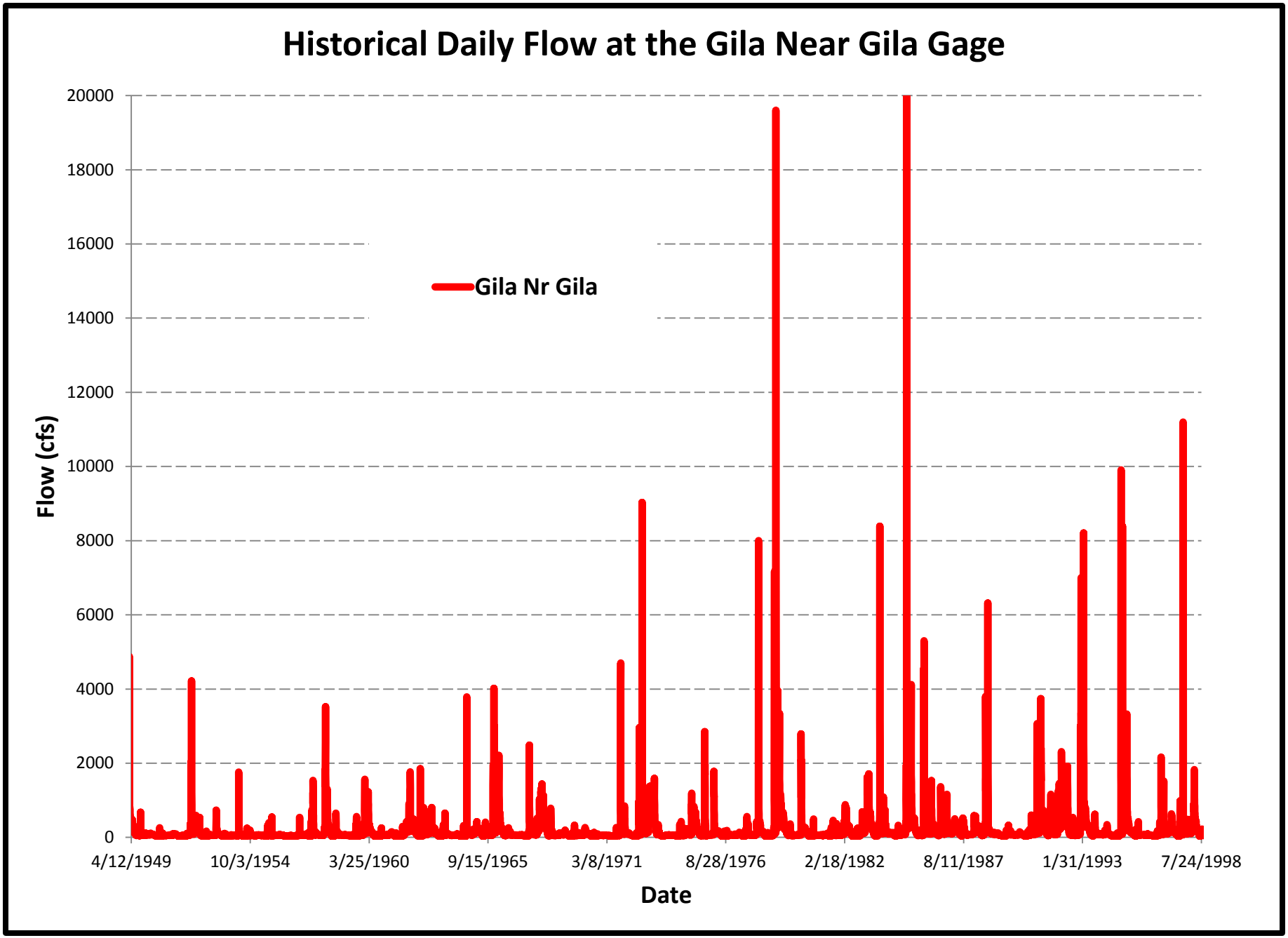
Boys,

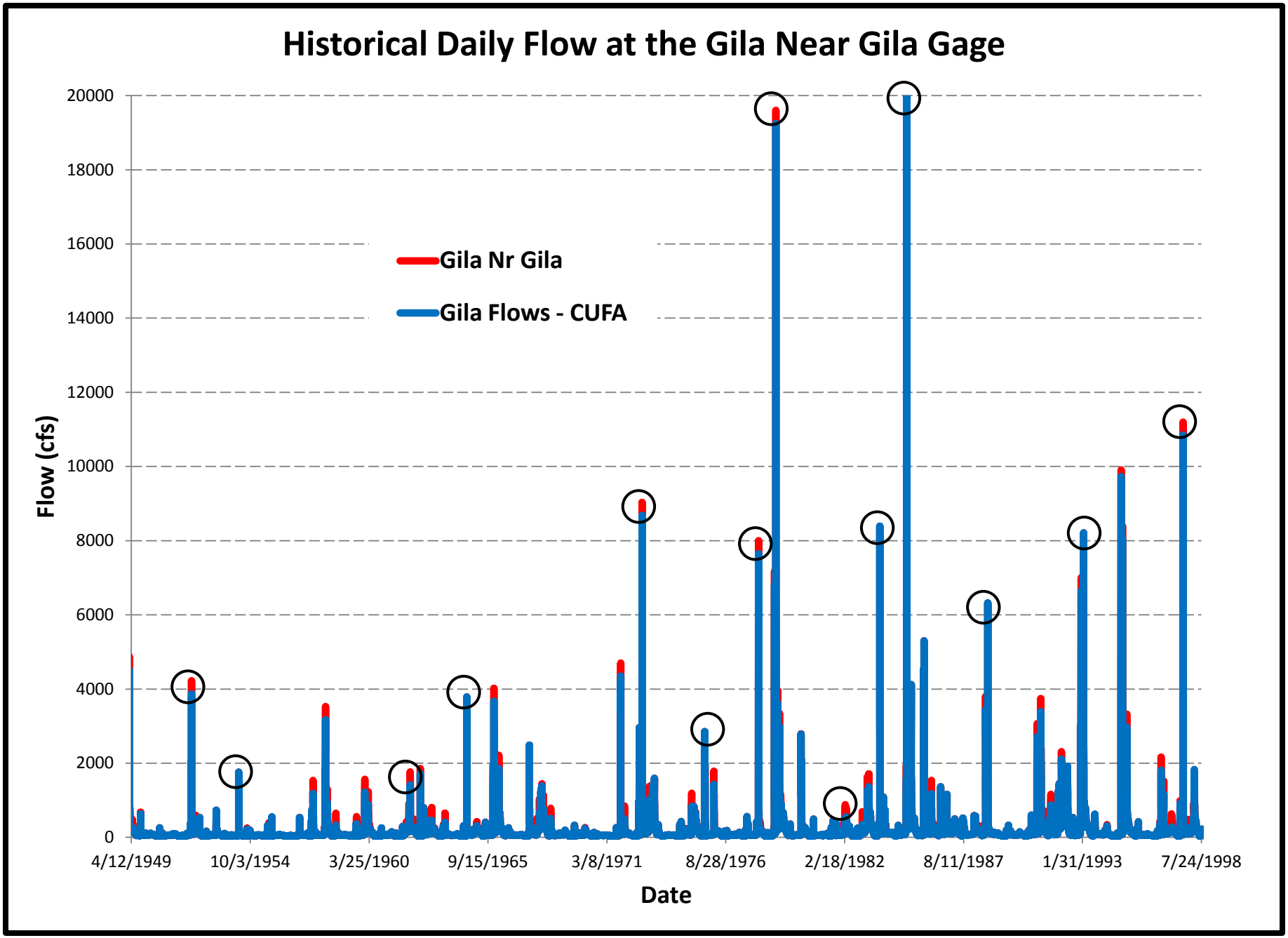
There are lies,

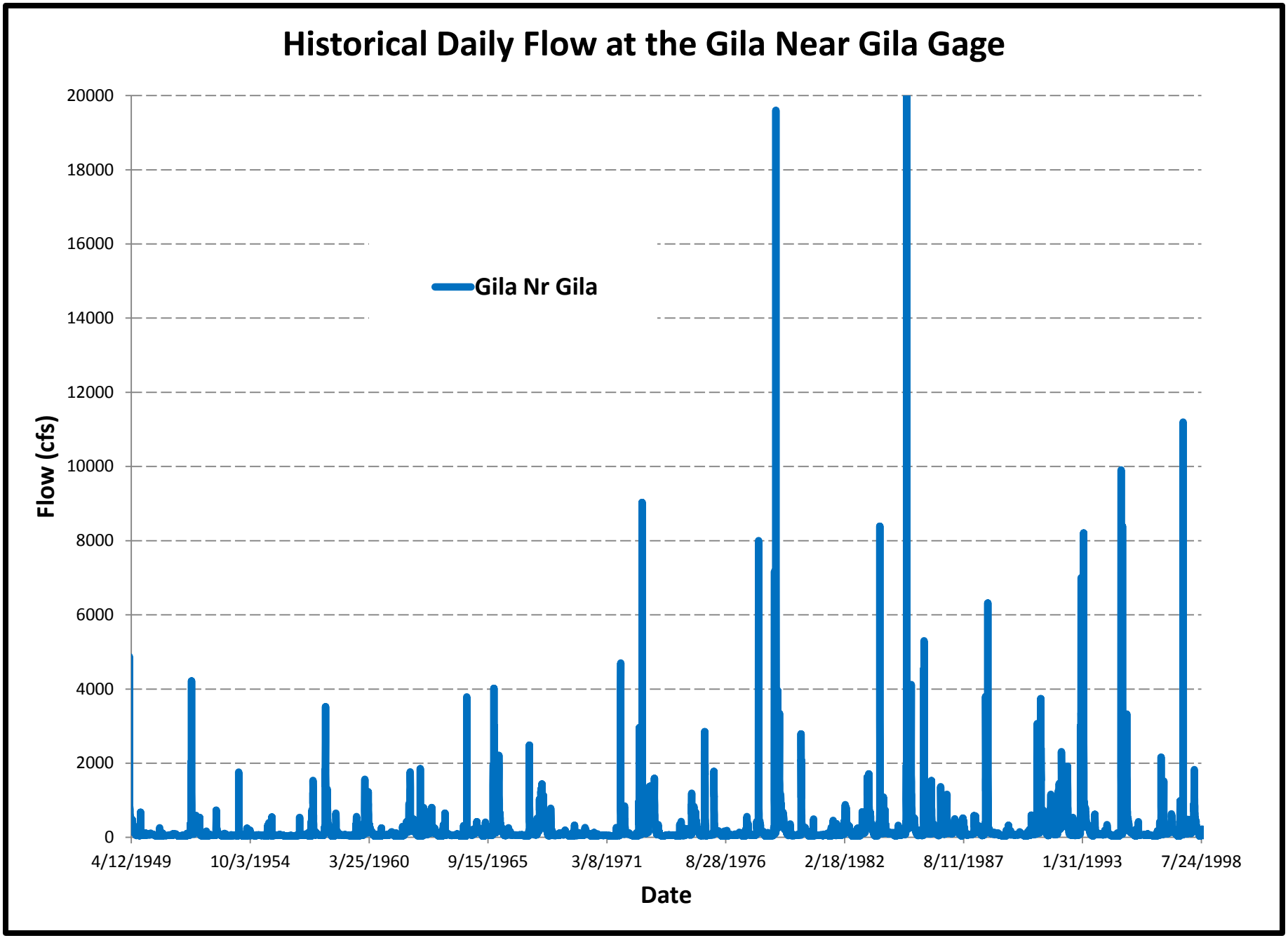
There are Damn Lies,

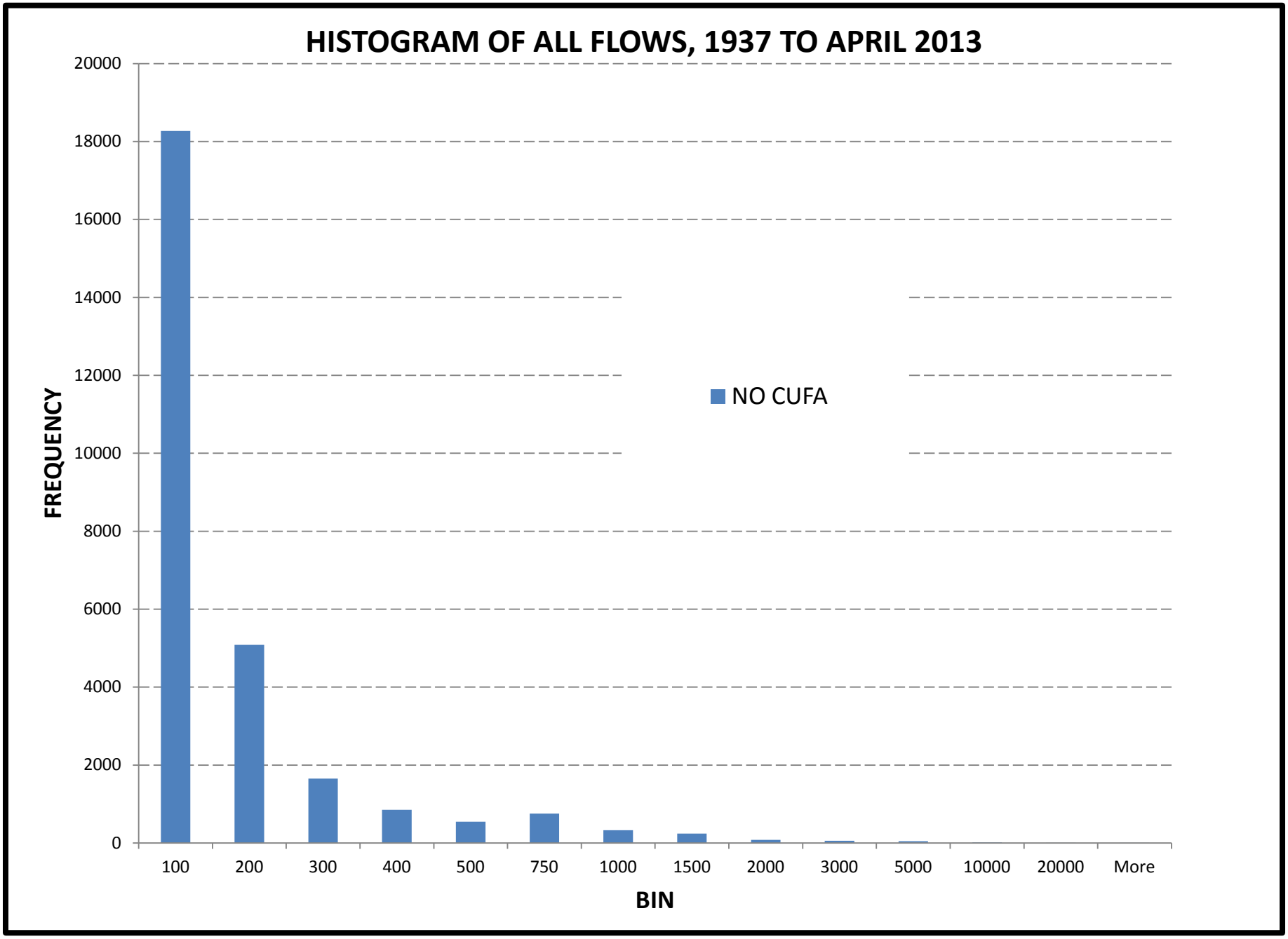
And then there are ***STATISTICS***!

