



----------------------
<< Low Outlier Test >>
----------------------
 Based on 50 events, 10 percent outlier test deviate K(N) = 2.768
                     Computed low outlier test value = 2,110.3215

       0 low outlier(s) identified below test value of 2,110.3215



-----------------------
<< High Outlier Test >>
-----------------------
 Based on 50 events, 10 percent outlier test deviate K(N) = 2.768
                   Computed high outlier test value = 36,702.5172

     0 high outlier(s) identified above test value of 36,702.5172



--- Final Results ---
```

<< Plotting Positions >>
Below Glenwood - RF

Events Analyzed				Ordered Events			
Day	Mon	Year	FLOW CFS	Rank	Water Year	FLOW CFS	Median Plot Pos
05	Jun	1967	9,590.000	1	1984	22,870.000	1.39
06	Jun	1968	10,500.000	2	2011	20,070.000	3.37
28	May	1969	7,730.000	3	2014	18,650.000	5.36
23	May	1970	13,700.000	4	1983	16,700.000	7.34
25	Jun	1971	10,700.000	5	1997	15,810.000	9.33
08	Jun	1972	8,590.000	6	2010	15,650.000	11.31
15	Jun	1973	13,210.000	7	2008	14,170.000	13.29
30	May	1974	10,320.000	8	2015	14,160.000	15.28
16	Jun	1975	8,820.000	9	1970	13,700.000	17.26
06	Jun	1976	5,910.000	10	1995	13,600.000	19.25
07	Jun	1977	2,830.000	11	1973	13,210.000	21.23
16	Jun	1978	12,170.000	12	1986	13,180.000	23.21
16	Jun	1979	11,360.000	13	2016	12,790.000	25.20
12	Jun	1980	11,630.000	14	1996	12,420.000	27.18
10	Jun	1981	5,200.000	15	2003	12,350.000	29.17
29	Jun	1982	7,230.000	16	1978	12,170.000	31.15
25	Jun	1983	16,700.000	17	1985	11,910.000	33.13
25	May	1984	22,870.000	18	2009	11,750.000	35.12
09	Jun	1985	11,910.000	19	1980	11,630.000	37.10
07	Jun	1986	13,180.000	20	1979	11,360.000	39.09
09	Jun	1987	5,380.000	21	1993	11,030.000	41.07
07	Jun	1988	6,910.000	22	1971	10,700.000	43.06
30	May	1989	4,800.000	23	1968	10,500.000	45.04
11	Jun	1990	5,430.000	24	1974	10,320.000	47.02
15	Jun	1991	7,430.000	25	1967	9,590.000	49.01
27	May	1992	3,720.000	26	2006	8,960.000	50.99
28	May	1993	11,030.000	27	1975	8,820.000	52.98
02	Jun	1994	5,150.000	28	1972	8,590.000	54.96
18	Jun	1995	13,600.000	29	1999	8,550.000	56.94
20	May	1996	12,420.000	30	2000	8,480.000	58.93
05	Jun	1997	15,810.000	31	1998	7,850.000	60.91
02	Jun	1998	7,850.000	32	1969	7,730.000	62.90
09	Jun	1999	8,550.000	33	2005	7,600.000	64.88
30	May	2000	8,480.000	34	2007	7,490.000	66.87
02	Jun	2001	4,670.000	35	1991	7,430.000	68.85
01	Jun	2002	2,310.000	36	1982	7,230.000	70.83
02	Jun	2003	12,350.000	37	1988	6,910.000	72.82
08	Jun	2004	3,370.000	38	2013	6,550.000	74.80
23	May	2005	7,600.000	39	1976	5,910.000	76.79
23	May	2006	8,960.000	40	1990	5,430.000	78.77
20	Jun	2007	7,490.000	41	1987	5,380.000	80.75
03	Jun	2008	14,170.000	42	1981	5,200.000	82.74
21	May	2009	11,750.000	43	1994	5,150.000	84.72
08	Jun	2010	15,650.000	44	1989	4,800.000	86.71
26	Jun	2011	20,070.000	45	2001	4,670.000	88.69
24	Jul	2012	3,846.000	46	2012	3,846.000	90.67
11	Jun	2013	6,550.000	47	1992	3,720.000	92.66
02	Jun	2014	18,650.000	48	2004	3,370.000	94.64
18	Jun	2015	14,160.000	49	1977	2,830.000	96.63
08	Jun	2016	12,790.000	50	2002	2,310.000	98.61

<< Skew Weighting >>

Based on 50 events, mean-square error of station skew = 0.146
Mean-square error of regional skew = -?

<< Frequency Curve >>
Below Glenwood - RF

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
27,211.253	28,398.687	0.2	35,295.010	22,367.642
25,104.911	25,995.332	0.5	32,116.464	20,827.601
23,366.877	24,065.713	1.0	29,534.613	19,541.163
21,483.254	22,000.171	2.0	26,781.513	18,128.954
18,722.302	19,041.274	5.0	22,839.319	16,019.570
16,369.833	16,555.064	10.0	19,579.387	14,177.303
13,694.627	13,782.924	20.0	16,003.393	12,016.893
9,250.955	9,250.955	50.0	10,466.079	8,200.103
5,821.871	5,765.180	80.0	6,623.262	4,998.769
4,436.834	4,348.420	90.0	5,151.743	3,675.379
3,489.421	3,375.350	95.0	4,149.409	2,784.241
2,137.174	1,974.541	99.0	2,691.342	1,566.056

<< Systematic Statistics >>
Below Glenwood - RF

Log Transform: FLOW, CFS		Number of Events	
Mean	3.945	Historic Events	0
Standard Dev	0.224	High Outliers	0
Station Skew	-0.583	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-0.583	Systematic Events	50

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis

22 Aug 2017 10:27 AM

--- Input Data ---

Analysis Name: @Below Glenwood - 17B

Description:

Data Set Name: COLORADO RIVER- BELOW GLENWOOD SPRINGS,

DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss

DSS Pathname: /COLORADO RIVER/GLENWOOD SPRINGS, CO/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Below_Glenwood_-_17B\@Below_Glenwood_-_17B.rpt

XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Below_Glenwood_-_17B\@Below_Glenwood_-_17B.xml

Start Date:

End Date:

Skew Option: Use Station Skew

Regional Skew: -Infinity

Regional Skew MSE: -Infinity

Plotting Position Type: Median

Upper Confidence Level: 0.05

Lower Confidence Level: 0.95

Use Historic Data

Historic Period Start Year: 1921

Historic Period End Year: 1921

Year: 1921   Value: 44,400

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

--- Preliminary Results ---

<< Plotting Positions >>

COLORADO RIVER- BELOW GLENWOOD SPRINGS,

Events Analyzed		Ordered Events			
	FLOW		Water	FLOW	Median
Day Mon Year	CFS	Rank	Year	CFS	Plot Pos
16 Jun 1921	44,400.0	1	1921	44,400.0	0.73
05 Jun 1922	---	2	1984	31,500.0	1.76
05 Jun 1923	---	3	1983	27,900.0	2.80
05 Jun 1924	---	4	2011	27,600.0	3.84
05 Jun 1925	---	5	2014	24,900.0	4.88
05 Jun 1926	---	6	2010	24,300.0	5.91

05 Jun 1927	---	7	1995	23,800.0	6.95	
05 Jun 1928	---	8	1997	23,400.0	7.99	
05 Jun 1929	---	9	1985	21,600.0	9.02	
05 Jun 1930	---	10	2015	21,200.0	10.06	
05 Jun 1931	---	11	2008	20,500.0	11.10	
05 Jun 1932	---	12	1973	20,500.0	12.14	
05 Jun 1933	---	13	1986	20,200.0	13.17	
05 Jun 1934	---	14	1978	19,400.0	14.21	
05 Jun 1935	---	15	1970	19,200.0	15.25	
05 Jun 1936	---	16	1980	18,800.0	16.29	
05 Jun 1937	---	17	2016	18,700.0	17.32	
05 Jun 1938	---	18	2003	18,500.0	18.36	
05 Jun 1939	---	19	1996	18,200.0	19.40	
05 Jun 1940	---	20	2009	17,800.0	20.44	
05 Jun 1941	---	21	1993	17,700.0	21.47	
05 Jun 1942	---	22	1979	17,700.0	22.51	
05 Jun 1943	---	23	1971	17,600.0	23.55	
05 Jun 1944	---	24	1968	17,400.0	24.59	
05 Jun 1945	---	25	1974	15,100.0	25.62	
05 Jun 1946	---	26	2006	14,600.0	26.66	
05 Jun 1947	---	27	1972	14,400.0	27.70	
05 Jun 1948	---	28	1975	14,200.0	28.73	
05 Jun 1949	---	29	1967	14,200.0	29.77	
05 Jun 1950	---	30	2000	13,800.0	30.81	
05 Jun 1951	---	31	1969	13,300.0	31.85	
05 Jun 1952	---	32	1999	13,000.0	32.88	
05 Jun 1953	---	33	2005	12,800.0	33.92	
05 Jun 1954	---	34	1998	12,800.0	34.96	
05 Jun 1955	---	35	1982	12,600.0	36.00	

05 Jun 1956	---	36	1991	12,100.0	37.03	
05 Jun 1957	---	37	1987	11,100.0	38.07	
05 Jun 1958	---	38	1988	11,000.0	39.11	
05 Jun 1959	---	39	2007	10,700.0	40.15	
05 Jun 1960	---	40	2013	10,500.0	41.18	
05 Jun 1961	---	41	1976	9,960.0	42.22	
05 Jun 1962	---	42	1990	9,810.0	43.26	
05 Jun 1963	---	43	1981	9,310.0	44.29	
05 Jun 1964	---	44	1994	9,180.0	45.33	
05 Jun 1965	---	45	2001	8,130.0	46.37	
05 Jun 1966	---	46	1989	7,620.0	47.41	
05 Jun 1967	14,200.0	47	2004	6,920.0	48.44	
06 Jun 1968	17,400.0	48	1992	6,550.0	49.48	
28 May 1969	13,300.0	49	1977	4,830.0	50.52	
23 May 1970	19,200.0	50	2012	4,480.0	51.56	
25 Jun 1971	17,600.0	51	2002	4,480.0	52.59	
08 Jun 1972	14,400.0	52	1966	---	53.63	
15 Jun 1973	20,500.0	53	1965	---	54.67	
30 May 1974	15,100.0	54	1964	---	55.71	
16 Jun 1975	14,200.0	55	1963	---	56.74	
06 Jun 1976	9,960.0	56	1962	---	57.78	
07 Jun 1977	4,830.0	57	1961	---	58.82	
16 Jun 1978	19,400.0	58	1960	---	59.85	
16 Jun 1979	17,700.0	59	1959	---	60.89	
12 Jun 1980	18,800.0	60	1958	---	61.93	
10 Jun 1981	9,310.0	61	1957	---	62.97	
29 Jun 1982	12,600.0	62	1956	---	64.00	
25 Jun 1983	27,900.0	63	1955	---	65.04	
25 May 1984	31,500.0	64	1954	---	66.08	

09 Jun 1985	21,600.0	65	1953	---	67.12
07 Jun 1986	20,200.0	66	1952	---	68.15
09 Jun 1987	11,100.0	67	1951	---	69.19
07 Jun 1988	11,000.0	68	1950	---	70.23
30 May 1989	7,620.0	69	1949	---	71.27
11 Jun 1990	9,810.0	70	1948	---	72.30
15 Jun 1991	12,100.0	71	1947	---	73.34
27 May 1992	6,550.0	72	1946	---	74.38
28 May 1993	17,700.0	73	1945	---	75.41
02 Jun 1994	9,180.0	74	1944	---	76.45
18 Jun 1995	23,800.0	75	1943	---	77.49
20 May 1996	18,200.0	76	1942	---	78.53
05 Jun 1997	23,400.0	77	1941	---	79.56
02 Jun 1998	12,800.0	78	1940	---	80.60
09 Jun 1999	13,000.0	79	1939	---	81.64
30 May 2000	13,800.0	80	1938	---	82.68
02 Jun 2001	8,130.0	81	1937	---	83.71
01 Jun 2002	4,480.0	82	1936	---	84.75
02 Jun 2003	18,500.0	83	1935	---	85.79
08 Jun 2004	6,920.0	84	1934	---	86.83
23 May 2005	12,800.0	85	1933	---	87.86
23 May 2006	14,600.0	86	1932	---	88.90
20 Jun 2007	10,700.0	87	1931	---	89.94
03 Jun 2008	20,500.0	88	1930	---	90.98
21 May 2009	17,800.0	89	1929	---	92.01
08 Jun 2010	24,300.0	90	1928	---	93.05
26 Jun 2011	27,600.0	91	1927	---	94.09
24 Jul 2012	4,480.0	92	1926	---	95.12
11 Jun 2013	10,500.0	93	1925	---	96.16

02 Jun 2014	24,900.0	94	1924	---	97.20
18 Jun 2015	21,200.0	95	1923	---	98.24
08 Jun 2016	18,700.0	96	1922	---	99.27

Note: Adopted skew equals station skew and preliminary frequency statistics are for the conditional frequency curve because of zero or missing events.

Warning: Number of zero/missing values and low outliers is greater than 25% of the systematic record.

<< Frequency Curve >>

COLORADO RIVER- BELOW GLENWOOD SPRINGS,

Computed Curve	Expected Probability	Percent Chance Exceedance	Confidence Limits 0.05	Confidence Limits 0.95
FLOW, CFS			FLOW, CFS	
44,262.2	46,318.1	0.2	56,989.4	36,590.3
40,607.8	42,117.7	0.5	51,519.7	33,904.6
37,650.5	38,813.5	1.0	47,166.0	31,703.0
34,499.6	35,345.4	2.0	42,604.8	29,325.5
29,969.9	30,478.4	5.0	36,202.7	25,840.8
26,182.7	26,474.7	10.0	31,010.0	22,852.7

21,942.4	22,079.7	20.0	25,402.7	19,401.5
15,011.2	15,011.2	50.0	16,855.0	13,399.2
9,696.8	9,610.9	80.0	10,951.5	8,398.6
7,535.1	7,399.6	90.0	8,672.0	6,315.1
6,041.1	5,863.6	95.0	7,104.8	4,894.0
3,866.6	3,605.4	99.0	4,787.5	2,902.5

<< Conditional Statistics >>

COLORADO RIVER- BELOW GLENWOOD SPRINGS,

Log Transform: FLOW, CFS		Number of Events	
Mean	4.159	Historic Events	0
Standard Dev	0.213	High Outliers	0
Station Skew	-0.496	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	45
Adopted Skew	-0.496	Systematic Events	96

<< Conditional Probability Adjusted Ordinates >>

<< Frequency Curve >>

COLORADO RIVER- BELOW GLENWOOD SPRINGS,

Computed Curve (FLOW, CFS)	Expected Probability (FLOW, CFS)	Percent Chance Exceedance	Confidence Limits 0.05 (FLOW, CFS)	Confidence Limits 0.95 (FLOW, CFS)
41,741.9	---	0.2	---	---
37,910.0	---	0.5	---	---
34,776.4	---	1.0	---	---
31,417.9	---	2.0	---	---
26,518.4	---	5.0	---	---
22,322.8	---	10.0	---	---
17,405.9	---	20.0	---	---
6,342.8	---	50.0	---	---
---	---	80.0	---	---
---	---	90.0	---	---
---	---	95.0	---	---
---	---	99.0	---	---

--- End of Preliminary Results ---

Note: High outlier threshold is set to lowest historic value.

<< Low Outlier Test >>

Based on 51 events, 10 percent outlier test deviate K(N) = 2.775

Computed low outlier test value = 3,696.45

0 low outlier(s) identified below test value of 3,696.45

Based on statistics after 0 zero events and 45 missing events were deleted.

<< High Outlier Test >>

Based on 51 events, 10 percent outlier test deviate K(N) = 2.775

Computed high outlier test value = 56,224.7

0 high outlier(s) identified above input threshold of 44,400

Statistics and frequency curve adjusted for 0 high outlier(s)

and 1 historic event(s)

<< Conditional Statistics >>

COLORADO RIVER- BELOW GLENWOOD SPRINGS,

Log Transform: FLOW, CFS		Number of Events	
Mean	4.159	Historic Events	1
Standard Dev	0.213	High Outliers	0
Station Skew	-0.496	Low Outliers	0

Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	45
Adopted Skew	-0.496	Systematic Events	96

Warning: 46 percent of systematic record was truncated for low outliers, zero, or missing values.

Note: Statistics and frequency curve were modified
using conditional probablity adjustment.

--- Final Results ---

<< Plotting Positions >>

COLORADO RIVER- BELOW GLENWOOD SPRINGS,

Events Analyzed		Ordered Events			
Day Mon Year	FLOW CFS	Rank	Water Year	FLOW CFS	Median Plot Pos
16 Jun 1921	44,400.0	1	1921	44,400.0	0.73
05 Jun 1922	---	2	1984	31,500.0	1.76
05 Jun 1923	---	3	1983	27,900.0	2.80
05 Jun 1924	---	4	2011	27,600.0	3.84
05 Jun 1925	---	5	2014	24,900.0	4.88

05 Jun 1926	---	6	2010	24,300.0	5.91
05 Jun 1927	---	7	1995	23,800.0	6.95
05 Jun 1928	---	8	1997	23,400.0	7.99
05 Jun 1929	---	9	1985	21,600.0	9.02
05 Jun 1930	---	10	2015	21,200.0	10.06
05 Jun 1931	---	11	2008	20,500.0	11.10
05 Jun 1932	---	12	1973	20,500.0	12.14
05 Jun 1933	---	13	1986	20,200.0	13.17
05 Jun 1934	---	14	1978	19,400.0	14.21
05 Jun 1935	---	15	1970	19,200.0	15.25
05 Jun 1936	---	16	1980	18,800.0	16.29
05 Jun 1937	---	17	2016	18,700.0	17.32
05 Jun 1938	---	18	2003	18,500.0	18.36
05 Jun 1939	---	19	1996	18,200.0	19.40
05 Jun 1940	---	20	2009	17,800.0	20.44
05 Jun 1941	---	21	1993	17,700.0	21.47
05 Jun 1942	---	22	1979	17,700.0	22.51
05 Jun 1943	---	23	1971	17,600.0	23.55
05 Jun 1944	---	24	1968	17,400.0	24.59
05 Jun 1945	---	25	1974	15,100.0	25.62
05 Jun 1946	---	26	2006	14,600.0	26.66
05 Jun 1947	---	27	1972	14,400.0	27.70
05 Jun 1948	---	28	1975	14,200.0	28.73
05 Jun 1949	---	29	1967	14,200.0	29.77
05 Jun 1950	---	30	2000	13,800.0	30.81
05 Jun 1951	---	31	1969	13,300.0	31.85
05 Jun 1952	---	32	1999	13,000.0	32.88
05 Jun 1953	---	33	2005	12,800.0	33.92
05 Jun 1954	---	34	1998	12,800.0	34.96

05 Jun 1955	---	35	1982	12,600.0	36.00	
05 Jun 1956	---	36	1991	12,100.0	37.03	
05 Jun 1957	---	37	1987	11,100.0	38.07	
05 Jun 1958	---	38	1988	11,000.0	39.11	
05 Jun 1959	---	39	2007	10,700.0	40.15	
05 Jun 1960	---	40	2013	10,500.0	41.18	
05 Jun 1961	---	41	1976	9,960.0	42.22	
05 Jun 1962	---	42	1990	9,810.0	43.26	
05 Jun 1963	---	43	1981	9,310.0	44.29	
05 Jun 1964	---	44	1994	9,180.0	45.33	
05 Jun 1965	---	45	2001	8,130.0	46.37	
05 Jun 1966	---	46	1989	7,620.0	47.41	
05 Jun 1967	14,200.0	47	2004	6,920.0	48.44	
06 Jun 1968	17,400.0	48	1992	6,550.0	49.48	
28 May 1969	13,300.0	49	1977	4,830.0	50.52	
23 May 1970	19,200.0	50	2012	4,480.0	51.56	
25 Jun 1971	17,600.0	51	2002	4,480.0	52.59	
08 Jun 1972	14,400.0	52	1966	---	53.63	
15 Jun 1973	20,500.0	53	1965	---	54.67	
30 May 1974	15,100.0	54	1964	---	55.71	
16 Jun 1975	14,200.0	55	1963	---	56.74	
06 Jun 1976	9,960.0	56	1962	---	57.78	
07 Jun 1977	4,830.0	57	1961	---	58.82	
16 Jun 1978	19,400.0	58	1960	---	59.85	
16 Jun 1979	17,700.0	59	1959	---	60.89	
12 Jun 1980	18,800.0	60	1958	---	61.93	
10 Jun 1981	9,310.0	61	1957	---	62.97	
29 Jun 1982	12,600.0	62	1956	---	64.00	
25 Jun 1983	27,900.0	63	1955	---	65.04	

25 May 1984	31,500.0	64	1954	---	66.08
09 Jun 1985	21,600.0	65	1953	---	67.12
07 Jun 1986	20,200.0	66	1952	---	68.15
09 Jun 1987	11,100.0	67	1951	---	69.19
07 Jun 1988	11,000.0	68	1950	---	70.23
30 May 1989	7,620.0	69	1949	---	71.27
11 Jun 1990	9,810.0	70	1948	---	72.30
15 Jun 1991	12,100.0	71	1947	---	73.34
27 May 1992	6,550.0	72	1946	---	74.38
28 May 1993	17,700.0	73	1945	---	75.41
02 Jun 1994	9,180.0	74	1944	---	76.45
18 Jun 1995	23,800.0	75	1943	---	77.49
20 May 1996	18,200.0	76	1942	---	78.53
05 Jun 1997	23,400.0	77	1941	---	79.56
02 Jun 1998	12,800.0	78	1940	---	80.60
09 Jun 1999	13,000.0	79	1939	---	81.64
30 May 2000	13,800.0	80	1938	---	82.68
02 Jun 2001	8,130.0	81	1937	---	83.71
01 Jun 2002	4,480.0	82	1936	---	84.75
02 Jun 2003	18,500.0	83	1935	---	85.79
08 Jun 2004	6,920.0	84	1934	---	86.83
23 May 2005	12,800.0	85	1933	---	87.86
23 May 2006	14,600.0	86	1932	---	88.90
20 Jun 2007	10,700.0	87	1931	---	89.94
03 Jun 2008	20,500.0	88	1930	---	90.98
21 May 2009	17,800.0	89	1929	---	92.01
08 Jun 2010	24,300.0	90	1928	---	93.05
26 Jun 2011	27,600.0	91	1927	---	94.09
24 Jul 2012	4,480.0	92	1926	---	95.12

11 Jun 2013	10,500.0	93	1925	---	96.16
02 Jun 2014	24,900.0	94	1924	---	97.20
18 Jun 2015	21,200.0	95	1923	---	98.24
08 Jun 2016	18,700.0	96	1922	---	99.27

<< Skew Weighting >>

Based on 96 events, mean-square error of station skew = 0.216

Mean-square error of regional skew = -?

<< Frequency Curve >>

COLORADO RIVER- BELOW GLENWOOD SPRINGS,

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
38,276.3	38,627.2	0.2	57,172.5	27,266.7
36,607.4	36,967.6	0.5	54,438.9	26,159.6
34,776.4	35,151.7	1.0	51,456.4	24,939.5
32,266.1	32,617.4	2.0	47,397.4	23,257.1
27,542.3	27,847.1	5.0	39,860.7	20,057.9
22,607.7	22,801.2	10.0	32,146.0	16,662.5
16,322.5	16,421.8	20.0	22,599.0	12,239.2

6,342.8	6,342.8	50.0	8,324.7	4,882.1
1,488.4	1,461.4	80.0	1,967.8	1,090.7
556.4	534.3	90.0	777.4	375.0
217.9	203.3	95.0	327.3	132.9
27.3	22.8	99.0	49.6	13.0

<< Adjusted Statistics >>

COLORADO RIVER- BELOW GLENWOOD SPRINGS,

Log Transform: FLOW, CFS		Number of Events	
Mean	3.650	Historic Events	1
Standard Dev	0.677	High Outliers	0
Station Skew	-1.401	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	45
Adopted Skew	-1.401	Systematic Events	96

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis

22 Aug 2017 10:23 AM

--- Input Data ---

Analysis Name: @De Beque - 17B

Description:

Data Set Name: Colorado River-DE BEQUE, CO.-FLOW-ANNUAL PEAK

DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss

DSS Pathname: /COLORADO RIVER/DE BEQUE, CO./FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@De_Beque_-_17B\@De_Beque_-_17B.rpt

XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@De_Beque_-_17B\@De_Beque_-_17B.xml

Start Date:

End Date:

Skew Option: Use Station Skew

Regional Skew: 0.0

Regional Skew MSE: 0.302

Plotting Position Type: Median

Upper Confidence Level: 0.05

Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

--- Preliminary Results ---

Note: Adopted skew equals station skew and preliminary frequency statistics are for the conditional frequency curve because of zero or missing events.

Warning: Number of zero/missing values and low outliers is greater than 25% of the systematic record.

<< Frequency Curve >>

Colorado River-DE BEQUE, CO.-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
60,132.9	67,044.2	0.2	87,184.9	46,591.6
53,310.0	57,978.9	0.5	75,111.5	42,040.0

48,168.5	51,499.9	1.0	66,280.7	38,536.3
43,024.3	45,279.7	2.0	57,698.0	34,956.1
36,167.1	37,381.5	5.0	46,697.1	30,040.8
30,864.9	31,521.1	10.0	38,588.0	26,095.7
25,335.5	25,621.1	20.0	30,576.5	21,794.0
17,075.5	17,075.5	50.0	19,727.7	14,801.3
11,252.5	11,108.3	80.0	13,072.6	9,337.6
8,966.0	8,740.0	90.0	10,627.2	7,142.9
7,396.9	7,097.4	95.0	8,964.9	5,662.8
5,095.7	4,645.4	99.0	6,498.4	3,583.5

<< Conditional Statistics >>

Colorado River-DE BEQUE, CO.-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.225	Historic Events	0
Standard Dev	0.210	High Outliers	0
Station Skew	-0.198	Low Outliers	0
Regional Skew	0.000	Zero Events	0
Weighted Skew	---	Missing Events	45
Adopted Skew	-0.198	Systematic Events	77

<< Conditional Probability Adjusted Ordinates >>

<< Frequency Curve >>

Colorado River-DE BEQUE, CO.-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
53,590.8	---	0.2	---	---
46,787.4	---	0.5	---	---
41,647.2	---	1.0	---	---
36,454.7	---	2.0	---	---
29,403.1	---	5.0	---	---
23,782.8	---	10.0	---	---
17,464.8	---	20.0	---	---
---	---	50.0	---	---
---	---	80.0	---	---
---	---	90.0	---	---
---	---	95.0	---	---
---	---	99.0	---	---

--- End of Preliminary Results ---

<< Low Outlier Test >>

Based on 32 events, 10 percent outlier test deviate K(N) = 2.591

Computed low outlier test value = 4,808.05

0 low outlier(s) identified below test value of 4,808.05

Based on statistics after 0 zero events and 45 missing events were deleted.