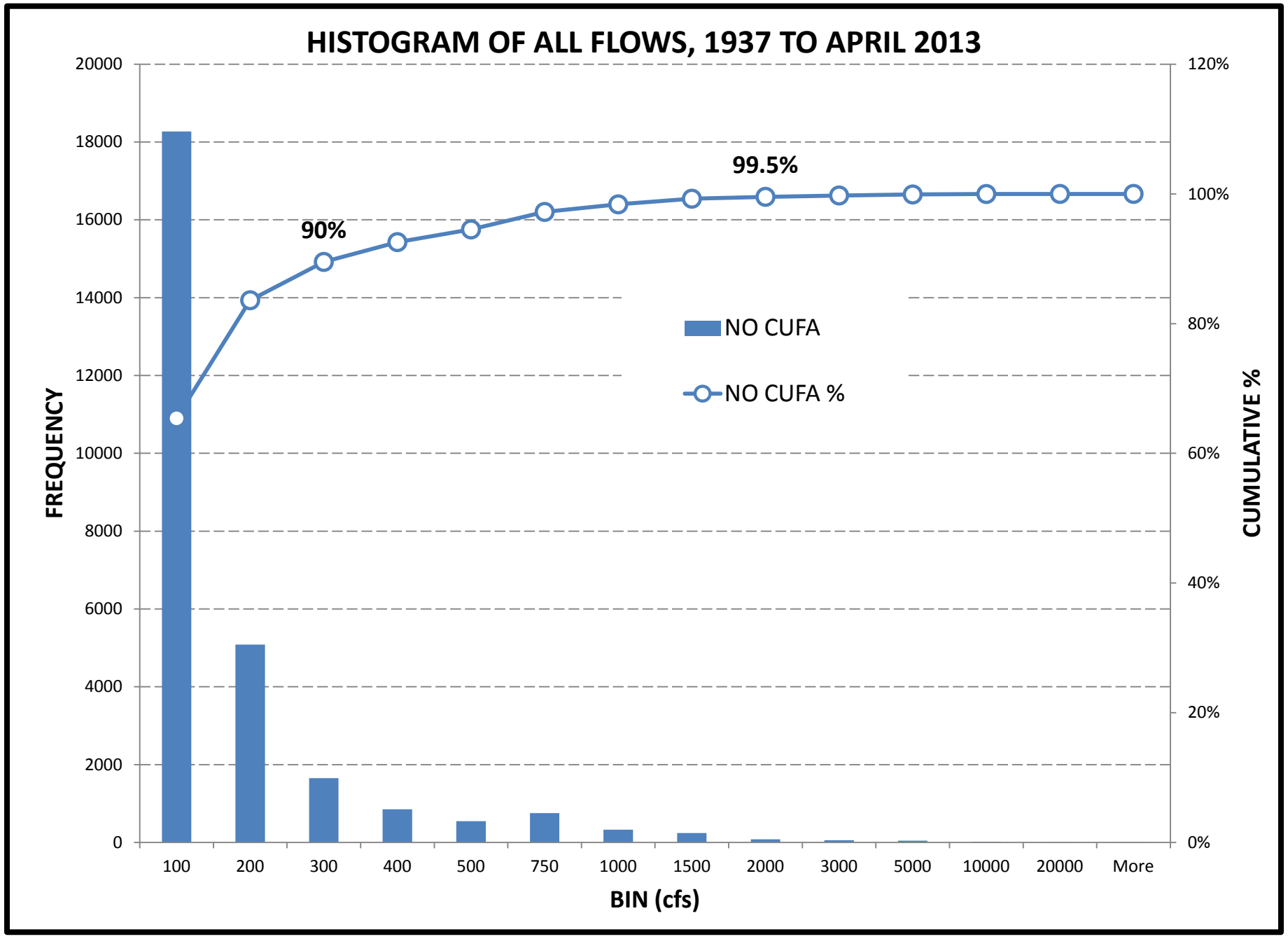
-- Samuel Clemens

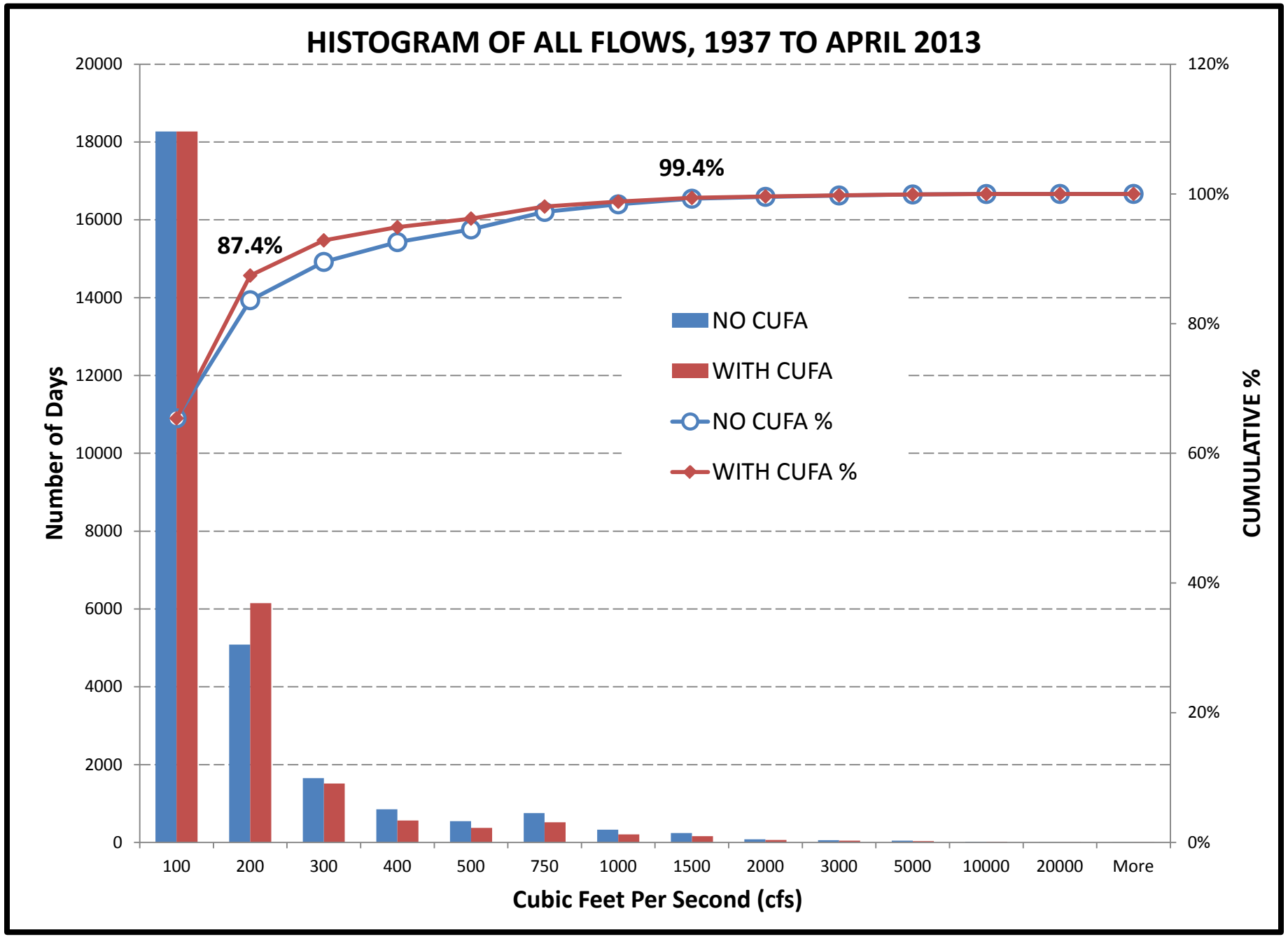

Historical Daily Flow at the Gila Near Gila Gage
Gila Nr Gila
Flow (cfs)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
4/12/1949
10/3/1954
3/25/1960
9/15/1965
3/8/1971
8/28/1976
2/18/1982
8/11/1987
1/31/1993
7/24/1998
Date

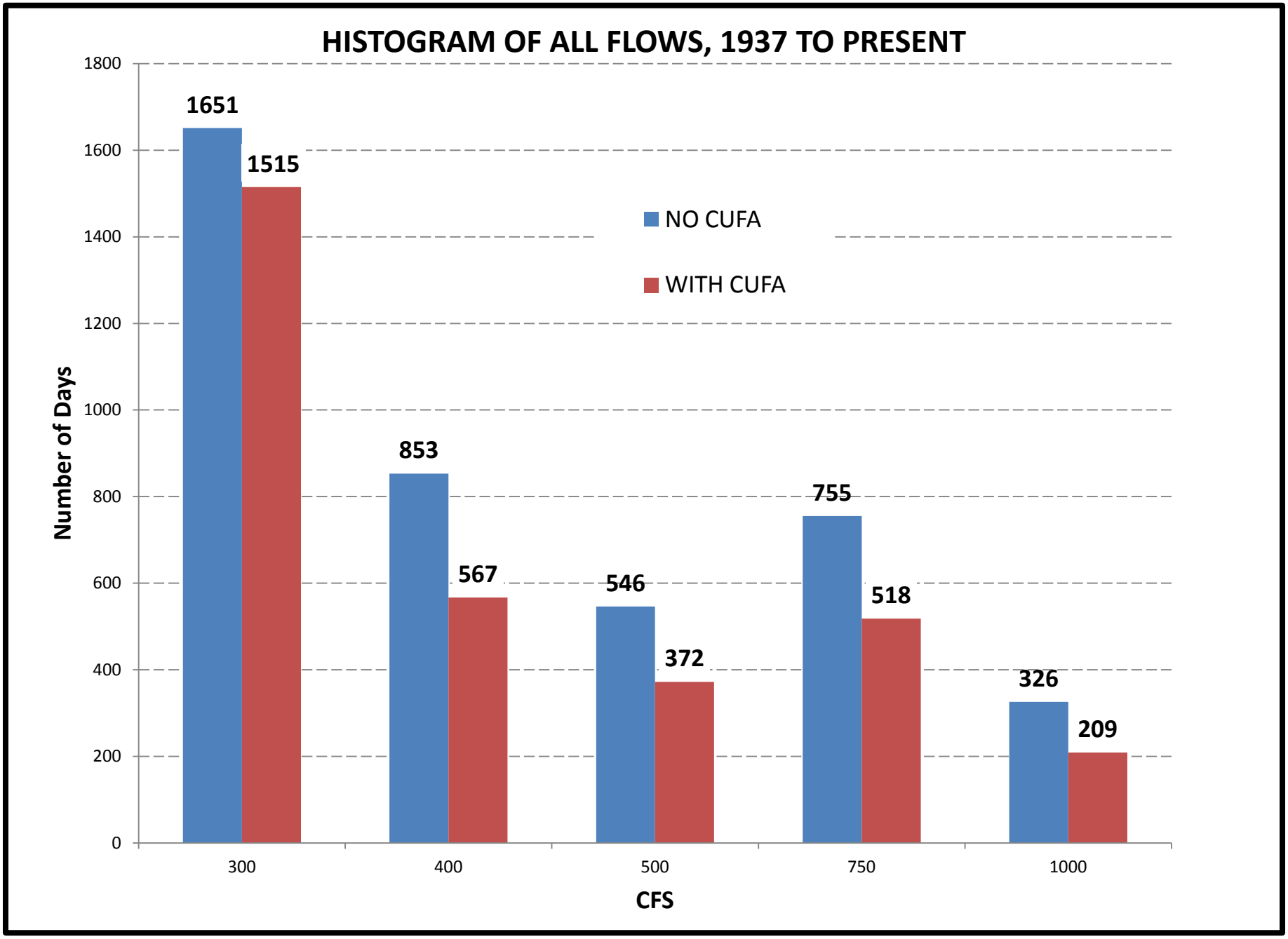

Historical Daily Flow at the Gila Near Gila Gage
Gila Nr Gila
Gila Flows - CUFA
Flow (cfs)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
4/12/1949
10/3/1954
3/25/1960
9/15/1965
3/8/1971
8/28/1976
2/18/1982
8/11/1987
1/31/1993
7/24/1998
Date