<< High Outlier Test >>

Based on 32 events, 10 percent outlier test deviate K(N) = 2.591

Computed high outlier test value = 58,745.99

0 high outlier(s) identified above test value of 58,745.99

Warning: 58 percent of systematic record was truncated for low outliers, zero, or missing values.

Error: Conditional probability adjustment failed.

Too many truncated events.

--- Final Results ---

<< Plotting Positions >>

Colorado River-DE BEQUE, CO.-FLOW-ANNUAL PEAK

Events Analyzed				Ordered Events			
			FLOW		Water	FLOW	Median
Day	Mon	Year	CFS	Rank	Year	CFS	Plot Pos
26	May	1921	47,733.0	1	1921	47,733.0	0.90
26	May	1922	---	2	1984	38,200.0	2.20
26	May	1923	---	3	1983	32,300.0	3.49
26	May	1924	---	4	1995	29,500.0	4.78
26	May	1925	---	5	1997	26,800.0	6.07
26	May	1926	---	6	1985	25,000.0	7.36
26	May	1927	---	7	1993	22,900.0	8.66
26	May	1928	---	8	1973	22,500.0	9.95
26	May	1929	---	9	1970	22,200.0	11.24
26	May	1930	---	10	1986	22,100.0	12.53
26	May	1931	---	11	1979	21,200.0	13.82
26	May	1932	---	12	1996	20,900.0	15.12
26	May	1933	---	13	1978	20,200.0	16.41
26	May	1934	---	14	1980	19,700.0	17.70
26	May	1935	---	15	1971	18,600.0	18.99
26	May	1936	---	16	1968	18,600.0	20.28
26	May	1937	---	17	1975	17,800.0	21.58
26	May	1938	---	18	1974	15,900.0	22.87
26	May	1939	---	19	1972	15,900.0	24.16
26	May	1940	---	20	1967	14,400.0	25.45
26	May	1941	---	21	1991	14,000.0	26.74
26	May	1942	---	22	1982	13,500.0	28.04
26	May	1943	---	23	1969	13,200.0	29.33

26 May 1944	---	24	1987	11,900.0	30.62
26 May 1945	---	25	1988	11,500.0	31.91
26 May 1946	---	26	1976	11,400.0	33.20
26 May 1947	---	27	1990	11,000.0	34.50
26 May 1948	---	28	1981	10,300.0	35.79
26 May 1949	---	29	1994	9,780.0	37.08
26 May 1950	---	30	1989	8,430.0	38.37
26 May 1951	---	31	1992	7,700.0	39.66
26 May 1952	---	32	1977	5,040.0	40.96
26 May 1953	---	33	1966	---	42.25
26 May 1954	---	34	1965	---	43.54
26 May 1955	---	35	1964	---	44.83
26 May 1956	---	36	1963	---	46.12
26 May 1957	---	37	1962	---	47.42
26 May 1958	---	38	1961	---	48.71
26 May 1959	---	39	1960	---	50.00
26 May 1960	---	40	1959	---	51.29
26 May 1961	---	41	1958	---	52.58
26 May 1962	---	42	1957	---	53.88
26 May 1963	---	43	1956	---	55.17
26 May 1964	---	44	1955	---	56.46
26 May 1965	---	45	1954	---	57.75
26 May 1966	---	46	1953	---	59.04
26 May 1967	14,400.0	47	1952	---	60.34
06 Jun 1968	18,600.0	48	1951	---	61.63
28 May 1969	13,200.0	49	1950	---	62.92
23 May 1970	22,200.0	50	1949	---	64.21
25 Jun 1971	18,600.0	51	1948	---	65.50
08 Jun 1972	15,900.0	52	1947	---	66.80

15 Jun 1973	22,500.0	53	1946	---	68.09
30 May 1974	15,900.0	54	1945	---	69.38
16 Jun 1975	17,800.0	55	1944	---	70.67
06 Jun 1976	11,400.0	56	1943	---	71.96
07 Jun 1977	5,040.0	57	1942	---	73.26
16 Jun 1978	20,200.0	58	1941	---	74.55
29 May 1979	21,200.0	59	1940	---	75.84
12 Jun 1980	19,700.0	60	1939	---	77.13
10 Jun 1981	10,300.0	61	1938	---	78.42
19 Jun 1982	13,500.0	62	1937	---	79.72
26 Jun 1983	32,300.0	63	1936	---	81.01
26 May 1984	38,200.0	64	1935	---	82.30
10 Jun 1985	25,000.0	65	1934	---	83.59
07 Jun 1986	22,100.0	66	1933	---	84.88
09 Jun 1987	11,900.0	67	1932	---	86.18
07 Jun 1988	11,500.0	68	1931	---	87.47
30 May 1989	8,430.0	69	1930	---	88.76
11 Jun 1990	11,000.0	70	1929	---	90.05
15 Jun 1991	14,000.0	71	1928	---	91.34
27 May 1992	7,700.0	72	1927	---	92.64
28 May 1993	22,900.0	73	1926	---	93.93
02 Jun 1994	9,780.0	74	1925	---	95.22
18 Jun 1995	29,500.0	75	1924	---	96.51
20 May 1996	20,900.0	76	1923	---	97.80
05 Jun 1997	26,800.0	77	1922	---	99.10

<< Skew Weighting >>

Based on 77 events, mean-square error of station skew = 0.079

Mean-square error of regional skew = 0.302

<< Frequency Curve >>

Colorado River-DE BEQUE, CO.-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
60,132.9	62,765.5	0.2	74,846.6	50,596.3
53,310.0	55,109.7	0.5	65,269.0	45,402.7
48,168.5	49,467.4	1.0	58,177.5	41,432.9
43,024.3	43,913.5	2.0	51,203.1	37,404.8
36,167.1	36,652.7	5.0	42,120.7	31,929.7
30,864.9	31,130.1	10.0	35,296.2	27,591.2
25,335.5	25,452.1	20.0	28,407.9	22,934.0
17,075.5	17,075.5	50.0	18,714.8	15,588.8
11,252.5	11,193.2	80.0	12,424.7	10,043.7
8,966.0	8,873.4	90.0	10,045.0	7,822.7
7,396.9	7,274.5	95.0	8,417.6	6,309.6
5,095.7	4,911.5	99.0	6,006.5	4,140.0

<< Conditional Statistics >>

Colorado River-DE BEQUE, CO.-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.225	Historic Events	0
Standard Dev	0.210	High Outliers	0
Station Skew	-0.198	Low Outliers	0
Regional Skew	0.000	Zero Events	0
Weighted Skew	-0.157	Missing Events	45
Adopted Skew	-0.198	Systematic Events	77

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis

22 Aug 2017   10:24 AM

--- Input Data ---

Analysis Name: @Cameo - 17B

Description:

Data Set Name: Colorado River-CAMEO, CO.-FLOW-ANNUAL PEAK

DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss

DSS Pathname: /COLORADO RIVER/CAMEO, CO./FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Cameo_-_17B\@Cameo_-_17B.rpt

XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Cameo_-_17B\@Cameo_-_17B.xml

Start Date:

End Date:

Skew Option: Use Station Skew

Regional Skew: 0.0

Regional Skew MSE: 0.302

Plotting Position Type: Median

Upper Confidence Level: 0.05

Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

--- Preliminary Results ---

Note: Adopted skew equals station skew and preliminary

frequency statistics are for the conditional frequency curve

because of zero or missing events.

<< Frequency Curve >>

Colorado River-CAMEO, CO.-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
44,628.9	45,334.7	0.2	52,568.6	39,074.0
42,309.7	42,882.5	0.5	49,515.8	37,217.7
40,257.9	40,740.9	1.0	46,837.0	35,564.2
37,891.8	38,273.9	2.0	43,774.9	33,642.7
34,151.3	34,413.5	5.0	38,999.0	30,569.7
30,703.9	30,865.8	10.0	34,675.8	27,692.4

26,485.1	26,568.7	20.0	29,504.8	24,098.1
18,750.9	18,750.9	50.0	20,469.1	17,212.7
12,142.1	12,073.7	80.0	13,321.2	10,931.9
9,314.5	9,204.9	90.0	10,386.3	8,178.8
7,331.2	7,188.2	95.0	8,334.1	6,264.3
4,443.0	4,234.3	99.0	5,296.1	3,561.1

<< Conditional Statistics >>

Colorado River-CAMEO, CO.-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.246	Historic Events	0
Standard Dev	0.207	High Outliers	0
Station Skew	-0.797	Low Outliers	0
Regional Skew	0.000	Zero Events	0
Weighted Skew	---	Missing Events	12
Adopted Skew	-0.797	Systematic Events	96

<< Conditional Probability Adjusted Ordinates >>

<< Frequency Curve >>

Colorado River-CAMEO, CO.-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
44,296.3	---	0.2	---	---
41,919.4	---	0.5	---	---
39,808.4	---	1.0	---	---
37,390.4	---	2.0	---	---
33,501.0	---	5.0	---	---
29,914.7	---	10.0	---	---
25,519.1	---	20.0	---	---
17,219.6	---	50.0	---	---
8,800.8	---	80.0	---	---
---	---	90.0	---	---
---	---	95.0	---	---
---	---	99.0	---	---

--- End of Preliminary Results ---

<< Low Outlier Test >>

Based on 84 events, 10 percent outlier test deviate K(N) = 2.957

Computed low outlier test value = 4,301.96

1 low outlier(s) identified below test value of 4,301.96

Based on statistics after 0 zero events and 12 missing events were deleted.

Statistics and frequency curve adjusted for 1 low outlier(s)

<< Conditional Statistics >>

Colorado River-CAMEO, CO.-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.253	Historic Events	0
Standard Dev	0.197	High Outliers	0
Station Skew	-0.673	Low Outliers	1
Regional Skew	0.000	Zero Events	0
Weighted Skew	---	Missing Events	12
Adopted Skew	-0.797	Systematic Events	96

<< High Outlier Test >>

Based on 83 events, 10 percent outlier test deviate K(N) = 2.953

Computed high outlier test value = 68,237.72

0 high outlier(s) identified above test value of 68,237.72

Note: Statistics and frequency curve were modified

using conditional probablity adjustment.

--- Final Results ---

<< Plotting Positions >>

Colorado River-CAMEO, CO.-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
	FLOW		Water	FLOW	Median
Day Mon Year	CFS	Rank	Year	CFS	Plot Pos
11 May 1921	50,249.0	1	1921	50,249.0	0.73
11 May 1922	---	2	1984	39,300.0	1.76
11 May 1923	---	3	1983	36,000.0	2.80
11 May 1924	---	4	1935	36,000.0	3.84
11 May 1925	---	5	1952	32,500.0	4.88
11 May 1926	---	6	1957	31,400.0	5.91
11 May 1927	---	7	1938	31,200.0	6.95
11 May 1928	---	8	2011	29,700.0	7.99
11 May 1929	---	9	1995	29,600.0	9.02
11 May 1930	---	10	1949	27,700.0	10.06
11 May 1931	---	11	1948	27,600.0	11.10
11 May 1932	---	12	1941	27,500.0	12.14

11 May 1933	---	13	1942	26,900.0	13.17
11 May 1934	14,700.0	14	1985	26,500.0	14.21
16 Jun 1935	36,000.0	15	1936	26,500.0	15.25
01 Jun 1936	26,500.0	16	1947	26,400.0	16.29
18 May 1937	20,200.0	17	1997	26,300.0	17.32
06 Jun 1938	31,200.0	18	1958	25,900.0	18.36
23 May 1939	19,900.0	19	2014	25,800.0	19.40
03 Jun 1940	16,600.0	20	1962	25,500.0	20.44
14 May 1941	27,500.0	21	1953	24,700.0	21.47
28 May 1942	26,900.0	22	2010	24,500.0	22.51
03 Jun 1943	22,600.0	23	1993	23,300.0	23.55
31 May 1944	19,000.0	24	1986	23,200.0	24.59
25 Jun 1945	18,800.0	25	2008	23,100.0	25.62
18 Jun 1946	19,400.0	26	1965	23,000.0	26.66
22 Jun 1947	26,400.0	27	1951	22,800.0	27.70
22 May 1948	27,600.0	28	1943	22,600.0	28.73
18 Jun 1949	27,700.0	29	1973	22,400.0	29.77
13 Jun 1950	17,600.0	30	1970	22,000.0	30.81
22 Jun 1951	22,800.0	31	2015	21,800.0	31.85
08 Jun 1952	32,500.0	32	1979	21,600.0	32.88
14 Jun 1953	24,700.0	33	1996	21,500.0	33.92
22 May 1954	8,490.0	34	2003	21,000.0	34.96
09 Jun 1955	10,400.0	35	1956	20,600.0	36.00
03 Jun 1956	20,600.0	36	1980	20,500.0	37.03
01 Jul 1957	31,400.0	37	1937	20,200.0	38.07
30 May 1958	25,900.0	38	1978	20,100.0	39.11
10 Jun 1959	16,400.0	39	2016	20,000.0	40.15
05 Jun 1960	16,700.0	40	1939	19,900.0	41.18
01 Jun 1961	13,100.0	41	2009	19,400.0	42.22

13 May 1962	25,500.0	42	1946	19,400.0	43.26	
19 May 1963	8,070.0	43	1971	19,200.0	44.29	
25 May 1964	14,000.0	44	1944	19,000.0	45.33	
18 Jun 1965	23,000.0	45	1945	18,800.0	46.37	
10 May 1966	8,750.0	46	1968	18,400.0	47.41	
26 May 1967	14,400.0	47	2006	17,700.0	48.44	
06 Jun 1968	18,400.0	48	1950	17,600.0	49.48	
28 May 1969	13,300.0	49	1975	17,400.0	50.52	
23 May 1970	22,000.0	50	2005	17,200.0	51.56	
25 Jun 1971	19,200.0	51	1960	16,700.0	52.59	
08 Jun 1972	16,200.0	52	1940	16,600.0	53.63	
15 Jun 1973	22,400.0	53	2000	16,400.0	54.67	
30 May 1974	16,000.0	54	1959	16,400.0	55.71	
16 Jun 1975	17,400.0	55	1972	16,200.0	56.74	
06 Jun 1976	11,500.0	56	1974	16,000.0	57.78	
07 Jun 1977	4,930.0	57	1998	15,700.0	58.82	
16 Jun 1978	20,100.0	58	1999	15,600.0	59.85	
29 May 1979	21,600.0	59	1934	14,700.0	60.89	
12 Jun 1980	20,500.0	60	1991	14,400.0	61.93	
10 Jun 1981	10,100.0	61	1967	14,400.0	62.97	
19 Jun 1982	13,600.0	62	1964	14,000.0	64.00	
26 Jun 1983	36,000.0	63	1982	13,600.0	65.04	
26 May 1984	39,300.0	64	1969	13,300.0	66.08	
09 Jun 1985	26,500.0	65	1987	13,100.0	67.12	
07 Jun 1986	23,200.0	66	1961	13,100.0	68.15	
17 May 1987	13,100.0	67	1988	13,000.0	69.19	
07 Jun 1988	13,000.0	68	1994	12,600.0	70.23	
30 May 1989	8,530.0	69	1990	11,700.0	71.27	
11 Jun 1990	11,700.0	70	1976	11,500.0	72.30	

15 Jun 1991	14,400.0	71	2007	10,900.0	73.34
27 May 1992	8,240.0	72	1955	10,400.0	74.38
28 May 1993	23,300.0	73	2013	10,300.0	75.41
02 Jun 1994	12,600.0	74	1981	10,100.0	76.45
18 Jun 1995	29,600.0	75	2001	9,720.0	77.49
20 May 1996	21,500.0	76	1966	8,750.0	78.53
05 Jun 1997	26,300.0	77	1989	8,530.0	79.56
02 Jun 1998	15,700.0	78	1954	8,490.0	80.60
10 Jun 1999	15,600.0	79	1992	8,240.0	81.64
30 May 2000	16,400.0	80	1963	8,070.0	82.68
02 Jun 2001	9,720.0	81	2004	7,450.0	83.71
01 Jun 2002	4,260.0	82	1977	4,930.0	84.75
02 Jun 2003	21,000.0	83	2012	4,440.0	85.79
08 Jun 2004	7,450.0	84	2002	4,260.0*	86.83
24 May 2005	17,200.0	85	1933	---	87.86
23 May 2006	17,700.0	86	1932	---	88.90
22 May 2007	10,900.0	87	1931	---	89.94
03 Jun 2008	23,100.0	88	1930	---	90.98
24 May 2009	19,400.0	89	1929	---	92.01
08 Jun 2010	24,500.0	90	1928	---	93.05
07 Jun 2011	29,700.0	91	1927	---	94.09
24 May 2012	4,440.0	92	1926	---	95.12
11 Jun 2013	10,300.0	93	1925	---	96.16
02 Jun 2014	25,800.0	94	1924	---	97.20
18 Jun 2015	21,800.0	95	1923	---	98.24
11 Jun 2016	20,000.0	96	1922	---	99.27

* Outlier

<< Skew Weighting >>

Based on 96 events, mean-square error of station skew = 0.101

Mean-square error of regional skew = 0.302

<< Frequency Curve >>

Colorado River-CAMEO, CO.-FLOW-ANNUAL PEAK

Computed Curve	Expected Probability	Percent Chance Exceedance	Confidence Limits 0.05	Confidence Limits 0.95
FLOW, CFS			FLOW, CFS	
45,506.3	46,235.9	0.2	53,865.8	39,614.1
42,786.3	43,369.4	0.5	50,296.5	37,438.5
40,416.0	40,900.7	1.0	47,212.4	35,528.8
37,720.8	38,098.9	2.0	43,737.6	33,340.5
33,537.5	33,791.0	5.0	38,417.7	29,903.4
29,760.7	29,914.6	10.0	33,701.2	26,750.6
25,237.3	25,314.9	20.0	28,179.5	22,896.9
17,227.7	17,227.7	50.0	18,846.5	15,778.1
10,700.9	10,643.4	80.0	11,773.5	9,611.5
8,015.2	7,925.7	90.0	8,968.0	7,020.5
6,178.5	6,064.3	95.0	7,051.2	5,265.9
3,591.1	3,431.8	99.0	4,301.4	2,870.8

<< Synthetic Statistics >>

Colorado River-CAMEO, CO.-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.207	Historic Events	0
Standard Dev	0.227	High Outliers	0
Station Skew	-0.768	Low Outliers	1
Regional Skew	0.000	Zero Events	0
Weighted Skew	-0.576	Missing Events	12
Adopted Skew	-0.768	Systematic Events	96

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis

22 Aug 2017 10:25 AM

--- Input Data ---

Analysis Name: @Palisade - 17B

Description:

Data Set Name: Colorado River-PALISADE, CO.-FLOW-ANNUAL PEAK

DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss

DSS Pathname: /COLORADO RIVER/PALISADE, CO./FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Palisade_-_17B\@Palisade_-_17B.rpt

XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Palisade_-_17B\@Palisade_-_17B.xml

Start Date:

End Date:

Skew Option: Use Station Skew

Regional Skew: 0.0

Regional Skew MSE: 0.302

Plotting Position Type: Median

Upper Confidence Level: 0.05

Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

--- Preliminary Results ---

Note: Adopted skew equals station skew and preliminary frequency statistics are for the conditional frequency curve because of zero or missing events.

Warning: Number of zero/missing values and low outliers is greater than 25% of the systematic record.

<< Frequency Curve >>

Colorado River-PALISADE, CO.-FLOW-ANNUAL PEAK

Computed Curve	Expected Probability	Percent Chance	Confidence Limits 0.05	Confidence Limits 0.95
FLOW, CFS		Exceedance	FLOW, CFS	
97,611.4	109,517.8	0.2	133,053.4	78,993.7
85,995.6	93,664.3	0.5	113,728.8	70,932.0

77,581.4	82,848.7	1.0	100,155.6	64,960.9
69,438.4	72,892.8	2.0	87,397.1	59,055.9
58,984.3	60,748.7	5.0	71,633.2	51,246.3
51,185.3	52,126.9	10.0	60,401.6	45,197.0
43,279.0	43,680.3	20.0	49,588.8	38,779.7
31,772.2	31,772.2	50.0	35,271.7	28,592.6
23,685.0	23,493.5	80.0	26,444.3	20,650.7
20,436.3	20,126.7	90.0	23,110.8	17,364.2
18,147.8	17,717.6	95.0	20,794.7	15,059.5
14,631.2	13,934.6	99.0	17,239.6	11,584.8

<< Conditional Statistics >>

Colorado River-PALISADE, CO.-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.507	Historic Events	0
Standard Dev	0.156	High Outliers	0
Station Skew	0.182	Low Outliers	0
Regional Skew	0.000	Zero Events	0
Weighted Skew	---	Missing Events	17
Adopted Skew	0.182	Systematic Events	50

<< Conditional Probability Adjusted Ordinates >>

<< Frequency Curve >>

Colorado River-PALISADE, CO.-FLOW-ANNUAL PEAK

Computed Curve	Expected Probability	Percent Chance Exceedance	Confidence Limits 0.05	Confidence Limits 0.95
FLOW, CFS			FLOW, CFS	
92,293.5	---	0.2	---	---
80,930.2	---	0.5	---	---
72,685.7	---	1.0	---	---
64,670.6	---	2.0	---	---
54,328.0	---	5.0	---	---
46,502.0	---	10.0	---	---
38,326.9	---	20.0	---	---
24,877.8	---	50.0	---	---
---	---	80.0	---	---
---	---	90.0	---	---
---	---	95.0	---	---
---	---	99.0	---	---

--- End of Preliminary Results ---

<< Low Outlier Test >>

Based on 33 events, 10 percent outlier test deviate K(N) = 2.604

Computed low outlier test value = 12,621.84

0 low outlier(s) identified below test value of 12,621.84

Based on statistics after 0 zero events and 17 missing events were deleted.

<< High Outlier Test >>

Based on 33 events, 10 percent outlier test deviate K(N) = 2.604

Computed high outlier test value = 81,728.29

0 high outlier(s) identified above test value of 81,728.29

Warning: 34 percent of systematic record was truncated for low outliers, zero, or missing values.

Note: Statistics and frequency curve were modified

using conditional probablity adjustment.

--- Final Results ---

<< Plotting Positions >>

Colorado River-PALISADE, CO.-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
	FLOW		Water	FLOW	Median
Day Mon Year	CFS	Rank	Year	CFS	Plot Pos
17 May 1884	81,339.0	1	1884	81,339.0	1.39
17 May 1885	---	2	1921	52,400.0	3.37
17 May 1886	---	3	1917	51,000.0	5.36
17 May 1887	---	4	1918	49,500.0	7.34
17 May 1888	---	5	1912	45,200.0	9.33
17 May 1889	---	6	1928	44,400.0	11.31
17 May 1890	---	7	1909	43,400.0	13.29
17 May 1891	---	8	1914	43,200.0	15.28
17 May 1892	---	9	1920	43,000.0	17.26
17 May 1893	---	10	1929	38,900.0	19.25
17 May 1894	---	11	1924	37,900.0	21.23
17 May 1895	---	12	1906	37,200.0	23.21
17 May 1896	---	13	1905	37,200.0	25.20
17 May 1897	---	14	1933	37,100.0	27.18
17 May 1898	---	15	1926	34,300.0	29.17
17 May 1899	---	16	1927	31,300.0	31.15
17 May 1900	---	17	1923	31,300.0	33.13
17 May 1901	---	18	1922	31,300.0	35.12
17 May 1902	18,400.0	19	1932	30,800.0	37.10
18 Jun 1903	26,500.0	20	1907	30,800.0	39.09
25 May 1904	25,300.0	21	1910	27,400.0	41.07
05 Jun 1905	37,200.0	22	1930	26,800.0	43.06

14 Jun 1906	37,200.0	23	1903	26,500.0	45.04
18 Jun 1907	30,800.0	24	1916	26,300.0	47.02
12 Jun 1908	21,300.0	25	1911	26,300.0	49.01
20 Jun 1909	43,400.0	26	1904	25,300.0	50.99
01 Jun 1910	27,400.0	27	1919	22,000.0	52.98
09 Jun 1911	26,300.0	28	1913	21,800.0	54.96
10 Jun 1912	45,200.0	29	1915	21,500.0	56.94
01 Jun 1913	21,800.0	30	1908	21,300.0	58.93
03 Jun 1914	43,200.0	31	1925	19,200.0	60.91
21 Jun 1915	21,500.0	32	1902	18,400.0	62.90
13 Jun 1916	26,300.0	33	1931	15,200.0	64.88
19 Jun 1917	51,000.0	34	1901	---	66.87
14 Jun 1918	49,500.0	35	1900	---	68.85
30 May 1919	22,000.0	36	1899	---	70.83
01 Jun 1920	43,000.0	37	1898	---	72.82
16 Jun 1921	52,400.0	38	1897	---	74.80
29 May 1922	31,300.0	39	1896	---	76.79
17 Jun 1923	31,300.0	40	1895	---	78.77
16 Jun 1924	37,900.0	41	1894	---	80.75
31 May 1925	19,200.0	42	1893	---	82.74
07 Jun 1926	34,300.0	43	1892	---	84.72
20 May 1927	31,300.0	44	1891	---	86.71
01 Jun 1928	44,400.0	45	1890	---	88.69
10 Jun 1929	38,900.0	46	1889	---	90.67
01 Jun 1930	26,800.0	47	1888	---	92.66
08 Jun 1931	15,200.0	48	1887	---	94.64
23 May 1932	30,800.0	49	1886	---	96.63
02 Jun 1933	37,100.0	50	1885	---	98.61

<< Skew Weighting >>

Based on 50 events, mean-square error of station skew = 0.121

Mean-square error of regional skew = 0.302

<< Frequency Curve >>

Colorado River-PALISADE, CO.-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
90,538.3	96,708.8	0.2	121,345.5	72,790.3
80,400.9	84,639.1	0.5	105,517.2	65,569.6
72,685.6	75,760.8	1.0	93,736.6	59,979.7
64,902.5	67,015.7	2.0	82,109.7	54,244.0
54,433.3	55,595.9	5.0	66,930.9	46,343.4
46,271.9	46,906.0	10.0	55,524.8	39,996.9
37,710.7	37,989.7	20.0	44,051.1	33,098.4
24,877.8	24,877.8	50.0	28,116.0	22,041.8
15,877.6	15,736.3	80.0	18,075.4	13,614.0
12,387.4	12,169.2	90.0	14,368.6	10,278.4
10,019.9	9,735.4	95.0	11,865.3	8,046.2
6,613.4	6,198.0	99.0	8,212.2	4,946.4

```
|------------------------|-------------|------------------------|
```

<< Synthetic Statistics >>

Colorado River-PALISADE, CO.-FLOW-ANNUAL PEAK

```
--------------------------------------------------------------
|      Log Transform:      |                     |
|        FLOW, CFS         |     Number of Events      |
|-----------------------------|------------------------------|
|  Mean              4.386  |  Historic Events         0  |
|  Standard Dev       0.224  |  High Outliers         0    |
|  Station Skew      -0.272  |  Low Outliers          0    |
|  Regional Skew      0.000  |  Zero Events           0    |
|  Weighted Skew     -0.194  |  Missing Events       17    |
|  Adopted Skew      -0.272  |  Systematic Events      50  |
|-----------------------------|------------------------------|
```

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis

22 Aug 2017 10:28 AM

--- Input Data ---

Analysis Name: @Grand Valley Div - 17B

Description:

Data Set Name: Colorado River- BELOW PALISADE

DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss

DSS Pathname: /COLO RIVER BELOW GRAND VALLEY DIV/PALISADE, CO/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Grand_Valley_Div_-_17B\@Grand_Valley_Div_-_17B.rpt

XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Grand_Valley_Div_-_17B\@Grand_Valley_Div_-_17B.xml

Start Date:

End Date:

Skew Option: Use Station Skew

Regional Skew: -Infinity

Regional Skew MSE: -Infinity

Plotting Position Type: Median

Upper Confidence Level: 0.05

Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

--- Preliminary Results ---

Note: Adopted skew equals station skew and preliminary frequency statistics are for the conditional frequency curve because of zero or missing events.