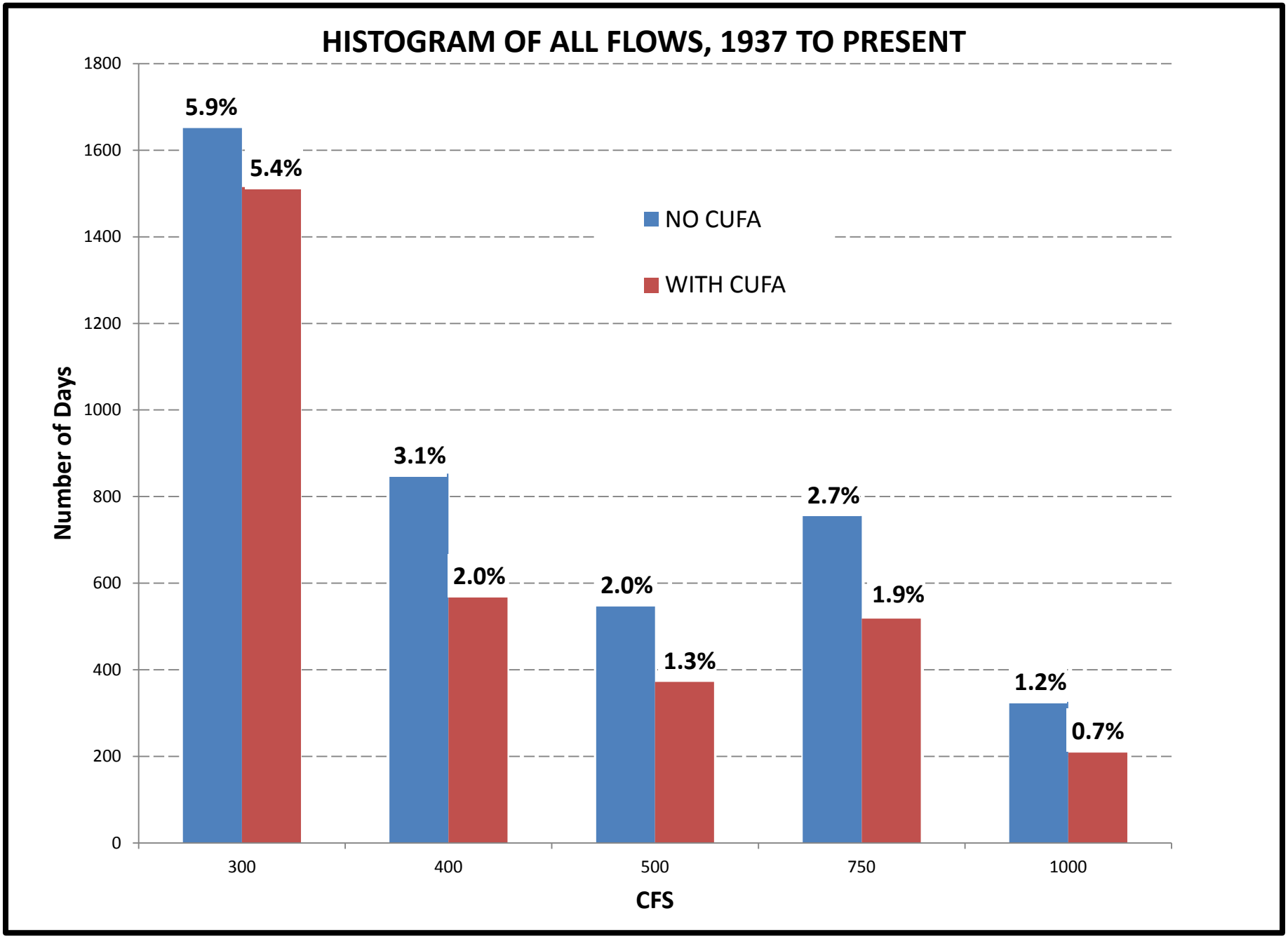

Historical Daily Flow at the Gila Near Gila Gage
Gila Nr Gila
Flow (cfs)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
4/12/1949
10/3/1954
3/25/1960
9/15/1965
3/8/1971
8/28/1976
2/18/1982
8/11/1987
1/31/1993
7/24/1998
Date

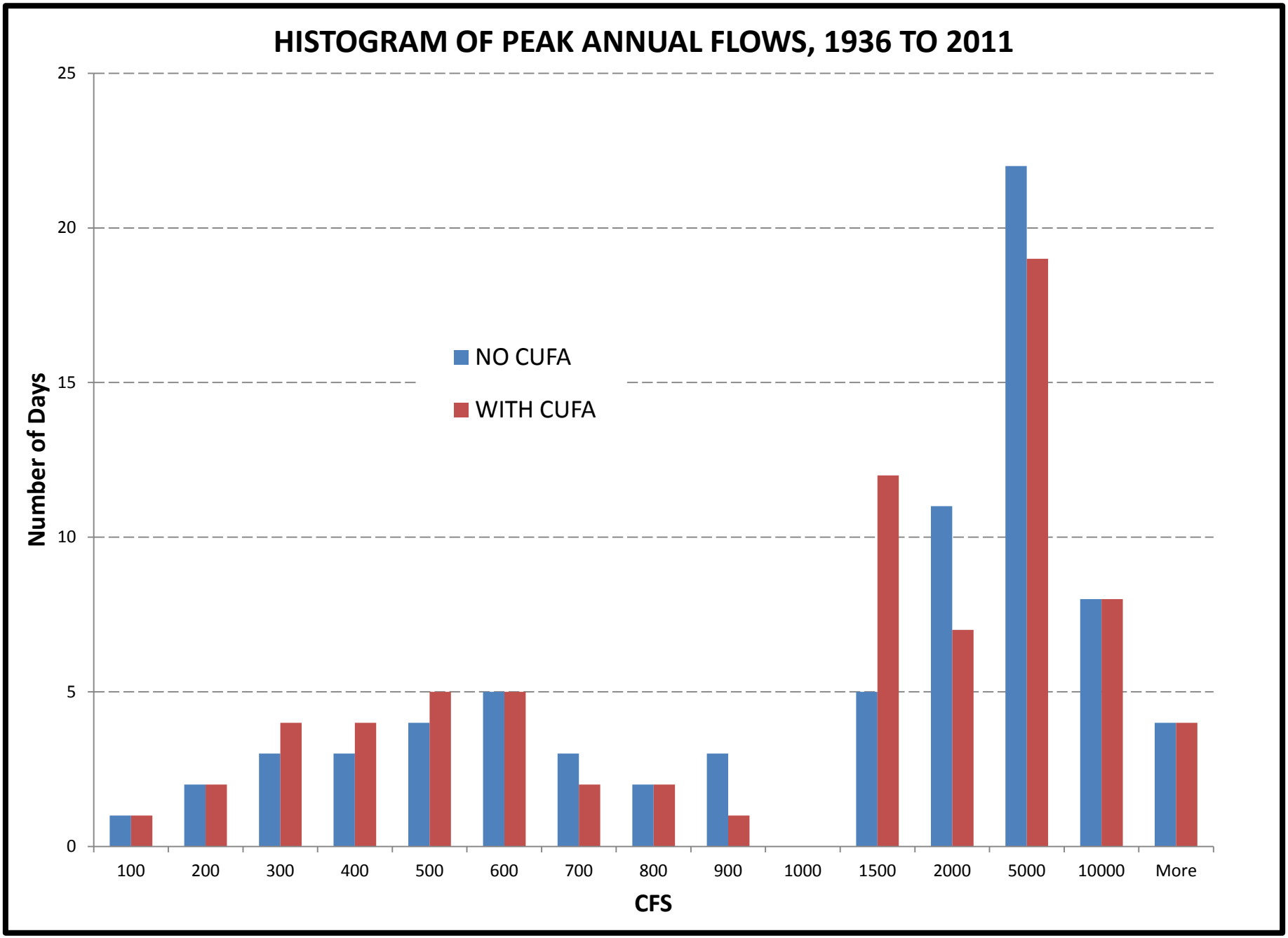

HISTOGRAM OF ALL FLOWS, 1937 TO APRIL 2013
FREQUENCY
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
NO CUFA
100
200
300
400
500
750
1000
1500
2000
3000
5000
10000
20000
More
BIN


HISTOGRAM OF ALL FLOWS, 1937 TO APRIL 2013
FREQUENCY
CUMULATIVE %
BIN (cfs)
NO CUFA
NO CUFA %
90%
99.5%
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
120%
100%
80%
60%
40%
20%
0%
100
200
300
400
500
750
1000
1500
2000
3000
5000
10000
20000
More


HISTOGRAM OF ALL FLOWS, 1937 TO APRIL 2013
Number of Days
CUMULATIVE %
Cubic Feet Per Second (cfs)
87.4%
99.4%
NO CUFA
WITH CUFA
NO CUFA %
WITH CUFA %
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
120%
100%
80%
60%
40%
20%
0%
100
200
300
400
500
750
1000
1500
2000
3000
5000
10000
20000
More


HISTOGRAM OF ALL FLOWS, 1937 TO PRESENT
1800
1600
1400
1200
1000
800
600
400
200
0
Number of Days
1651
1515
853
567
546
372
755
518
326
209
NO CUFA
WITH CUFA
300
400
500
750
1000
CFS


HISTOGRAM OF ALL FLOWS, 1937 TO PRESENT
1800
1600
1400
1200
1000
800
600
400
200
0
Number of Days
NO CUFA
WITH CUFA
5.9%
5.4%
3.1%
2.0%
2.0%
1.3%
2.7%
1.9%
1.2%
0.7%
300
400
500
750
1000
CFS


HISTOGRAM OF PEAK ANNUAL FLOWS, 1936 TO 2011
Number of Days
25
20
15
10
5
0
NO CUFA
WITH CUFA
100
200
300
400
500
600
700
800
900
1000
1500
2000
5000
10000
More
CFS

What does IHA tell us about CUFA diversions?

- No change to extreme low flows (150 cfs criterion)
- No change to low flows (150 cfs criterion)
- CUFA does not dry up the river (low flows not diverted)
- **No change to median monthly flows except in March (March median flow: 189→159 cfs)**
- High pulse events: **median peak change 221→205 cfs**
- Small floods: median peak change 2850→3072 cfs
- Large floods: median peak change 12100 →11930 cfs

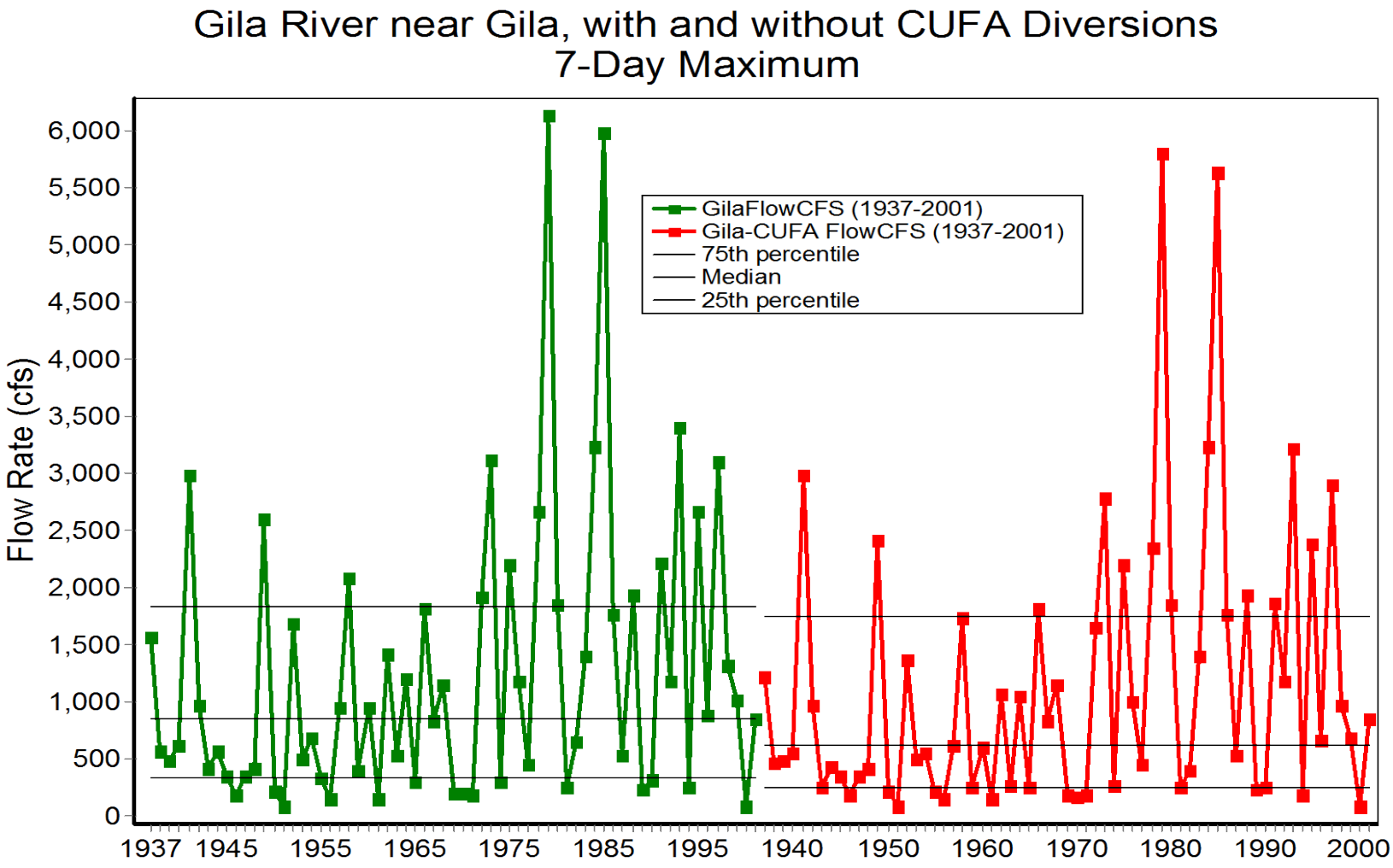

Gila River near Gila, with and without CUFA Diversions
7-Day Maximum
Flow Rate (cfs)
6,000
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1937
1945
1955
1965
1975
1985
1995
1940
1950
1960
1970
1980
1990
2000
GilaFlowCFS (1937-2001)
Gila-CUFA FlowCFS (1937-2001)
75th percentile
Median
25th percentile

Figure 49

Gila River near Gila, with and without CUFA Diversions
High Flow Pulses (Peak)