<< Frequency Curve >>

Colorado River- BELOW PALISADE

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
116,867.0	142,686.9	0.2	209,644.9	79,032.0
96,183.1	111,882.0	0.5	164,126.5	67,039.8
81,838.0	92,129.4	1.0	134,079.1	58,444.2
68,542.0	74,930.0	2.0	107,498.8	50,220.9
52,452.7	55,473.7	5.0	77,231.1	39,840.2

41,288.8	42,767.4	10.0	57,684.9	32,257.3
30,837.9	31,408.5	20.0	40,732.1	24,739.3
17,533.5	17,533.5	50.0	21,672.9	14,193.1
9,886.5	9,700.2	80.0	12,320.7	7,489.4
7,303.3	7,037.8	90.0	9,355.7	5,219.2
5,677.4	5,349.9	95.0	7,493.8	3,838.2
3,524.7	3,098.1	99.0	4,973.9	2,123.6

<< Conditional Statistics >>

Colorado River- BELOW PALISADE

Log Transform: FLOW, CFS		Number of Events	
Mean	4.241	Historic Events	0
Standard Dev	0.294	High Outliers	0
Station Skew	-0.052	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	6
Adopted Skew	-0.052	Systematic Events	35

<< Conditional Probability Adjusted Ordinates >>

<< Frequency Curve >>

Colorado River- BELOW PALISADE

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
112,447.0	---	0.2	---	---
92,177.4	---	0.5	---	---
78,123.4	---	1.0	---	---
65,106.5	---	2.0	---	---
49,336.8	---	5.0	---	---
38,383.0	---	10.0	---	---
28,090.2	---	20.0	---	---
14,679.6	---	50.0	---	---
5,029.9	---	80.0	---	---
---	---	90.0	---	---
---	---	95.0	---	---
---	---	99.0	---	---

--- End of Preliminary Results ---

<< Low Outlier Test >>

Based on 29 events, 10 percent outlier test deviate K(N) = 2.549

Computed low outlier test value = 3,111.71

0 low outlier(s) identified below test value of 3,111.71

Based on statistics after 0 zero events and 6 missing events were deleted.

<< High Outlier Test >>

Based on 29 events, 10 percent outlier test deviate K(N) = 2.549

Computed high outlier test value = 97,641.93

0 high outlier(s) identified above test value of 97,641.93

Note: Statistics and frequency curve were modified

using conditional probablity adjustment.

--- Final Results ---

<< Plotting Positions >>

Colorado River- BELOW PALISADE

| Events Analyzed | Ordered Events |

| FLOW | Water FLOW Median |

| Day Mon Year CFS | Rank Year CFS Plot Pos |

15 Jun 1884	81,785.0	1	1884	81,785.0	1.98
15 Jun 1921	53,062.0	2	1921	53,062.0	4.80
15 Jun 1984	42,065.0	3	1984	42,065.0	7.63
15 Jun 1985	---	4	2011	32,700.0	10.45
15 Jun 1986	---	5	1995	29,600.0	13.28
15 Jun 1987	---	6	1997	28,400.0	16.10
15 Jun 1988	---	7	1993	27,400.0	18.93
15 Jun 1989	---	8	2010	25,600.0	21.75
15 Jun 1990	---	9	2014	25,200.0	24.58
15 Jun 1991	14,100.0	10	2008	25,000.0	27.40
28 May 1992	8,070.0	11	2003	21,500.0	30.23
29 May 1993	27,400.0	12	1996	21,500.0	33.05
02 Jun 1994	11,600.0	13	2015	20,800.0	35.88
17 Jun 1995	29,600.0	14	2005	19,300.0	38.70
20 May 1996	21,500.0	15	2009	18,900.0	41.53
06 Jun 1997	28,400.0	16	2016	18,500.0	44.35
22 May 1998	14,800.0	17	2006	18,000.0	47.18
09 Jun 1999	13,300.0	18	1998	14,800.0	50.00
30 May 2000	14,400.0	19	2000	14,400.0	52.82
20 May 2001	8,010.0	20	1991	14,100.0	55.65
14 Mar 2002	4,520.0	21	1999	13,300.0	58.47
02 Jun 2003	21,500.0	22	1994	11,600.0	61.30
08 Jun 2004	5,970.0	23	2007	10,300.0	64.12
23 May 2005	19,300.0	24	2013	8,930.0	66.95
23 May 2006	18,000.0	25	1992	8,070.0	69.77
20 May 2007	10,300.0	26	2001	8,010.0	72.60
03 Jun 2008	25,000.0	27	2004	5,970.0	75.42
24 May 2009	18,900.0	28	2012	5,170.0	78.25

08 Jun 2010	25,600.0	29	2002	4,520.0	81.07
07 Jun 2011	32,700.0	30	1990	---	83.90
07 Nov 2011	5,170.0	31	1989	---	86.72
18 May 2013	8,930.0	32	1988	---	89.55
02 Jun 2014	25,200.0	33	1987	---	92.37
12 Jun 2015	20,800.0	34	1986	---	95.20
08 Jun 2016	18,500.0	35	1985	---	98.02

<< Skew Weighting >>

Based on 35 events, mean-square error of station skew = 0.159

Mean-square error of regional skew = -?

<< Frequency Curve >>

Colorado River- BELOW PALISADE

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
111,823.6	131,193.5	0.2	196,887.9	75,305.1
92,036.7	104,103.4	0.5	155,131.5	63,707.3
78,123.3	86,181.7	1.0	127,020.9	55,303.8
65,096.2	70,168.6	2.0	101,775.5	47,203.2

49,186.7	51,632.1	5.0	72,595.0	36,915.2
38,088.7	39,285.1	10.0	53,534.7	29,388.1
27,708.0	28,168.5	20.0	36,919.3	21,964.3
14,679.6	14,679.6	50.0	18,320.7	11,786.4
7,507.3	7,366.7	80.0	9,461.1	5,646.6
5,212.1	5,021.0	90.0	6,777.1	3,686.5
3,827.2	3,602.9	95.0	5,151.2	2,549.1
2,104.9	1,839.6	99.0	3,065.0	1,233.2

<< Synthetic Statistics >>

Colorado River- BELOW PALISADE

Log Transform: FLOW, CFS		Number of Events	
Mean	4.156	Historic Events	0
Standard Dev	0.337	High Outliers	0
Station Skew	-0.193	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	6
Adopted Skew	-0.193	Systematic Events	35

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis

22 Aug 2017 10:26 AM

--- Input Data ---

Analysis Name: @Fruita - 17B

Description:

Data Set Name: Colorado River-FRUITA, CO.-FLOW-ANNUAL PEAK

DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss

DSS Pathname: /COLORADO RIVER/FRUITA, CO./FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Fruita_-_17B\@Fruita_-_17B.rpt

XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@Fruita_-_17B\@Fruita_-_17B.xml

Start Date:

End Date:

Skew Option: Use Station Skew

Regional Skew: 0.0

Regional Skew MSE: 0.302

Plotting Position Type: Median

Upper Confidence Level: 0.05

Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

<< Low Outlier Test >>

Based on 17 events, 10 percent outlier test deviate K(N) = 2.309

Computed low outlier test value = 18,153.27

0 low outlier(s) identified below test value of 18,153.27

<< High Outlier Test >>

Based on 17 events, 10 percent outlier test deviate K(N) = 2.309

Computed high outlier test value = 135,022.61

0 high outlier(s) identified above test value of 135,022.61

--- Final Results ---

<< Plotting Positions >>

Colorado River-FRUITA, CO.-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
	FLOW		Water	FLOW	Median
Day Mon Year	CFS	Rank	Year	CFS	Plot Pos
04 Jul 1884	125,000.0	1	1884	125,000.0	4.02
13 Jun 1908	27,300.0	2	1921	81,100.0	9.77
09 Jun 1909	64,000.0	3	1920	79,100.0	15.52
04 Jun 1910	34,100.0	4	1917	64,000.0	21.26
10 Jun 1911	38,800.0	5	1909	64,000.0	27.01
07 Jun 1912	59,600.0	6	1914	59,600.0	32.76
28 May 1913	27,600.0	7	1912	59,600.0	38.51
03 Jun 1914	59,600.0	8	1918	57,000.0	44.25
12 Jun 1915	27,600.0	9	1922	54,100.0	50.00
14 Jun 1916	39,600.0	10	1923	51,100.0	55.75
20 Jun 1917	64,000.0	11	1916	39,600.0	61.49
14 Jun 1918	57,000.0	12	1911	38,800.0	67.24
29 May 1919	32,200.0	13	1910	34,100.0	72.99
23 May 1920	79,100.0	14	1919	32,200.0	78.74
16 Jun 1921	81,100.0	15	1915	27,600.0	84.48
29 May 1922	54,100.0	16	1913	27,600.0	90.23
29 May 1923	51,100.0	17	1908	27,300.0	95.98

<< Skew Weighting >>

Based on 17 events, mean-square error of station skew =   0.309

Mean-square error of regional skew =   0.302

<< Frequency Curve >>

Colorado River-FRUITA, CO.-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
198,378.3	273,984.6	0.2	363,223.5	140,011.0
168,499.3	212,777.7	0.5	289,799.9	122,842.9
147,675.5	176,180.3	1.0	241,654.8	110,431.1
128,219.8	145,685.2	2.0	199,143.3	98,419.7
104,314.4	112,539.4	5.0	150,555.1	82,942.7
87,324.0	91,432.9	10.0	118,818.7	71,269.9
70,899.1	72,533.4	20.0	90,786.7	59,165.4
48,588.1	48,588.1	50.0	58,143.5	40,462.5
34,195.5	33,553.5	80.0	41,012.5	26,627.9
28,754.9	27,747.8	90.0	35,122.5	21,293.8
25,051.9	23,686.9	95.0	31,194.4	17,740.3
19,587.4	17,481.0	99.0	25,407.2	12,723.7

<< Systematic Statistics >>

Colorado River-FRUITA, CO.-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.695	Historic Events	0
Standard Dev	0.189	High Outliers	0
Station Skew	0.260	Low Outliers	0
Regional Skew	0.000	Zero Events	0
Weighted Skew	0.128	Missing Events	0
Adopted Skew	0.260	Systematic Events	17

--- End of Analytical Frequency Curve ---

Bulletin 17B Frequency Analysis

22 Aug 2017 10:29 AM

--- Input Data ---

Analysis Name: @State Line - 17B

Description:

Data Set Name: COLORADO RIVER-COLORADO-UTAH STATE LINE-FLOW-ANNUAL PEAK

DSS File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Colorado_River.dss

DSS Pathname: /COLORADO RIVER/COLORADO-UTAH STATE LINE/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@State_Line_-_17B\@State_Line_-_17B.rpt

XML File Name: H:\32790068 - Granby to the State Line\8.0 Project Design\8.4 HH\HEC-SSP\Colorado_River\Bulletin17Results\@State_Line_-_17B\@State_Line_-_17B.xml

Start Date:

End Date:

Skew Option: Use Station Skew

Regional Skew: -Infinity

Regional Skew MSE: -Infinity

Plotting Position Type: Median

Upper Confidence Level: 0.05

Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

--- Preliminary Results ---

Note: Adopted skew equals station skew and preliminary
frequency statistics are for the conditional frequency curve
because of zero or missing events.