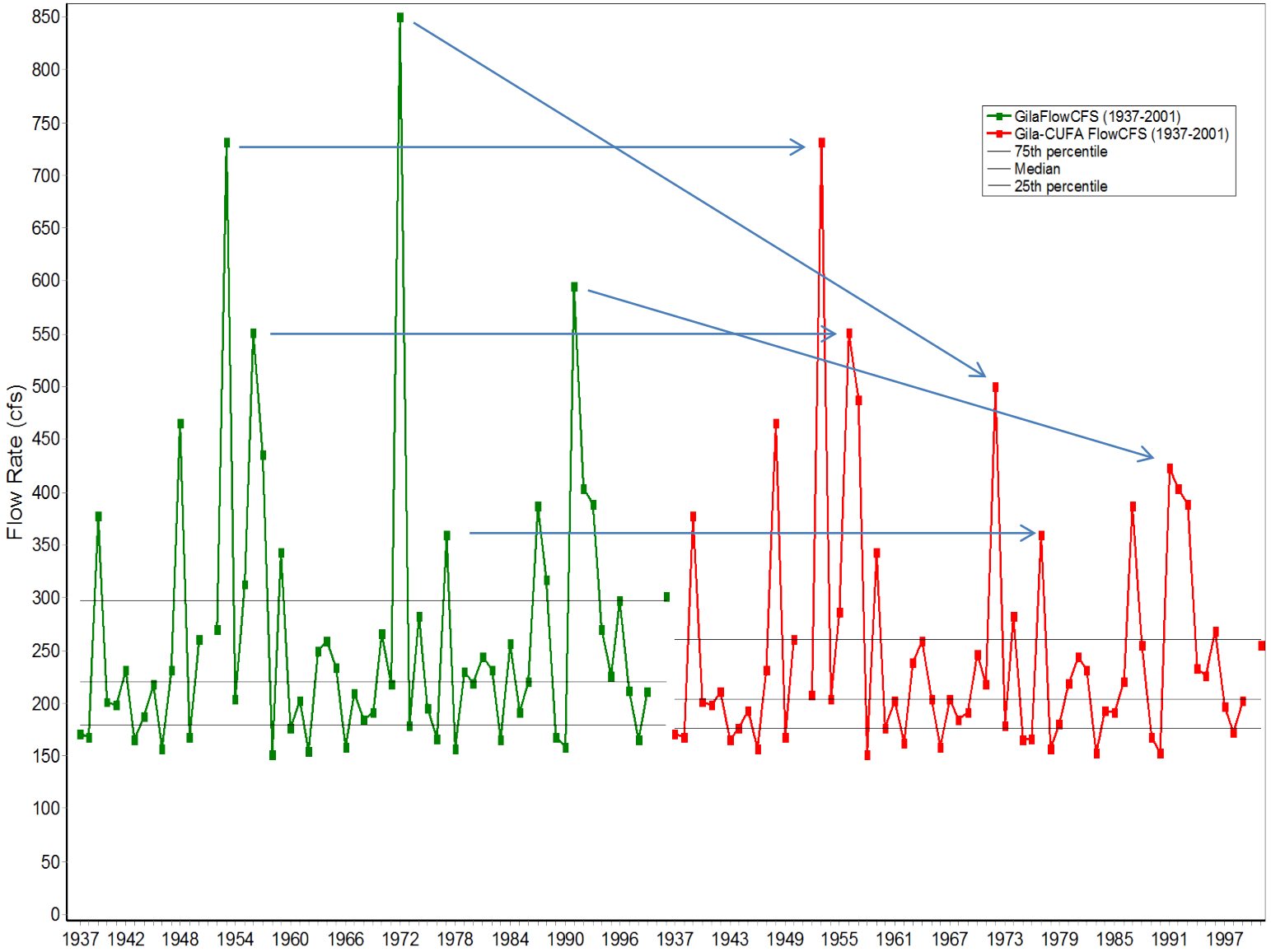
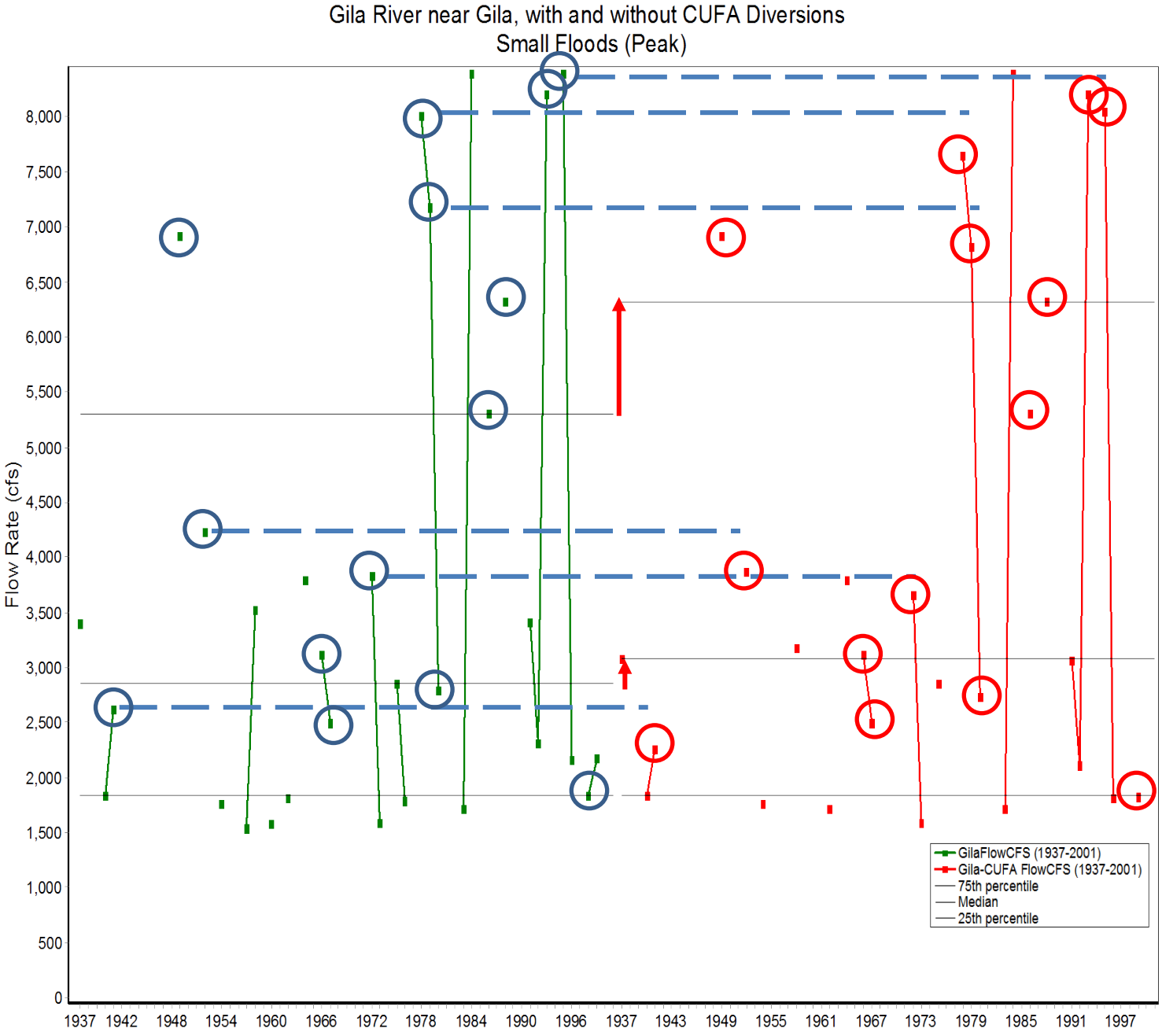
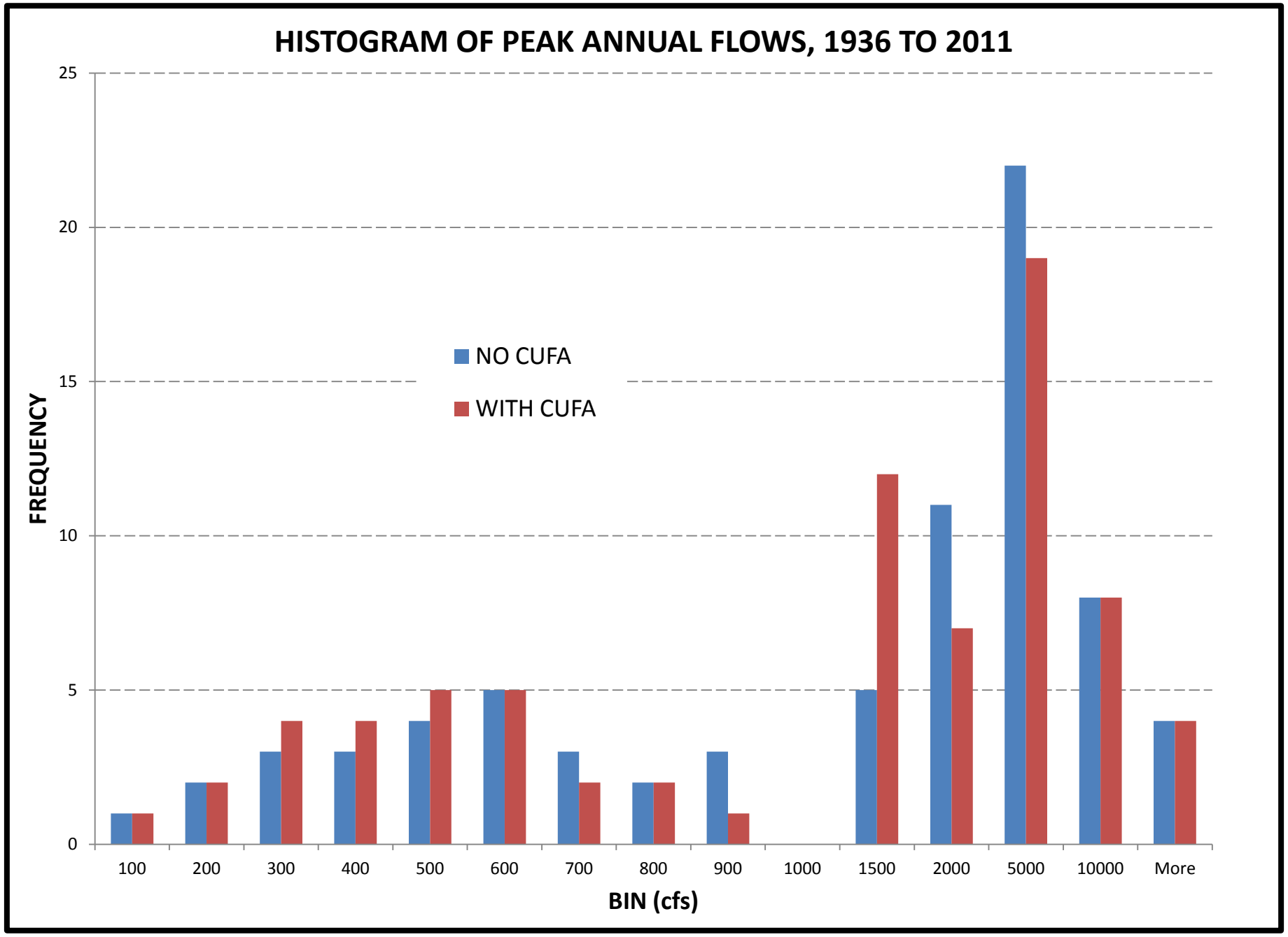


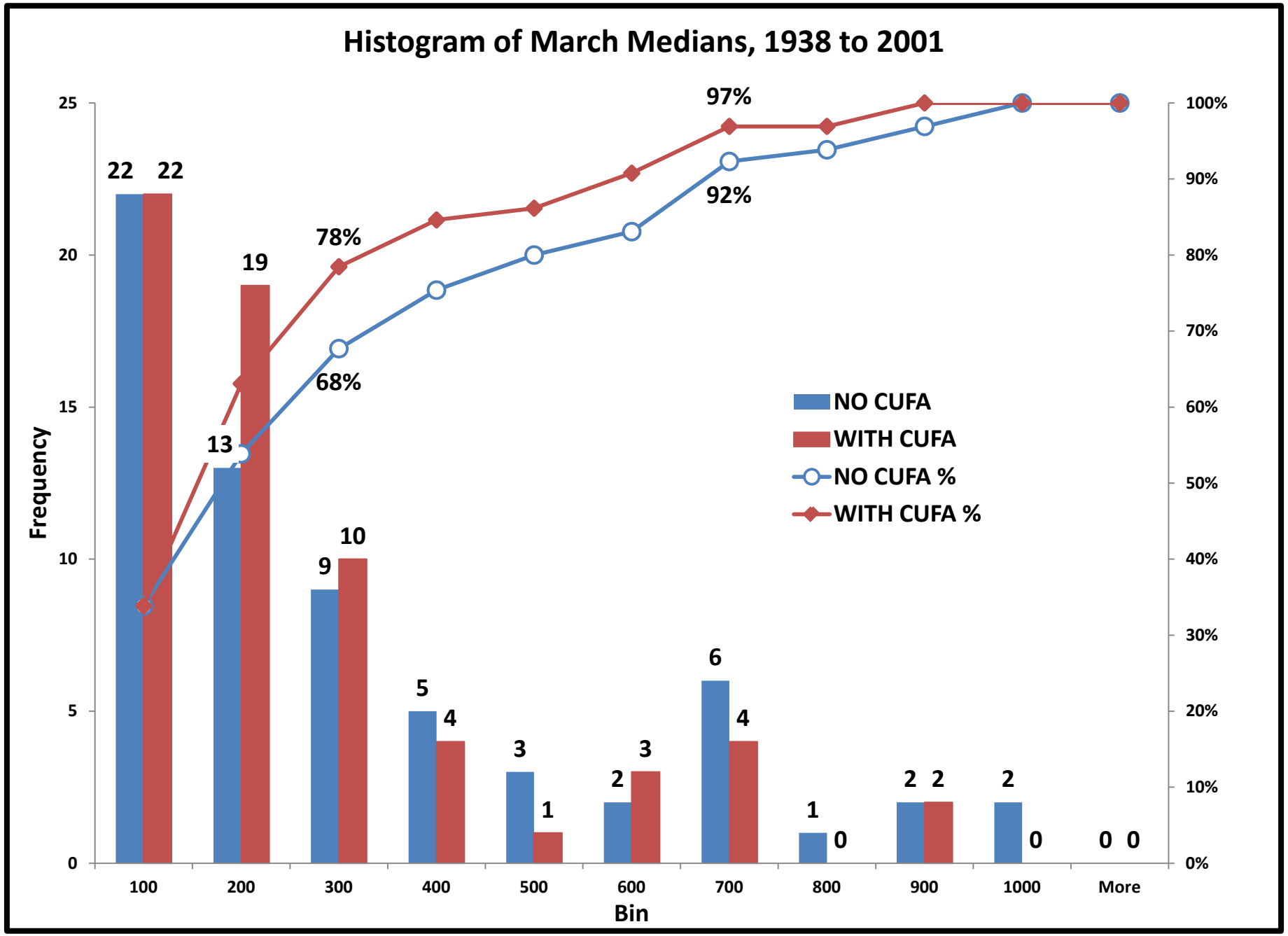
Figure 55

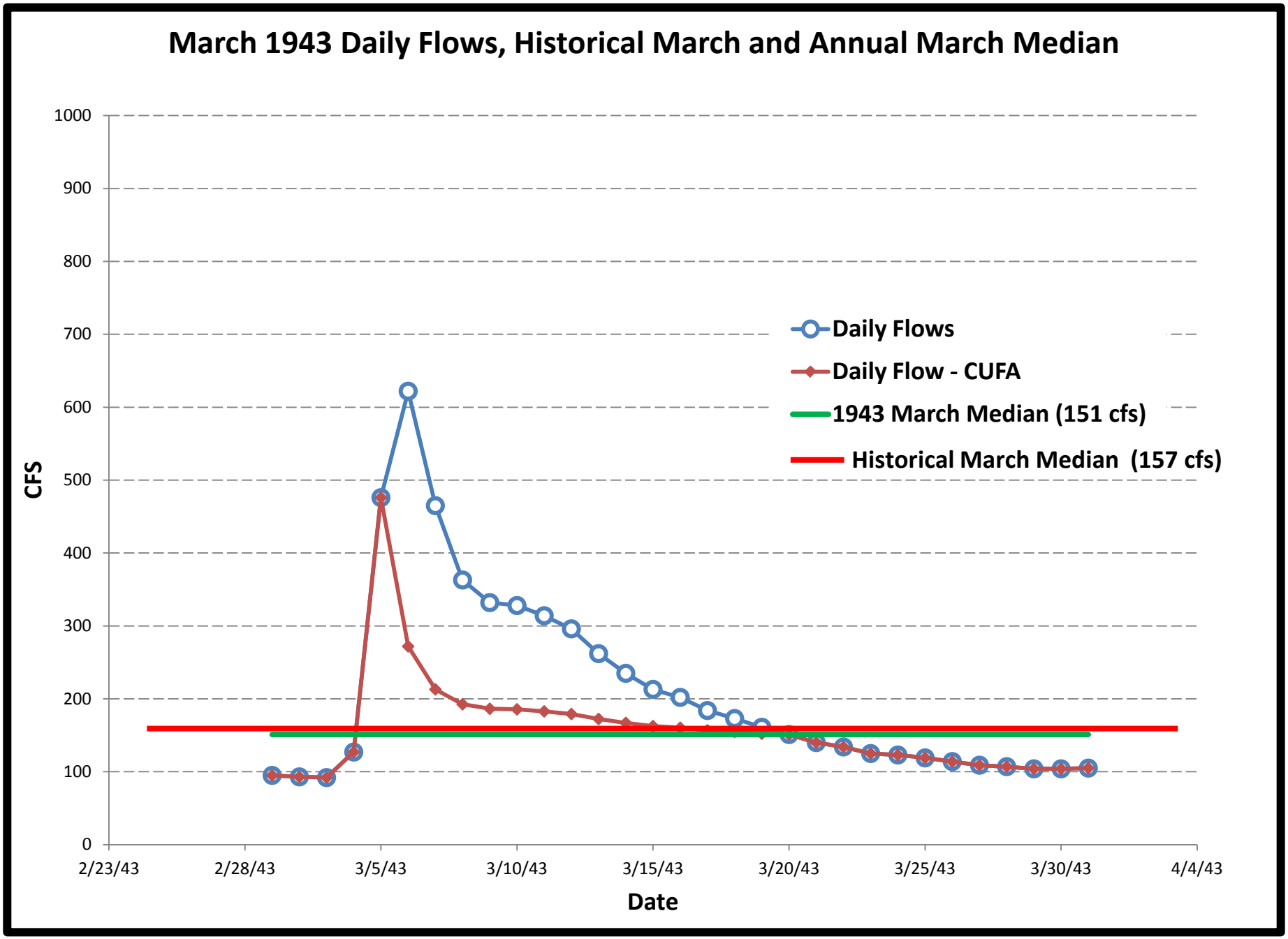

Gila River near Gila, with and without CUFA Diversions
Small Floods (Peak)
Flow Rate (cfs)
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
6,000
6,500
7,000
7,500
8,000
1937 1942 1948 1954 1960 1966 1972 1978 1984 1990 1996 1937 1943 1949 1955 1961 1967 1973 1979 1985 1991 1997
GilaFlowCFS (1937-2001)
Gila-CUFA FlowCFS (1937-2001)
75th percentile
Median
25th percentile

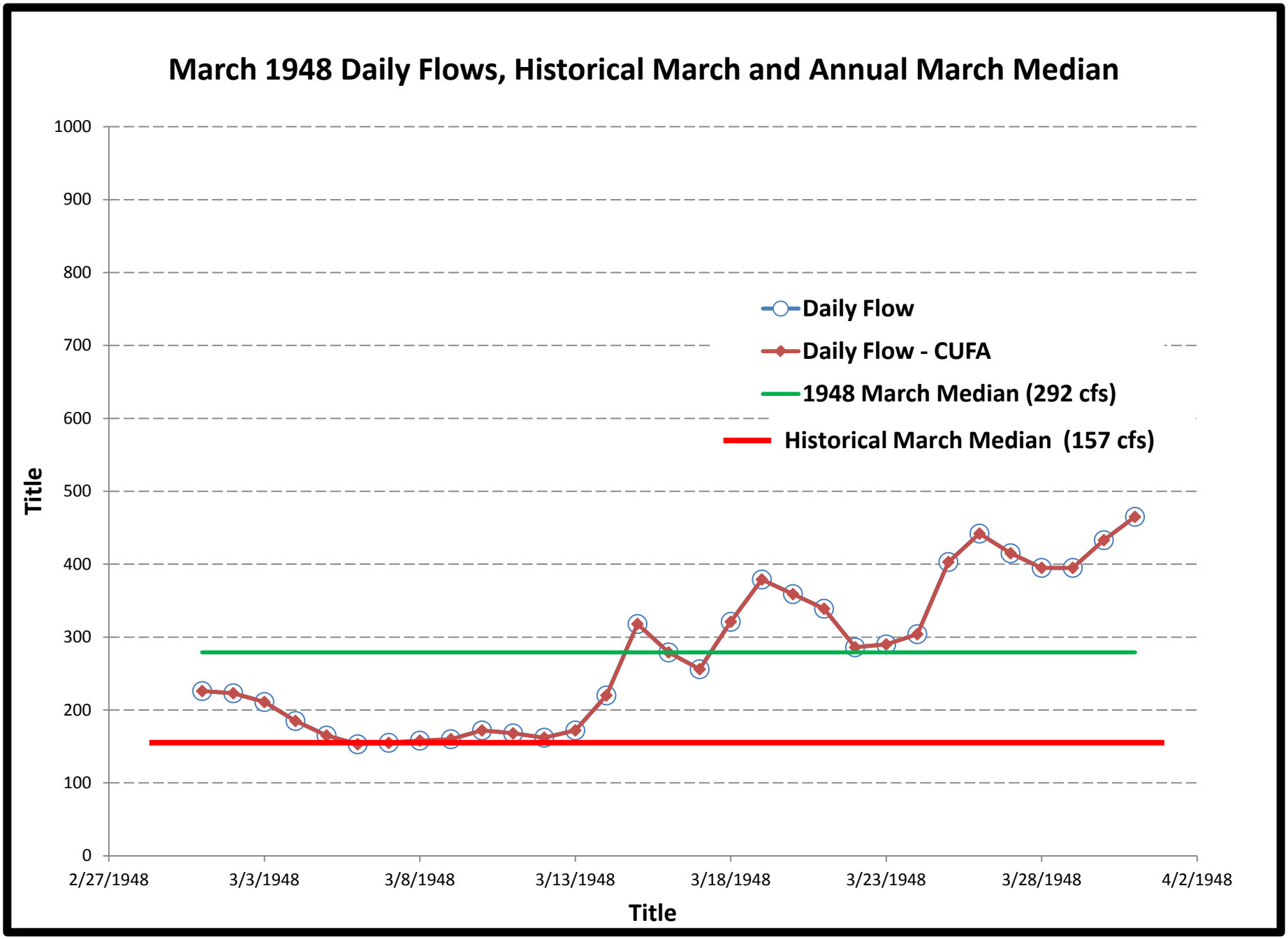

HISTOGRAM OF PEAK ANNUAL FLOWS, 1936 TO 2011
FREQUENCY
25
20
15
10
5
0
NO CUFA
WITH CUFA
100
200
300
400
500
600
700
800
900
1000
1500
2000
5000
10000
More
BIN (cfs)

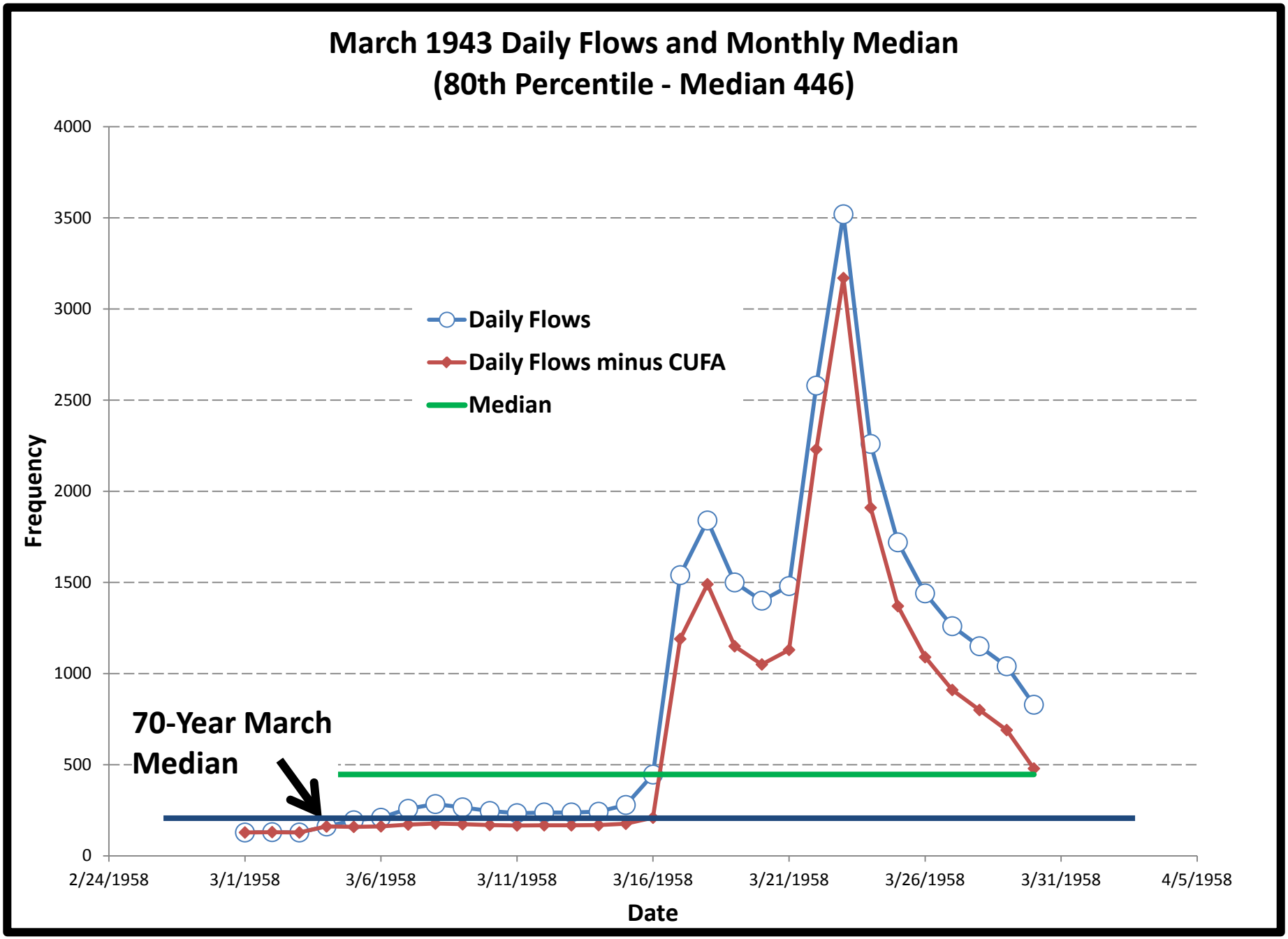
What does IHA tell us about CUFA diversions?

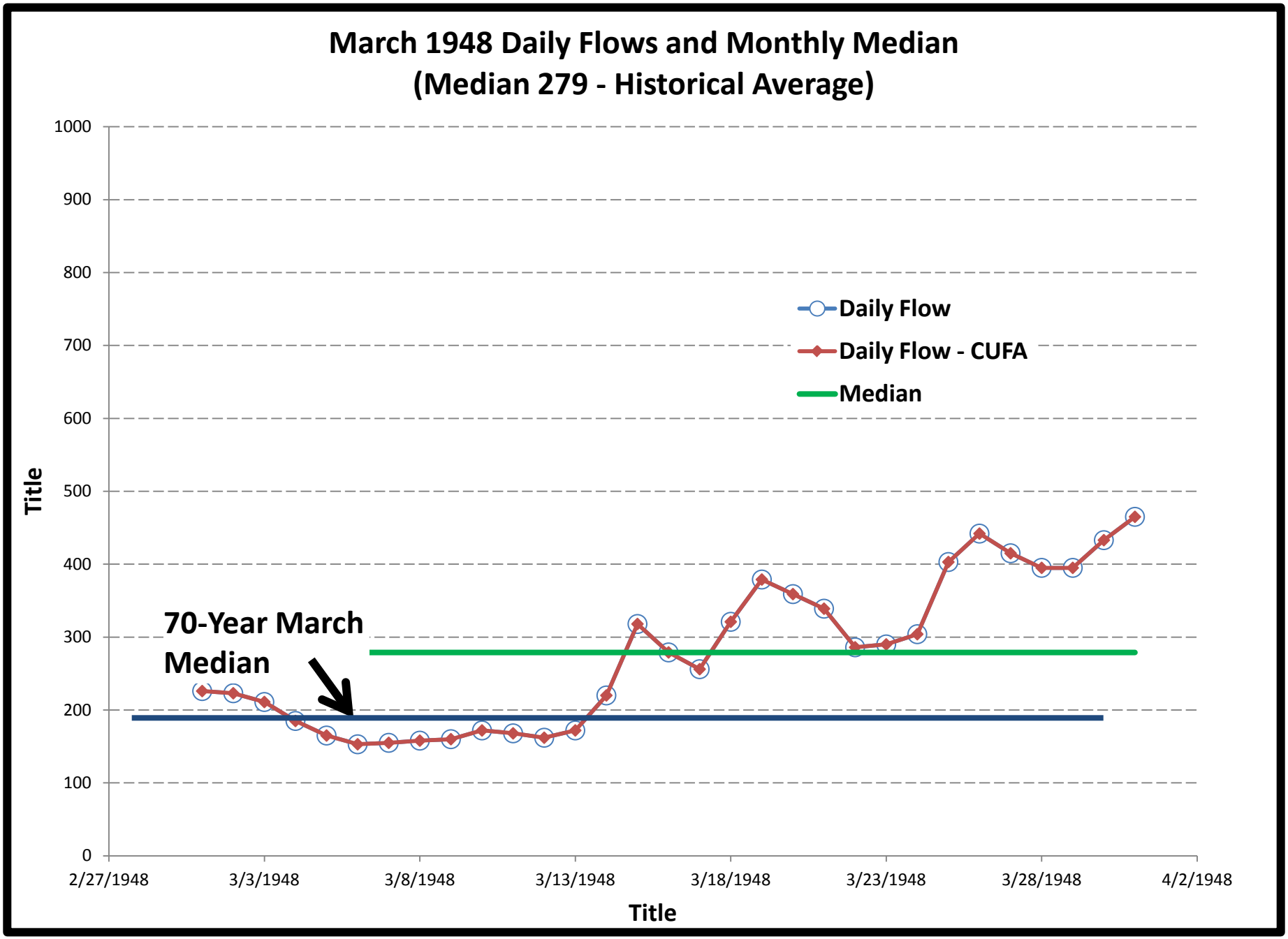
- No change to extreme low flows (150 cfs criterion)
- No change to low flows (150 cfs criterion)
- CUFA does not dry up the river (low flows not diverted)
- No change to **median monthly flows** except in March (March median flow: 189→159 cfs)
- High pulse events: **median peak** change 221→205 cfs
- Small floods: **median** peak change 2850→3072 cfs
- Large floods: **median** peak change 12100 →11930 cfs