Warning: Number of zero/missing values and low outliers
is greater than 25% of the systematic record.

<< Frequency Curve >>

COLORADO RIVER-COLORADO-UTAH STATE LINE-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
123,365.4	131,390.9	0.2	166,409.4	97,789.7

105,622.0	110,892.9	0.5	139,243.5	85,121.5
92,702.4	96,381.2	1.0	119,925.2	75,725.3
80,190.1	82,619.0	2.0	101,638.2	66,459.8
64,206.0	65,461.6	5.0	78,979.2	54,329.4
52,441.5	53,095.5	10.0	62,904.8	45,127.3
40,787.8	41,059.1	20.0	47,616.9	35,692.3
24,737.3	24,737.3	50.0	27,985.9	21,882.2
14,623.0	14,513.4	80.0	16,700.9	12,538.4
10,994.2	10,833.1	90.0	12,799.3	9,140.1
8,639.7	8,437.2	95.0	10,267.5	6,966.7
5,424.1	5,148.5	99.0	6,751.5	4,096.6

<< Conditional Statistics >>

COLORADO RIVER-COLORADO-UTAH STATE LINE-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.385	Historic Events	0
Standard Dev	0.265	High Outliers	0
Station Skew	-0.179	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	65
Adopted Skew	-0.179	Systematic Events	133

<< Conditional Probability Adjusted Ordinates >>

<< Frequency Curve >>

COLORADO RIVER-COLORADO-UTAH STATE LINE-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
110,265.3	---	0.2	---	---
93,108.4	---	0.5	---	---
80,583.3	---	1.0	---	---
68,429.6	---	2.0	---	---
52,813.0	---	5.0	---	---
41,159.1	---	10.0	---	---
29,229.7	---	20.0	---	---
6,733.3	---	50.0	---	---
---	---	80.0	---	---
---	---	90.0	---	---
---	---	95.0	---	---
---	---	99.0	---	---

--- End of Preliminary Results ---

<< Low Outlier Test >>

Based on 68 events, 10 percent outlier test deviate K(N) = 2.883

Computed low outlier test value = 4,181.53

0 low outlier(s) identified below test value of 4,181.53

Based on statistics after 0 zero events and 65 missing events were deleted.

<< High Outlier Test >>

Based on 68 events, 10 percent outlier test deviate K(N) = 2.883

Computed high outlier test value = 141,134.75

0 high outlier(s) identified above test value of 141,134.75

Warning: 48 percent of systematic record was truncated for low outliers, zero, or missing values.

Note: Statistics and frequency curve were modified

using conditional probablity adjustment.

--- Final Results ---

<< Plotting Positions >>

COLORADO RIVER-COLORADO-UTAH STATE LINE-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
	FLOW		Water	FLOW	Median
Day Mon Year	CFS	Rank	Year	CFS	Plot Pos
23 Jun 1884	128,753.0	1	1884	128,753.0	0.52
23 Jun 1885	---	2	1921	83,535.0	1.27
23 Jun 1886	---	3	1984	69,800.0	2.02
23 Jun 1887	---	4	1983	62,100.0	2.77
23 Jun 1888	---	5	1957	56,800.0	3.52
23 Jun 1889	---	6	1952	52,000.0	4.27
23 Jun 1890	---	7	1995	49,300.0	5.02
23 Jun 1891	---	8	2011	47,700.0	5.77
23 Jun 1892	---	9	1958	45,000.0	6.52
23 Jun 1893	---	10	1993	44,300.0	7.27
23 Jun 1894	---	11	1962	40,500.0	8.02
23 Jun 1895	---	12	2008	39,600.0	8.77
23 Jun 1896	---	13	1985	39,300.0	9.52
23 Jun 1897	---	14	2014	38,000.0	10.27
23 Jun 1898	---	15	1997	37,500.0	11.02
23 Jun 1899	---	16	1953	37,300.0	11.77
23 Jun 1900	---	17	1965	36,400.0	12.52
23 Jun 1901	---	18	1979	36,000.0	13.27
23 Jun 1902	---	19	1973	35,000.0	14.02
23 Jun 1903	---	20	1986	33,800.0	14.77
23 Jun 1904	---	21	1970	33,000.0	15.52

23 Jun 1905	---	22	1980	32,100.0	16.27	
23 Jun 1906	---	23	2015	31,400.0	17.02	
23 Jun 1907	---	24	2005	31,000.0	17.77	
23 Jun 1908	---	25	2010	30,300.0	18.52	
23 Jun 1909	---	26	1951	30,200.0	19.27	
23 Jun 1910	---	27	1996	29,100.0	20.01	
23 Jun 1911	---	28	2009	29,000.0	20.76	
23 Jun 1912	---	29	1956	28,900.0	21.51	
23 Jun 1913	---	30	1978	27,800.0	22.26	
23 Jun 1914	---	31	1964	27,300.0	23.01	
23 Jun 1915	---	32	1968	26,600.0	23.76	
23 Jun 1916	---	33	1975	26,300.0	24.51	
23 Jun 1917	---	34	2003	26,100.0	25.26	
23 Jun 1918	---	35	1998	26,100.0	26.01	
23 Jun 1919	---	36	1960	24,700.0	26.76	
23 Jun 1920	---	37	2016	24,500.0	27.51	
23 Jun 1921	83,535.0	38	1959	23,200.0	28.26	
23 Jun 1922	---	39	1974	22,800.0	29.01	
23 Jun 1923	---	40	1987	22,500.0	29.76	
23 Jun 1924	---	41	1971	22,200.0	30.51	
23 Jun 1925	---	42	2006	21,700.0	31.26	
23 Jun 1926	---	43	1969	20,400.0	32.01	
23 Jun 1927	---	44	1991	19,800.0	32.76	
23 Jun 1928	---	45	1967	19,400.0	33.51	
23 Jun 1929	---	46	1982	19,300.0	34.26	
23 Jun 1930	---	47	1961	19,300.0	35.01	
23 Jun 1931	---	48	1972	18,400.0	35.76	
23 Jun 1932	---	49	2000	17,900.0	36.51	
23 Jun 1933	---	50	1999	17,900.0	37.26	

23 Jun 1934	---	51	1955	17,100.0	38.01
23 Jun 1935	---	52	1992	16,500.0	38.76
23 Jun 1936	---	53	1988	15,400.0	39.51
23 Jun 1937	---	54	2007	14,700.0	40.25
23 Jun 1938	---	55	1976	14,400.0	41.00
23 Jun 1939	---	56	1966	14,400.0	41.75
23 Jun 1940	---	57	1994	13,600.0	42.50
23 Jun 1941	---	58	2001	13,200.0	43.25
23 Jun 1942	---	59	2013	13,100.0	44.00
23 Jun 1943	---	60	1990	12,600.0	44.75
23 Jun 1944	---	61	1981	12,100.0	45.50
23 Jun 1945	---	62	1954	11,600.0	46.25
23 Jun 1946	---	63	1963	11,300.0	47.00
23 Jun 1947	---	64	1989	9,970.0	47.75
23 Jun 1948	---	65	2004	9,450.0	48.50
23 Jun 1949	---	66	2012	5,960.0	49.25
23 Jun 1950	---	67	2002	5,520.0	50.00
23 Jun 1951	30,200.0	68	1977	5,080.0	50.75
09 Jun 1952	52,000.0	69	1950	---	51.50
15 Jun 1953	37,300.0	70	1949	---	52.25
23 May 1954	11,600.0	71	1948	---	53.00
10 Jun 1955	17,100.0	72	1947	---	53.75
04 Jun 1956	28,900.0	73	1946	---	54.50
09 Jun 1957	56,800.0	74	1945	---	55.25
31 May 1958	45,000.0	75	1944	---	56.00
11 Jun 1959	23,200.0	76	1943	---	56.75
05 Jun 1960	24,700.0	77	1942	---	57.50
31 May 1961	19,300.0	78	1941	---	58.25
14 May 1962	40,500.0	79	1940	---	59.00

20 May 1963	11,300.0	80	1939	---	59.75
27 May 1964	27,300.0	81	1938	---	60.49
20 Jun 1965	36,400.0	82	1937	---	61.24
11 May 1966	14,400.0	83	1936	---	61.99
27 May 1967	19,400.0	84	1935	---	62.74
07 Jun 1968	26,600.0	85	1934	---	63.49
26 Jun 1969	20,400.0	86	1933	---	64.24
24 May 1970	33,000.0	87	1932	---	64.99
19 Jun 1971	22,200.0	88	1931	---	65.74
09 Jun 1972	18,400.0	89	1930	---	66.49
16 Jun 1973	35,000.0	90	1929	---	67.24
11 May 1974	22,800.0	91	1928	---	67.99
09 Jun 1975	26,300.0	92	1927	---	68.74
07 Jun 1976	14,400.0	93	1926	---	69.49
10 Jun 1977	5,080.0	94	1925	---	70.24
17 Jun 1978	27,800.0	95	1924	---	70.99
30 May 1979	36,000.0	96	1923	---	71.74
24 May 1980	32,100.0	97	1922	---	72.49
09 Jun 1981	12,100.0	98	1920	---	73.24
20 Jun 1982	19,300.0	99	1919	---	73.99
27 Jun 1983	62,100.0	100	1918	---	74.74
27 May 1984	69,800.0	101	1917	---	75.49
05 May 1985	39,300.0	102	1916	---	76.24
08 Jun 1986	33,800.0	103	1915	---	76.99
18 May 1987	22,500.0	104	1914	---	77.74
19 May 1988	15,400.0	105	1913	---	78.49
31 May 1989	9,970.0	106	1912	---	79.24
12 Jun 1990	12,600.0	107	1911	---	79.99
16 Jun 1991	19,800.0	108	1910	---	80.73

28 May 1992	16,500.0	109	1909	---	81.48
28 May 1993	44,300.0	110	1908	---	82.23
19 May 1994	13,600.0	111	1907	---	82.98
19 Jun 1995	49,300.0	112	1906	---	83.73
20 May 1996	29,100.0	113	1905	---	84.48
10 Jun 1997	37,500.0	114	1904	---	85.23
22 May 1998	26,100.0	115	1903	---	85.98
01 Jun 1999	17,900.0	116	1902	---	86.73
31 May 2000	17,900.0	117	1901	---	87.48
18 May 2001	13,200.0	118	1900	---	88.23
12 Sep 2002	5,520.0	119	1899	---	88.98
02 Jun 2003	26,100.0	120	1898	---	89.73
12 May 2004	9,450.0	121	1897	---	90.48
25 May 2005	31,000.0	122	1896	---	91.23
24 May 2006	21,700.0	123	1895	---	91.98
23 May 2007	14,700.0	124	1894	---	92.73
04 Jun 2008	39,600.0	125	1893	---	93.48
25 May 2009	29,000.0	126	1892	---	94.23
09 Jun 2010	30,300.0	127	1891	---	94.98
09 Jun 2011	47,700.0	128	1890	---	95.73
07 Oct 2011	5,960.0	129	1889	---	96.48
19 May 2013	13,100.0	130	1888	---	97.23
03 Jun 2014	38,000.0	131	1887	---	97.98
13 Jun 2015	31,400.0	132	1886	---	98.73
08 Jun 2016	24,500.0	133	1885	---	99.48

<< Skew Weighting >>

Based on 133 events, mean-square error of station skew = 0.165

Mean-square error of regional skew = -?

<< Frequency Curve >>

COLORADO RIVER-COLORADO-UTAH STATE LINE-FLOW-ANNUAL PEAK

Computed Curve	Expected Probability	Percent Chance Exceedance	Confidence Limits 0.05	Confidence Limits 0.95
FLOW, CFS			FLOW, CFS	
94,290.6	95,355.0	0.2	152,114.7	62,337.7
87,550.0	88,577.7	0.5	140,374.6	58,149.0
80,583.3	81,591.7	1.0	128,329.2	53,794.4
71,608.4	72,490.9	2.0	112,955.1	48,143.0
56,178.5	56,856.9	5.0	86,948.4	38,300.7
41,820.6	42,205.6	10.0	63,323.3	28,966.1
25,959.7	26,126.3	20.0	38,063.1	18,385.8
6,733.3	6,733.3	50.0	9,282.8	4,932.0
887.0	870.9	80.0	1,239.3	614.7
227.2	218.3	90.0	339.6	143.1
62.5	58.3	95.0	101.8	35.1
3.6	3.0	99.0	7.4	1.5

<< Synthetic Statistics >>

COLORADO RIVER-COLORADO-UTAH STATE LINE-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.623	Historic Events	0
Standard Dev	0.947	High Outliers	0
Station Skew	-1.342	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	65
Adopted Skew	-1.342	Systematic Events	133

--- End of Analytical Frequency Curve ---

Supplemental Data

Windy Gap/Hot Sulphur Springs Combination Analysis Data

WINDY GAP, NEAR GRANBY, CO.			