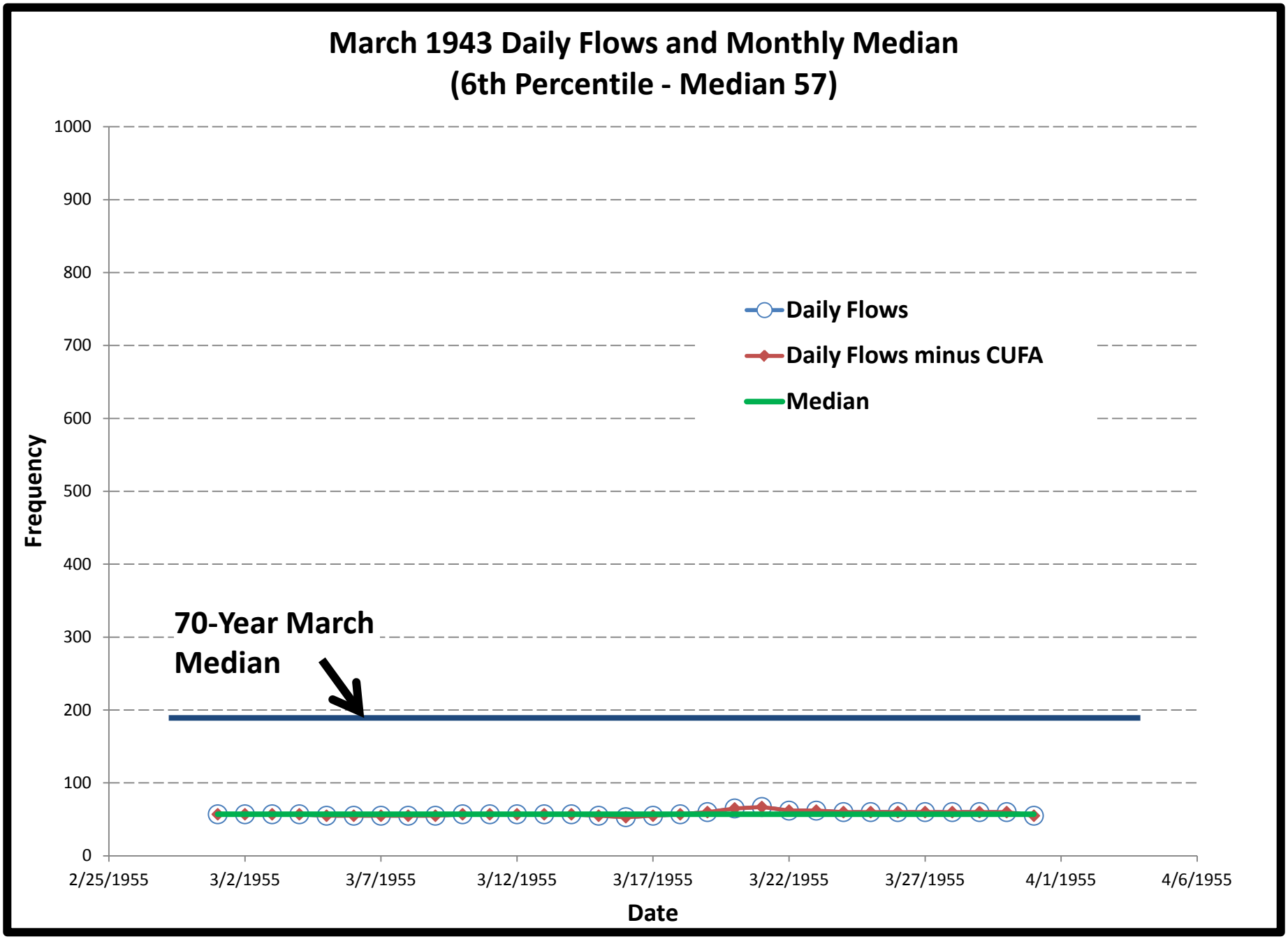

Histogram of March Medians, 1938 to 2001
Frequency
Bin
NO CUFA
WITH CUFA
NO CUFA %
WITH CUFA %
0
5
10
15
20
25
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
100
200
300
400
500
600
700
800
900
1000
More
22
22
13
19
9
10
5
4
3
1
2
3
6
4
1
0
2
2
2
0
0
0
68%
78%
92%
97%

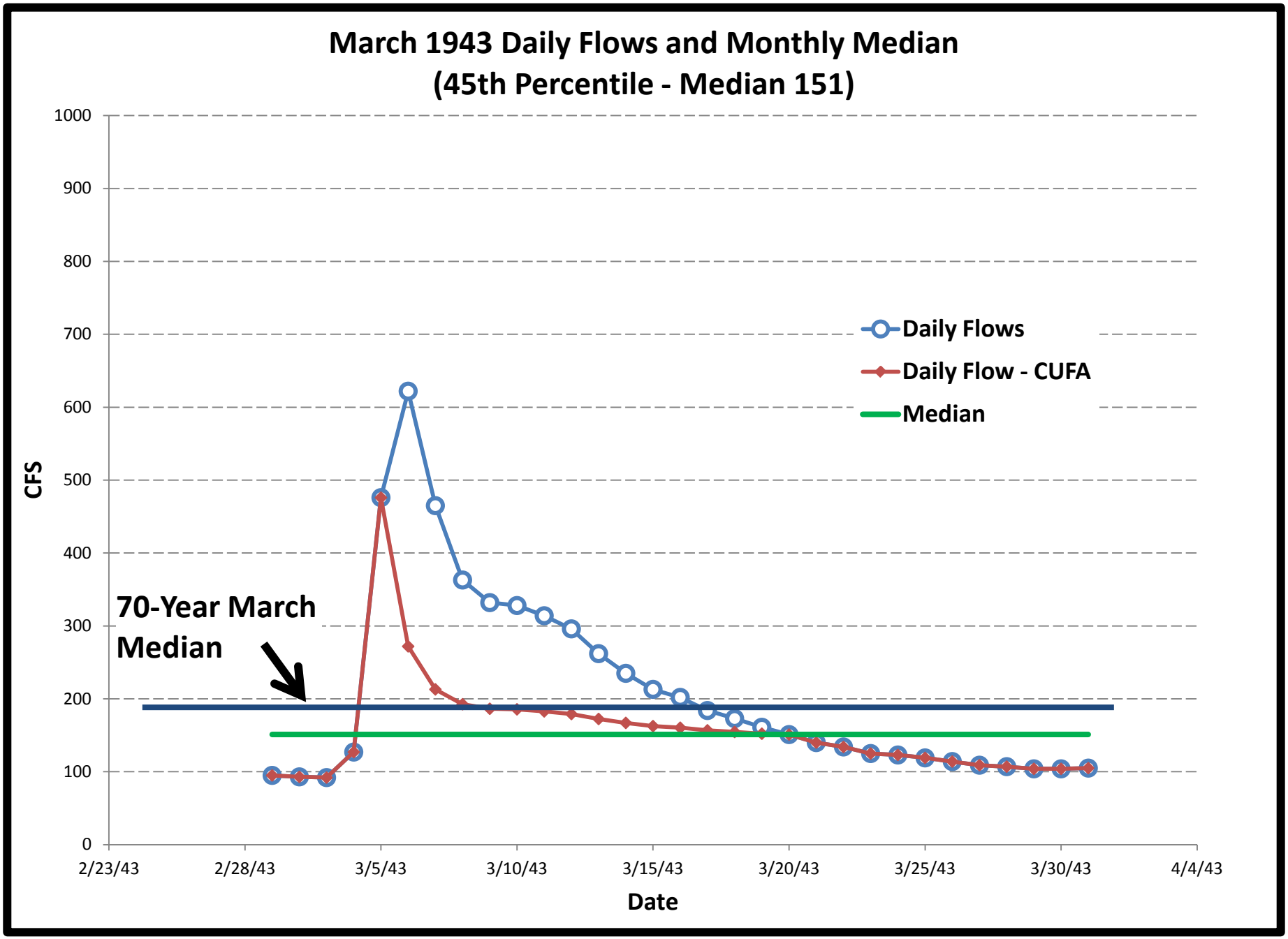

March 1943 Daily Flows, Historical March and Annual March Median
1000
900
800
700
600
500
400
300
200
100
0
CFS
2/23/43
2/28/43
3/5/43
3/10/43
3/15/43
3/20/43
3/25/43
3/30/43
4/4/43
Date
Daily Flows
Daily Flow - CUFA
1943 March Median (151 cfs)
Historical March Median (157 cfs)


March 1948 Daily Flows, Historical March and Annual March Median
1000
900
800
700
600
500
400
300
200
100
0
Title
2/27/1948
3/3/1948
3/8/1948
3/13/1948
3/18/1948
3/23/1948
3/28/1948
4/2/1948
Title
Daily Flow
Daily Flow - CUFA
1948 March Median (292 cfs)
Historical March Median (157 cfs)


March 1943 Daily Flows and Monthly Median
(80th Percentile - Median 446)
4000
3500
3000
2500
2000
1500
1000
500
0
Frequency
Daily Flows
Daily Flows minus CUFA
Median
70-Year March
Median
2/24/1958
3/1/1958
3/6/1958
3/11/1958
3/16/1958
3/21/1958
3/26/1958
3/31/1958
4/5/1958
Date


March 1948 Daily Flows and Monthly Median
(Median 279 - Historical Average)
1000
900
800
700
600
500
400
300
200
100
0
Title
Daily Flow
Daily Flow - CUFA
Median
70-Year March
Median
2/27/1948
3/3/1948
3/8/1948
3/13/1948
3/18/1948
3/23/1948
3/28/1948
4/2/1948
Title


March 1943 Daily Flows and Monthly Median
(6th Percentile - Median 57)
1000
900
800
700
600
500
400
300
200
100
0
Frequency
Daily Flows
Daily Flows minus CUFA
Median
70-Year March
Median
2/25/1955
3/2/1955
3/7/1955
3/12/1955
3/17/1955
3/22/1955
3/27/1955
4/1/1955
4/6/1955
Date


March 1943 Daily Flows and Monthly Median
(45th Percentile - Median 151)
1000
900
800
700
600
500
400
300
200
100
0
CFS
Daily Flows
Daily Flow - CUFA
Median
70-Year March
Median
2/23/43
2/28/43
3/5/43
3/10/43
3/15/43
3/20/43
3/25/43
3/30/43
4/4/43
Date

Evaluating Ecosystem Response to CUFA Diversions

Step 1: Characterize altered hydrograph

Step 2: Articulate flow-ecology relationships

a. Identify physical changes to hydrologic environment

b. Characterize ecological response to physical change

Step 3: Evaluate benefits/trade-offs, accept/mitigate/reject

Illustrative Scenarios, Cliff-Gila Reach 1

- Scenario 1: CUFA Diversions, 13,500 acre feet simulated
- Scenario 2: CUFA + 30% Increase in Irrigation
- Scenario 3: CUFA + 30% Increase in Riparian Vegetation

Illustrative Scenarios, Cliff-Gila Reach 1

- Scenario 1: CUFA Diversions, 13,500 acre feet simulated
- Scenario 2: CUFA and 30% Increase in Irrigated Agriculture
- Scenario 3: CUFA and 30% Increase in Riparian Vegetation