Record Number	Date	Time	Peak Flow (cfs)
1	7/3/1982	24:00:00	1,050
2	7/11/1983	24:00:00	4,480
3	5/25/1984	24:00:00	5,260
4	6/10/1985	24:00:00	1,880
5	6/20/1986	24:00:00	1,730
6	6/10/1987	24:00:00	1,110
7	5/20/1988	24:00:00	1,590
8	4/18/1989	24:00:00	371
9	7/10/1990	24:00:00	480
10	6/2/1991	24:00:00	864
11	6/15/1992	24:00:00	445
12	5/29/1993	24:00:00	1,790
13	6/1/1994	24:00:00	786
14	6/18/1995	24:00:00	2,700
15	6/23/1996	24:00:00	4,650
16	6/9/1997	19:00	4,470
17	7/2/1998	8:50	1,450
18	6/26/1999	6:20	2,000
19	6/1/2000	6:20	2,330
20	7/13/2001	21:40	422
21	6/5/2002	15:00	300
22	5/30/2003	10:00	1,980
23	7/1/2004	2:15	422
24	6/20/2005	8:15	966
25	4/15/2006	0:30	861
26	6/18/2007	7:15	921
27	5/22/2008	13:15	2,030
28	6/27/2009	6:29	1,540
29	6/8/2010	10:15	2,340
30	6/25/2011	11:30	5,100
31	7/6/2012	0:45	329
32	5/16/2013	17:30	1,040
33	5/31/2014	7:45	3,500
34	6/14/2015	10:30	4,300
35	6/23/2016	9:00	2,470

Drainage Area: 788 Sq. Miles

PROJECTED WINDY GAP, NEAR GRANBY, CO.			
Record Number	Date	Time	Peak Flow (cfs)
1	6/18/1995	24:00:00	2,787
2	6/23/1996	24:00:00	4,800
3	6/9/1997	19:00:00	4,614
4	7/2/1998	8:50:00	1,497
5	6/26/1999	6:20:00	2,064
6	6/1/2000	6:20:00	2,405
7	7/13/2001	21:40:00	436
8	6/5/2002	15:00:00	310
9	5/30/2003	10:00:00	2,044
10	7/1/2004	2:15:00	436
11	6/20/2005	8:15:00	997
12	4/15/2006	0:30:00	889
13	6/18/2007	7:15:00	951
14	5/22/2008	13:15:00	2,095
15	6/27/2009	6:29:00	1,590
16	6/8/2010	10:15:00	2,415
17	6/25/2011	11:30:00	5,264
18	7/6/2012	0:45:00	340
19	5/16/2013	17:30:00	1,073
20	5/31/2014	7:45:00	3,613
21	6/14/2015	10:30:00	4,438
22	6/23/2016	9:00:00	2,549

HOT SULPHUR SPRINGS, CO.			
Record Number	Date	Time	Peak Flow (cfs)
1	6/20/1953	24:00:00	1,930
2	5/23/1954	24:00:00	358
3	5/16/1955	24:00:00	485
4	5/23/1956	24:00:00	2,220
5	6/8/1957	24:00:00	3,430
6	5/27/1958	24:00:00	2,830
7	6/28/1959	24:00:00	832
8	6/18/1960	24:00:00	1,220
9	9/29/1961	24:00:00	638
10	5/13/1962	24:00:00	2,720
11	4/8/1963	24:00:00	562
12	5/27/1964	24:00:00	768
13	6/18/1965	24:00:00	1,760
14	5/10/1966	24:00:00	424
15	6/23/1967	24:00:00	876
16	6/6/1968	24:00:00	760
17	6/18/1969	24:00:00	1,510
18	5/23/1970	24:00:00	2,500
19	6/26/1971	24:00:00	2,880
20	6/9/1972	24:00:00	1,150
21	6/14/1973	24:00:00	2,200
22	6/19/1974	24:00:00	2,820
23	7/9/1975	24:00:00	970
24	6/17/1976	24:00:00	424
25	6/7/1977	24:00:00	351
26	5/26/1978	24:00:00	1,200
27	6/15/1979	24:00:00	1,580
28	6/12/1980	24:00:00	1,810
29	5/29/1981	24:00:00	595
30	7/3/1982	24:00:00	1,100
31	7/11/1983	24:00:00	4,620
32	5/25/1984	24:00:00	5,720
33	6/10/1985	24:00:00	1,890
34	6/20/1986	24:00:00	1,740
35	6/10/1987	24:00:00	983
36	5/20/1988	24:00:00	1,550
37	5/12/1989	24:00:00	393
38	7/8/1990	24:00:00	474
39	6/16/1991	24:00:00	873
40	6/15/1992	24:00:00	439
41	5/29/1993	24:00:00	1,910
42	6/1/1994	24:00:00	795

Drainage Area: 825 Sq. Miles

Combined Gage (used in analysis)			
Record Number	Date	Time	Peak Flow (cfs)
1	6/20/1953	24:00:00	1,930
2	5/23/1954	24:00:00	358
3	5/16/1955	24:00:00	485
4	5/23/1956	24:00:00	2,220
5	6/8/1957	24:00:00	3,430
6	5/27/1958	24:00:00	2,830
7	6/28/1959	24:00:00	832
8	6/18/1960	24:00:00	1,220
9	9/29/1961	24:00:00	638
10	5/13/1962	24:00:00	2,720
11	4/8/1963	24:00:00	562
12	5/27/1964	24:00:00	768
13	6/18/1965	24:00:00	1,760
14	5/10/1966	24:00:00	424
15	6/23/1967	24:00:00	876
16	6/6/1968	24:00:00	760
17	6/18/1969	24:00:00	1,510
18	5/23/1970	24:00:00	2,500
19	6/26/1971	24:00:00	2,880
20	6/9/1972	24:00:00	1,150
21	6/14/1973	24:00:00	2,200
22	6/19/1974	24:00:00	2,820
23	7/9/1975	24:00:00	970
24	6/17/1976	24:00:00	424
25	6/7/1977	24:00:00	351
26	5/26/1978	24:00:00	1,200
27	6/15/1979	24:00:00	1,580
28	6/12/1980	24:00:00	1,810
29	5/29/1981	24:00:00	595
30	7/3/1982	24:00:00	1,100
31	7/11/1983	24:00:00	4,620
32	5/25/1984	24:00:00	5,720
33	6/10/1985	24:00:00	1,890
34	6/20/1986	24:00:00	1,740
35	6/10/1987	24:00:00	983
36	5/20/1988	24:00:00	1,550
37	5/12/1989	24:00:00	393
38	7/8/1990	24:00:00	474
39	6/16/1991	24:00:00	873
40	6/15/1992	24:00:00	439
41	5/29/1993	24:00:00	1,910
42	6/1/1994	24:00:00	795
43	6/18/1995	24:00:00	2,787

Combined Gage (used in analysis)			
Record Number	Date	Time	Peak Flow (cfs)
44	6/23/1996	24:00:00	4,800
45	6/9/1997	19:00:00	4,614
46	7/2/1998	8:50:00	1,497
47	6/26/1999	6:20:00	2,064
48	6/1/2000	6:20:00	2,405
49	7/13/2001	21:40:00	436
50	6/5/2002	15:00:00	310
51	5/30/2003	10:00:00	2,044
52	7/1/2004	2:15:00	436
53	6/20/2005	8:15:00	997
54	4/15/2006	0:30:00	889
55	6/18/2007	7:15:00	951
56	5/22/2008	13:15:00	2,095
57	6/27/2009	6:29:00	1,590
58	6/8/2010	10:15:00	2,415
59	6/25/2011	11:30:00	5,264
60	7/6/2012	0:45:00	340
61	5/16/2013	17:30:00	1,073
62	5/31/2014	7:45:00	3,613
63	6/14/2015	10:30:00	4,438
64	6/23/2016	9:00:00	2,549

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

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.

Reference: Water Resources Investigations Report 99-4190 "Analysis of the Magnitude and Frequency of Floods in Colorado"

Table 2. Basin characteristics and the range of values used in the analysis

Basin characteristics	Range of values
Drainage-basin area, in square miles	5.5 to 988.0
Mean annual precipitation, in inches	7.0 to 49.0
Mean drainage-basin elevation, in feet	2.805 to 12,200
Mean drainage-basin slope, in foot per foot	0.081 to 0.562

Flood region	Exponent
Mountains	0.69
Rio Grande	0.88
Southwest	0.71
Northwest	0.64
Plains	0.40

Exponent
0.69

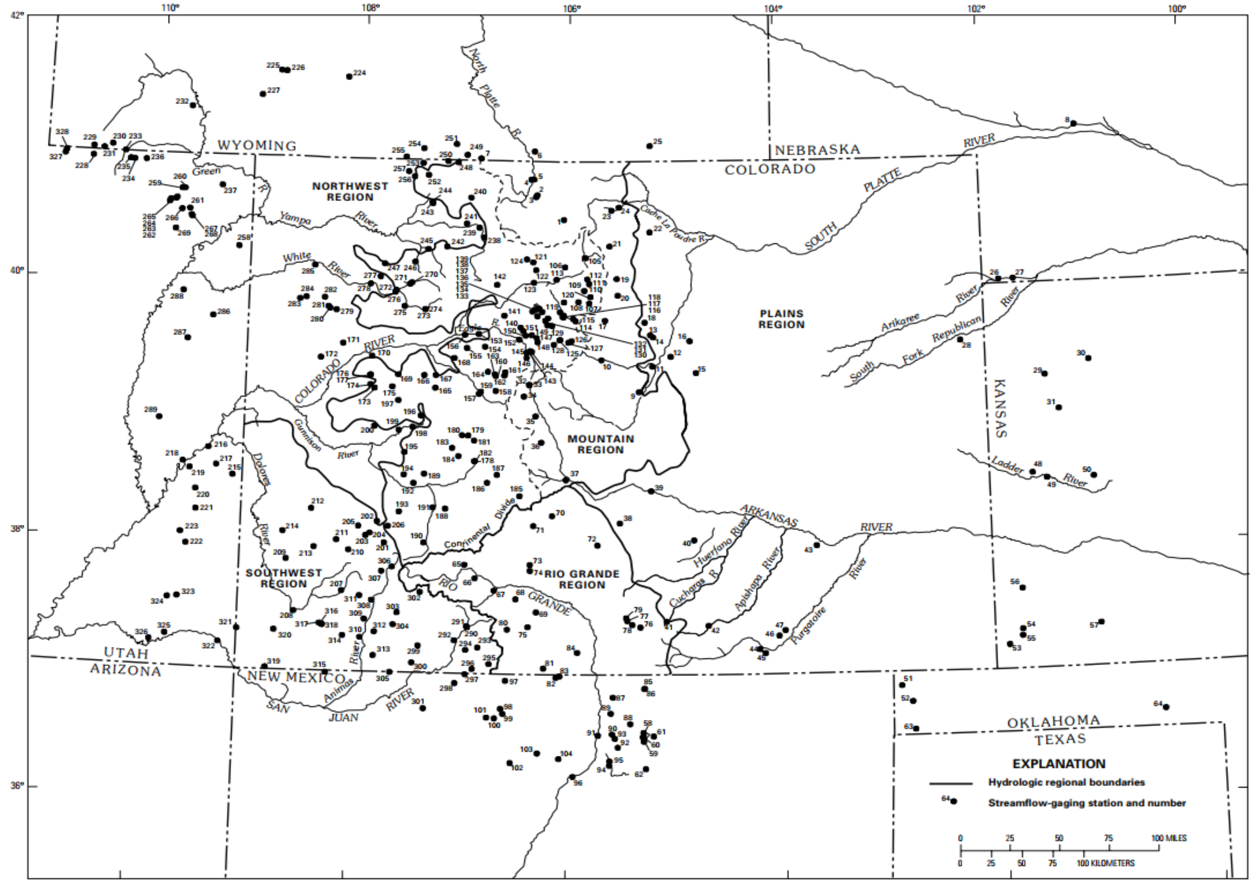

Figure 1. Boundaries of hydrologic regions and location of streamflow-gaging stations in Colorado and adjacent States.