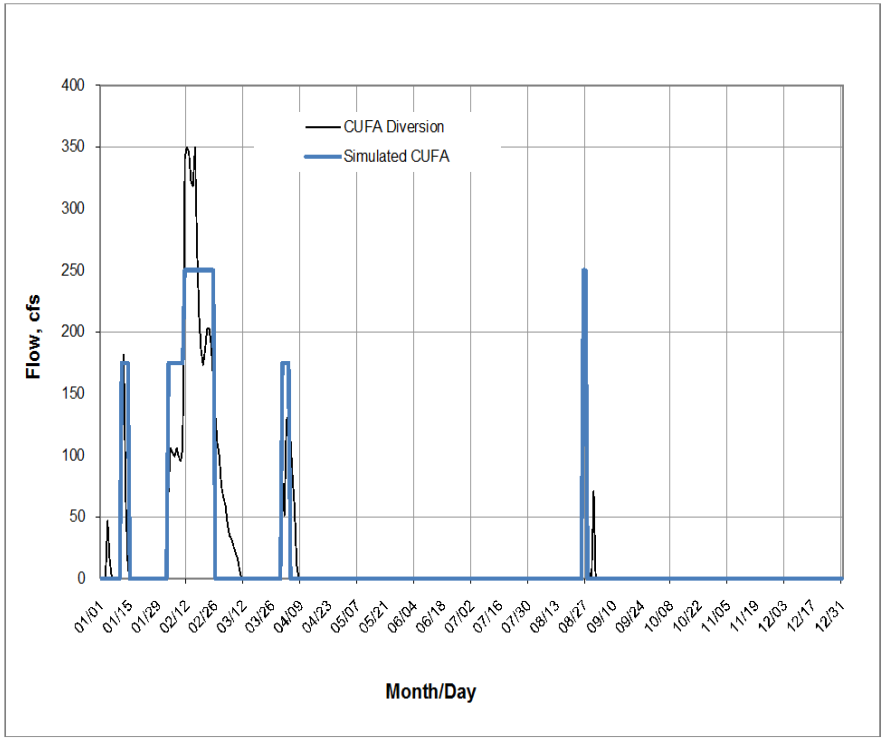
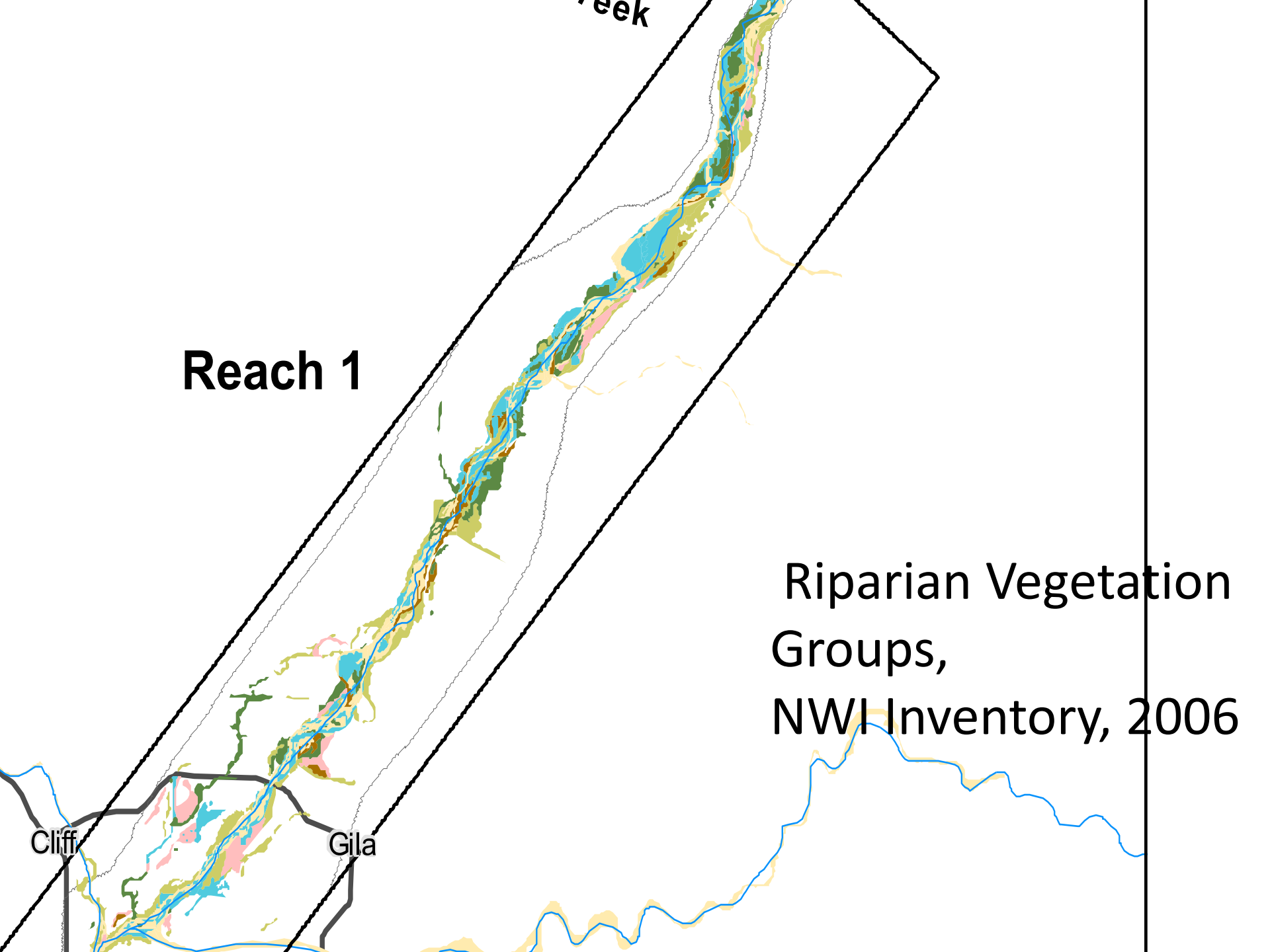