Below Glenwood Minus Roaring Fork Analysis Data

Colorado River near Dotsero, CO			
HEC-SSP Input Data			
Ordinate	Date	Time	Value
Units			CFS
Type			INST-VAL
1	6/6/1968	24:00:00	9,270.00
2	6/25/1969	24:00:00	6,730.00
3	5/22/1970	24:00:00	13,900.00
4	6/25/1971	24:00:00	10,300.00
5	6/7/1972	24:00:00	8,420.00
6	6/15/1973	24:00:00	11,300.00
7	5/10/1974	24:00:00	11,200.00
8	6/9/1975	24:00:00	9,410.00
9	7/12/1976	24:00:00	7,310.00
10	6/7/1977	24:00:00	2,800.00
11	6/16/1978	24:00:00	11,600.00
12	5/29/1979	24:00:00	11,800.00
13	6/12/1980	24:00:00	10,700.00
14	6/9/1981	24:00:00	4,900.00
15	6/29/1982	24:00:00	6,820.00
16	6/27/1983	24:00:00	17,700.00
17	5/25/1984	24:00:00	22,200.00
18	6/9/1985	24:00:00	11,600.00
19	6/7/1986	24:00:00	11,100.00
20	5/17/1987	24:00:00	5,840.00
21	6/7/1988	24:00:00	6,300.00
22	5/24/1989	24:00:00	4,420.00
23	6/8/1990	24:00:00	5,060.00
24	6/15/1991	24:00:00	7,200.00
25	5/27/1992	24:00:00	3,700.00
26	5/29/1993	24:00:00	11,500.00
27	6/2/1994	24:00:00	4,630.00
28	6/18/1995	24:00:00	15,400.00
29	5/20/1996	24:00:00	13,800.00
30	6/4/1997	11:00	16,100.00
31	6/2/1998	6:30	7,550.00
32	6/9/1999	9:45	8,310.00
33	5/30/2000	10:45	8,790.00
34	5/20/2001	10:45	4,400.00
35	6/1/2002	9:00	2,020.00
36	6/2/2003	6:30	11,700.00
37	6/8/2004	12:45	3,240.00
38	5/24/2005	12:30	7,390.00
39	5/23/2006	12:00	9,600.00
40	6/19/2007	15:15	6,720.00
41	5/22/2008	12:15	13,000.00
42	5/21/2009	12:30	10,400.00
43	6/8/2010	13:00	14,600.00
44	6/7/2011	12:00	18,500.00
45	7/24/2012	23:00	5,020.00
46	5/18/2013	8:15	5,990.00
47	6/1/2014	12:15	17,200.00
48	6/18/2015	10:45	13,000.00
49	6/10/2016	9:30	11,700.00

HEC-SSP Results		
% Chance Exceedance	**Computed Curve Flow (cfs)**	**Final Rounded Flow (cfs)**
0.2	27161.5	27,200
1	23022.5	23,000
2	21055.6	21,100
4	18948.7	18,900
10	15884.7	15,900

Projected using Northwest Exponent of 0.64
DA of Dotsero Gage - 4,390 square miles
DA of Below Glenwood Gage - 4,560 square miles

Projected HEC-SSP Results		
% Chance Exceedance	**Computed Curve Flow (cfs)**	**Final Rounded Flow (cfs)**
0.2	27830.0	27,800
1	23589.2	23,600
2	21573.9	21,600
4	19415.1	19,400
10	16275.7	16,300

Colorado River below Glenwood Springs, CO
HEC-SSP Input Data

			GLENWOOD SPRINGS, CO
Ordinate	Date	Time	FLOW-ANNUAL PEAK
			USGS
Units			CFS
Type			INST-VAL
1	6/16/1921	24:00:00	44,400.00
2	6/5/1922	24:00:00	
3	6/5/1923	24:00:00	
4	6/5/1924	24:00:00	
5	6/5/1925	24:00:00	
6	6/5/1926	24:00:00	
7	6/5/1927	24:00:00	
8	6/5/1928	24:00:00	
9	6/5/1929	24:00:00	
10	6/5/1930	24:00:00	
11	6/5/1931	24:00:00	
12	6/5/1932	24:00:00	
13	6/5/1933	24:00:00	
14	6/5/1934	24:00:00	
15	6/5/1935	24:00:00	
16	6/5/1936	24:00:00	
17	6/5/1937	24:00:00	
18	6/5/1938	24:00:00	
19	6/5/1939	24:00:00	
20	6/5/1940	24:00:00	
21	6/5/1941	24:00:00	
22	6/5/1942	24:00:00	
23	6/5/1943	24:00:00	
24	6/5/1944	24:00:00	
25	6/5/1945	24:00:00	
26	6/5/1946	24:00:00	
27	6/5/1947	24:00:00	
28	6/5/1948	0:00	
29	6/5/1949	0:00	
30	6/5/1950	0:00	
31	6/5/1951	0:00	
32	6/5/1952	0:00	
33	6/5/1953	0:00	
34	6/5/1954	0:00	
35	6/5/1955	0:00	
36	6/5/1956	0:00	
37	6/5/1957	0:00	
38	6/5/1958	0:00	

HEC-SSP Results		
% Chance Exceedance	**Computed Curve Flow (cfs)**	**Final Rounded Flow (cfs)**
0.2	36842.9	36,800
1	32889.3	32,900
2	30814.3	30,800
4	28444.9	28,400
10	24717.5	24,700

39	6/5/1959	0:00	
40	6/5/1960	0:00	
41	6/5/1961	0:00	
42	6/5/1962	0:00	
43	6/5/1963	0:00	
44	6/5/1964	0:00	
45	6/5/1965	0:00	
46	6/5/1966	0:00	
47	6/5/1967	0:00	14,200.00
48	6/6/1968	0:00	17,400.00
49	5/28/1969	24:00:00	13,300.00
50	5/23/1970	24:00:00	19,200.00
51	6/25/1971	24:00:00	17,600.00
52	6/8/1972	24:00:00	14,400.00
53	6/15/1973	24:00:00	20,500.00
54	5/30/1974	24:00:00	15,100.00
55	6/16/1975	24:00:00	14,200.00
56	6/6/1976	24:00:00	9,960.00
57	6/7/1977	24:00:00	4,830.00
58	6/16/1978	24:00:00	19,400.00
59	6/16/1979	24:00:00	17,700.00
60	6/12/1980	24:00:00	18,800.00
61	6/10/1981	24:00:00	9,310.00
62	6/29/1982	24:00:00	12,600.00
63	6/25/1983	24:00:00	27,900.00
64	5/25/1984	24:00:00	31,500.00
65	6/9/1985	24:00:00	21,600.00
66	6/7/1986	24:00:00	20,200.00
67	6/9/1987	24:00:00	11,100.00
68	6/7/1988	24:00:00	11,000.00
69	5/30/1989	24:00:00	7,620.00
70	6/11/1990	24:00:00	9,810.00
71	6/15/1991	24:00:00	12,100.00
72	5/27/1992	24:00:00	6,550.00
73	5/28/1993	24:00:00	17,700.00
74	6/2/1994	24:00:00	9,180.00
75	6/18/1995	24:00:00	23,800.00
76	5/20/1996	24:00:00	18,200.00
77	6/5/1997	12:00	23,400.00
78	6/2/1998	7:30	12,800.00
79	6/9/1999	10:00	13,000.00
80	5/30/2000	11:00	13,800.00
81	6/2/2001	9:45	8,130.00
82	6/1/2002	9:15	4,480.00
83	6/2/2003	6:30	18,500.00
84	6/8/2004	10:15	6,920.00
85	5/23/2005	9:45	12,800.00

86	5/23/2006	9:45	14,600.00
87	6/20/2007	7:15	10,700.00
88	6/3/2008	11:30	20,500.00
89	5/21/2009	8:15	17,800.00
90	6/8/2010	13:45	24,300.00
91	6/26/2011	8:45	27,600.00
92	7/25/2012	3:15	4,480.00
93	6/11/2013	10:30	10,500.00
94	6/2/2014	15:15	24,900.00
95	6/18/2015	8:30	21,200.00
96	6/8/2016	11:00	18,700.00

Roaring Fork River at Glenwood Springs, CO
HEC-SSP Input Data

Roaring Fork at Glenwood Springs				
Units	Daily Maximum		CFS	
Type			INST-VAL	
1	6/5/1967	24:00:00	4,610	
2	6/6/1968	24:00:00	6,900	
3	5/28/1969	24:00:00	5,570	Used Daily Maximum on the date of annual
4	5/23/1970	24:00:00	5,500	peak for the Colorado. Assumed peak time
5	6/25/1971	24:00:00	6,900	of 24:00. Dates in table correspond to date
6	6/8/1972	24:00:00	5,810	of maximum annual peak on the Colorado
7	6/15/1973	24:00:00	7,290	River below Glenwood Springs.
8	5/30/1974	24:00:00	4,780	
9	6/16/1975	24:00:00	5,380	
10	6/6/1976	24:00:00	4,050	
11	6/7/1977	24:00:00	2,000	
12	6/16/1978	24:00:00	7,230	
13	6/16/1979	24:00:00	6,340	
14	6/12/1980	24:00:00	7,170	
15	6/10/1981	24:00:00	4,110	
16	6/29/1982	24:00:00	5,370	
17	6/25/1983	24:00:00	11,200	
18	5/25/1984	24:00:00	8,630	
19	6/9/1985	24:00:00	9,690	
20	6/7/1986	24:00:00	7,020	
21	6/9/1987	24:00:00	5,720	
22	6/7/1988	24:00:00	4,090	
23	5/30/1989	24:00:00	2,820	
24	6/11/1990	24:00:00	4,380	
25	6/15/1991	24:00:00	4,670	
26	5/27/1992	24:00:00	2,830	
27	5/28/1993	24:00:00	6,670	
28	6/2/1994	24:00:00	4,030	
29	6/18/1995	24:00:00	10,200	
30	5/20/1996	24:00:00	5,780	
31	6/5/1997	24:00:00	7,590	
32	6/2/1998	24:00:00	4,950	
33	6/9/1999	24:00:00	4,450	
34	5/30/2000	24:00:00	5,320	
35	6/2/2001	24:00:00	3,460	
36	6/1/2002	24:00:00	2,170	
37	6/2/2003	24:00:00	6,150	
38	6/8/2004	24:00:00	3,550	
39	5/23/2005	24:00:00	5,200	
40	5/23/2006	24:00:00	5,640	
41	6/20/2007	24:00:00	3,210	
42	6/3/2008	24:00:00	6,330	
43	5/21/2009	24:00:00	6,050	
44	6/8/2010	24:00:00	8,650	
45	6/26/2011	24:00:00	7,530	
46	7/25/2012	24:00:00	634	
47	6/11/2013	24:00:00	3,950	
48	6/2/2014	24:00:00	6,250	
49	6/18/2015	24:00:00	7,040	
50	6/8/2016	24:00:00	5,910	

Calculated
Below Glenwood - Roaring Fork

6/5/1967	0:00	9,590.00
6/6/1968	0:00	10,500.00
5/28/1969	0:00	7,730.00
5/23/1970	0:00	13,700.00
6/25/1971	0:00	10,700.00
6/8/1972	0:00	8,590.00
6/15/1973	0:00	13,210.00
5/30/1974	0:00	10,320.00
6/16/1975	0:00	8,820.00
6/6/1976	0:00	5,910.00
6/7/1977	0:00	2,830.00
6/16/1978	0:00	12,170.00
6/16/1979	0:00	11,360.00
6/12/1980	0:00	11,630.00
6/10/1981	0:00	5,200.00
6/29/1982	0:00	7,230.00
6/25/1983	0:00	16,700.00
5/25/1984	0:00	22,870.00
6/9/1985	0:00	11,910.00
6/7/1986	0:00	13,180.00
6/9/1987	0:00	5,380.00
6/7/1988	0:00	6,910.00
5/30/1989	0:00	4,800.00
6/11/1990	0:00	5,430.00
6/15/1991	0:00	7,430.00
5/27/1992	0:00	3,720.00
5/28/1993	0:00	11,030.00
6/2/1994	0:00	5,150.00
6/18/1995	0:00	13,600.00
5/20/1996	0:00	12,420.00
6/5/1997	12:00	15,810.00
6/2/1998	7:30	7,850.00
6/9/1999	10:00	8,550.00
5/30/2000	11:00	8,480.00
6/2/2001	9:45	4,670.00
6/1/2002	9:15	2,310.00
6/2/2003	6:30	12,350.00
6/8/2004	10:15	3,370.00
5/23/2005	9:45	7,600.00
5/23/2006	9:45	8,960.00
6/20/2007	7:15	7,490.00
6/3/2008	11:30	14,170.00
5/21/2009	8:15	11,750.00
6/8/2010	13:45	15,650.00
6/26/2011	8:45	20,070.00
7/25/2012	3:15	3,846.00
6/11/2013	10:30	6,550.00
6/2/2014	15:15	18,650.00
6/18/2015	8:30	14,160.00
6/8/2016	11:00	12,790.00

HEC-SSP Results		
% Chance Exceedance	Computed Curve Flow (cfs)	Final Rounded Flow (cfs)
0.2	27209	27,200
1	23366.6	23,400
2	21483.5	21,500
4	19427.7	19,400
10	16370.4	16,400

Below Glenwood - Roaring Fork		
HEC-SSP Results		
% Chance Exceedance	Computed Curve Flow (cfs)	Final Rounded Flow (cfs)
0.2	27209.0	27,200
1	23366.6	23,400
2	21483.5	21,500
4	19427.7	19,400
10	16370.4	16,400

Projected Dotsero		
HEC-SSP Results		
% Chance Exceedance	Computed Curve Flow (cfs)	Final Rounded Flow (cfs)
0.2	27830.0	27,800
1	23589.2	23,600
2	21573.9	21,600
4	19415.1	19,400
10	16275.7	16,300

Percent Difference	
HEC-SSP Results	
% Chance Exceedance	Percent Difference (%)
0.2	-2.2%
1	-0.8%
2	-0.5%
4	0.0%
10	0.6%