Figure 4.1. CUFA Diversion and Adjusted Step-Function Approximation


Reach 1
Riparian Vegetation Groups,
NWI Inventory, 2006
Cliff
Gila

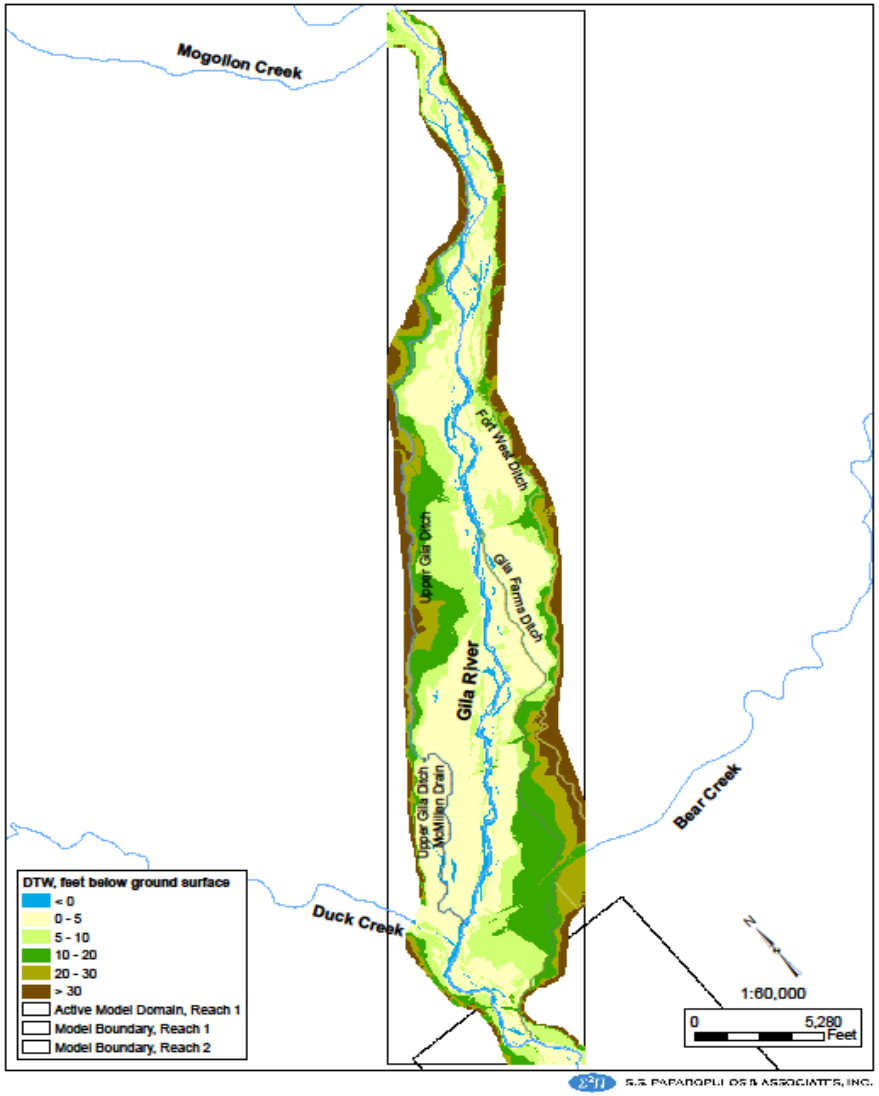


Figure 3.2. Depth to Groundwater, Post-Winter Run-off, Baseline Condition

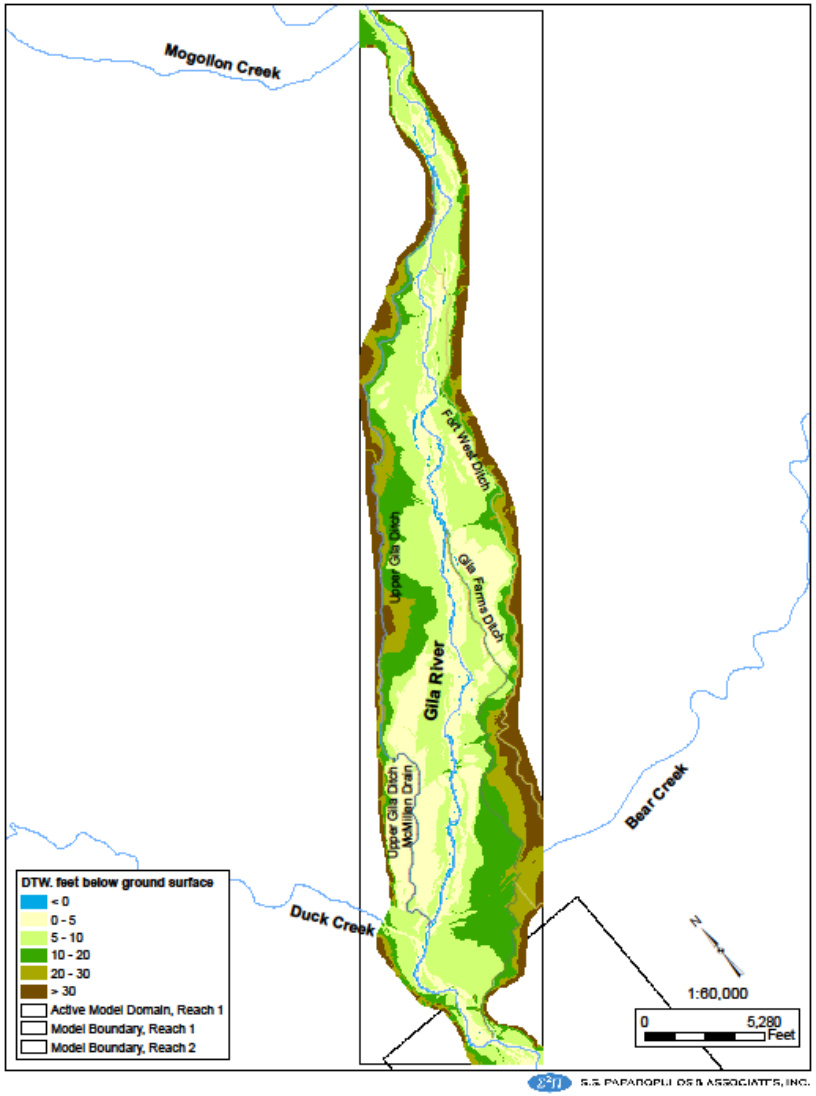


Figure 3.3. Depth to Groundwater, Summer Dry Period, Baseline Condition

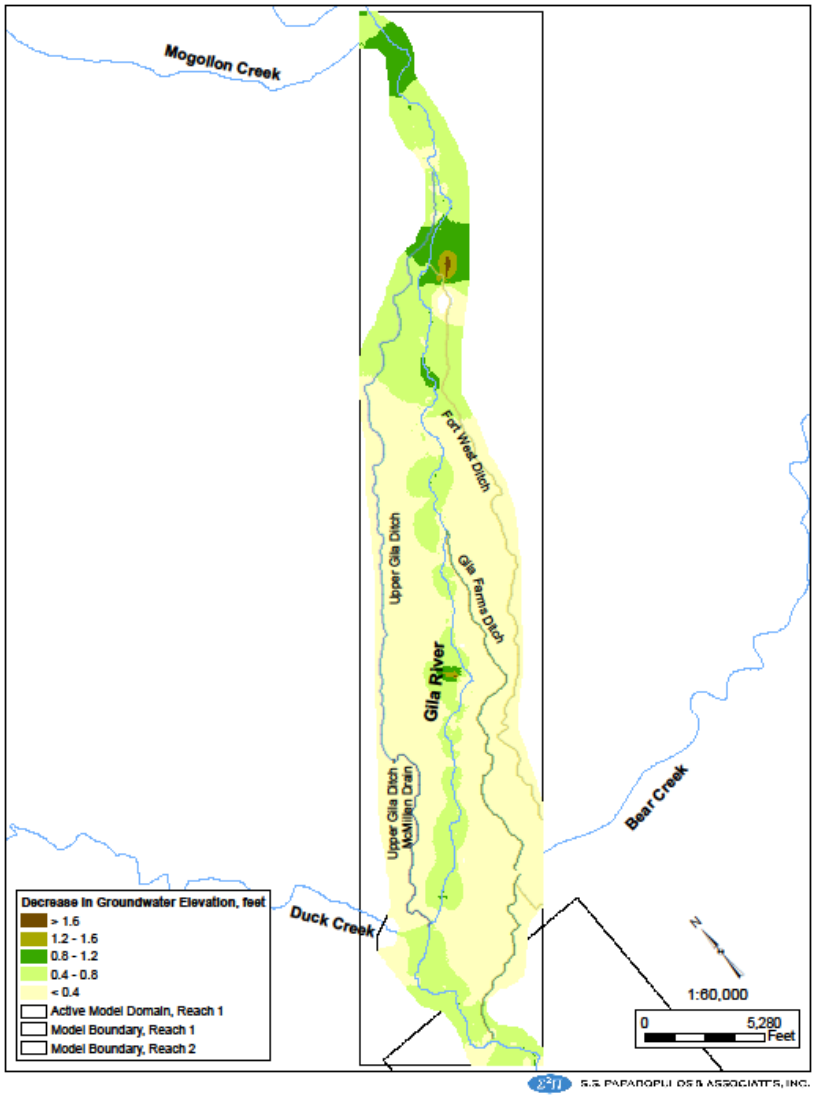


Figure 4.4. Decrease in Groundwater Elevations, Post-Winter Run-off, Scenario 1

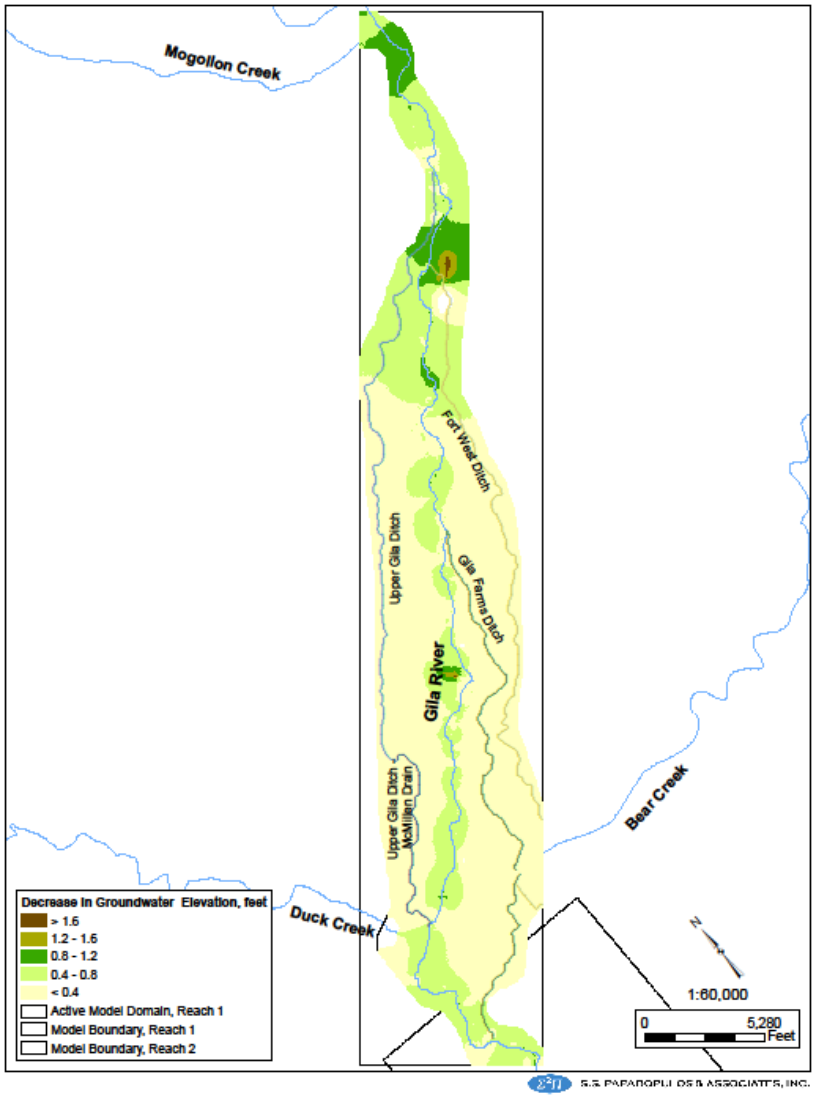


Figure 4.6. Decrease in Groundwater Elevations, Post-Winter Run-off, Scenario 2

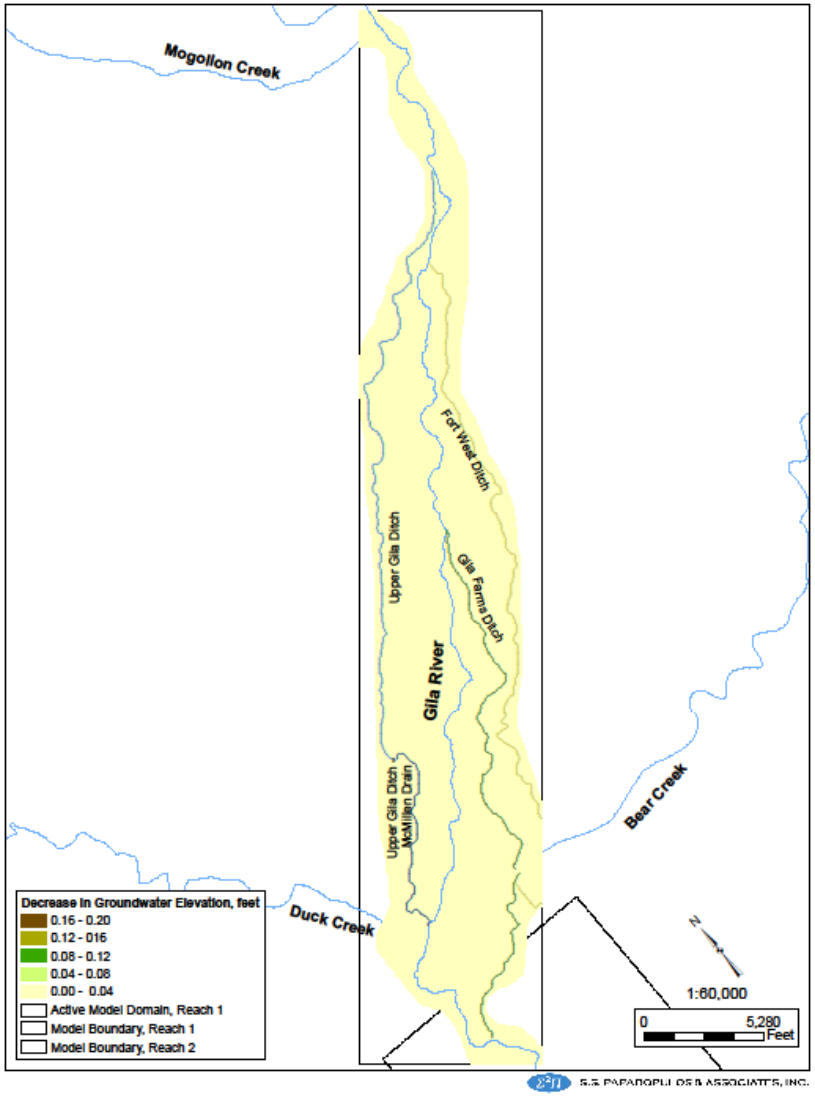


Figure 4.5. Decrease in Groundwater Elevations, Summer Dry Period, Scenario 1

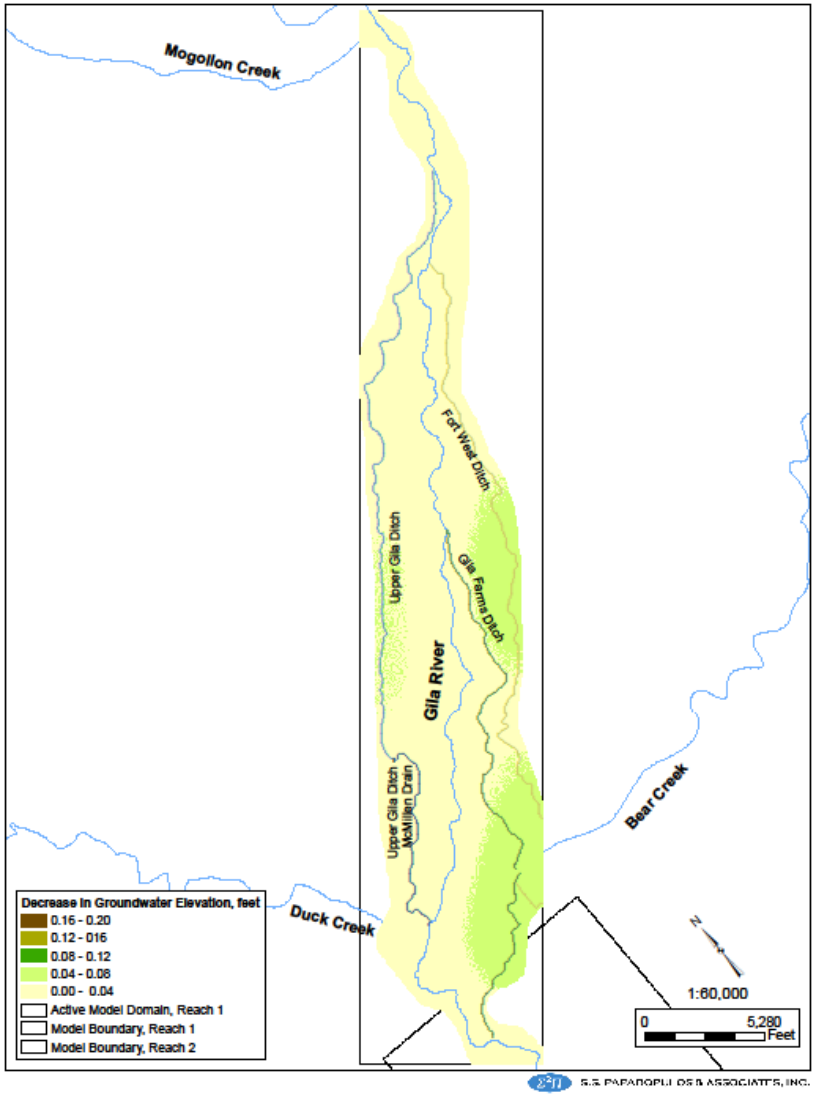


Figure 4.7. Decrease in Groundwater Elevations, Summer Dry Period, Scenario 2

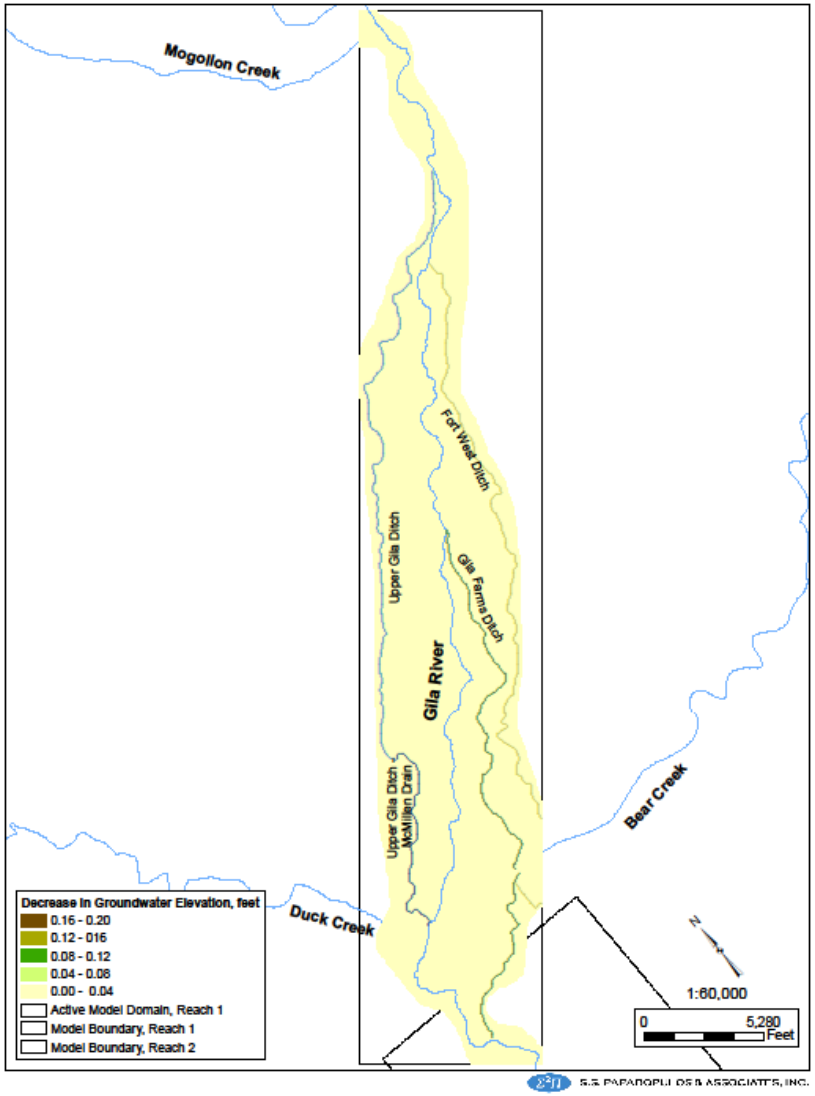


Figure 4.5. Decrease in Groundwater Elevations, Summer Dry Period, Scenario 1

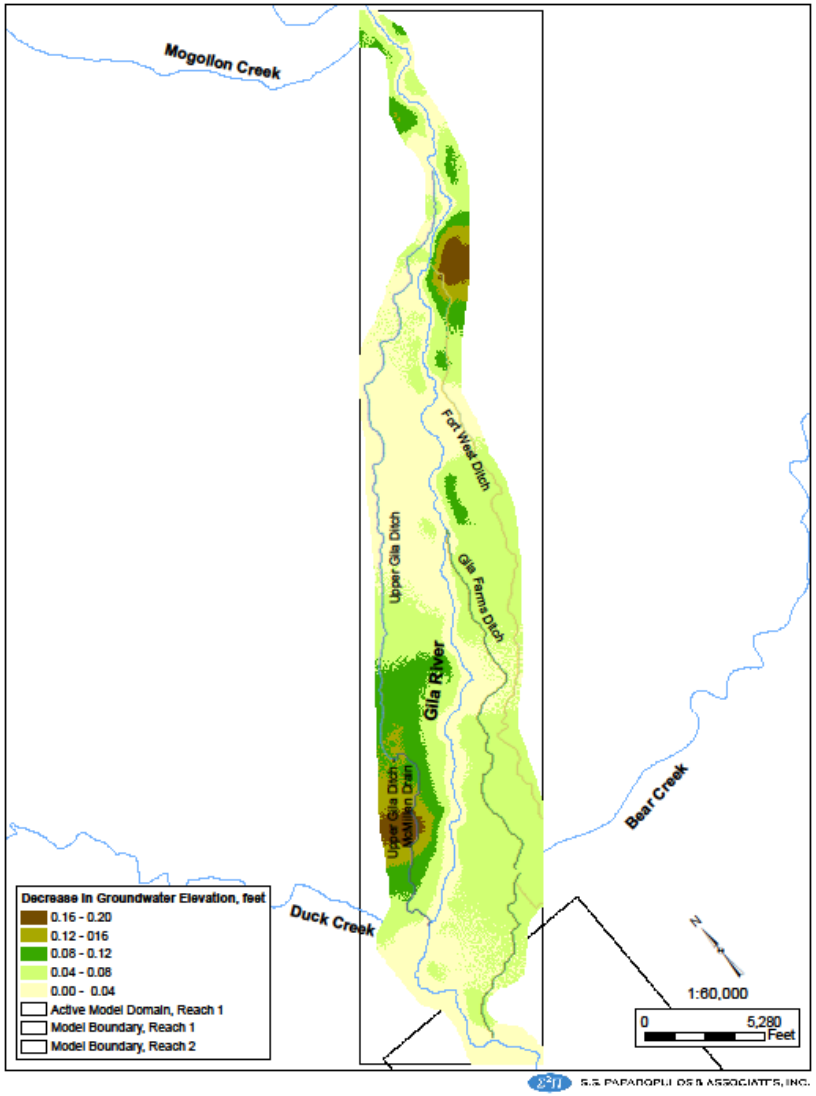
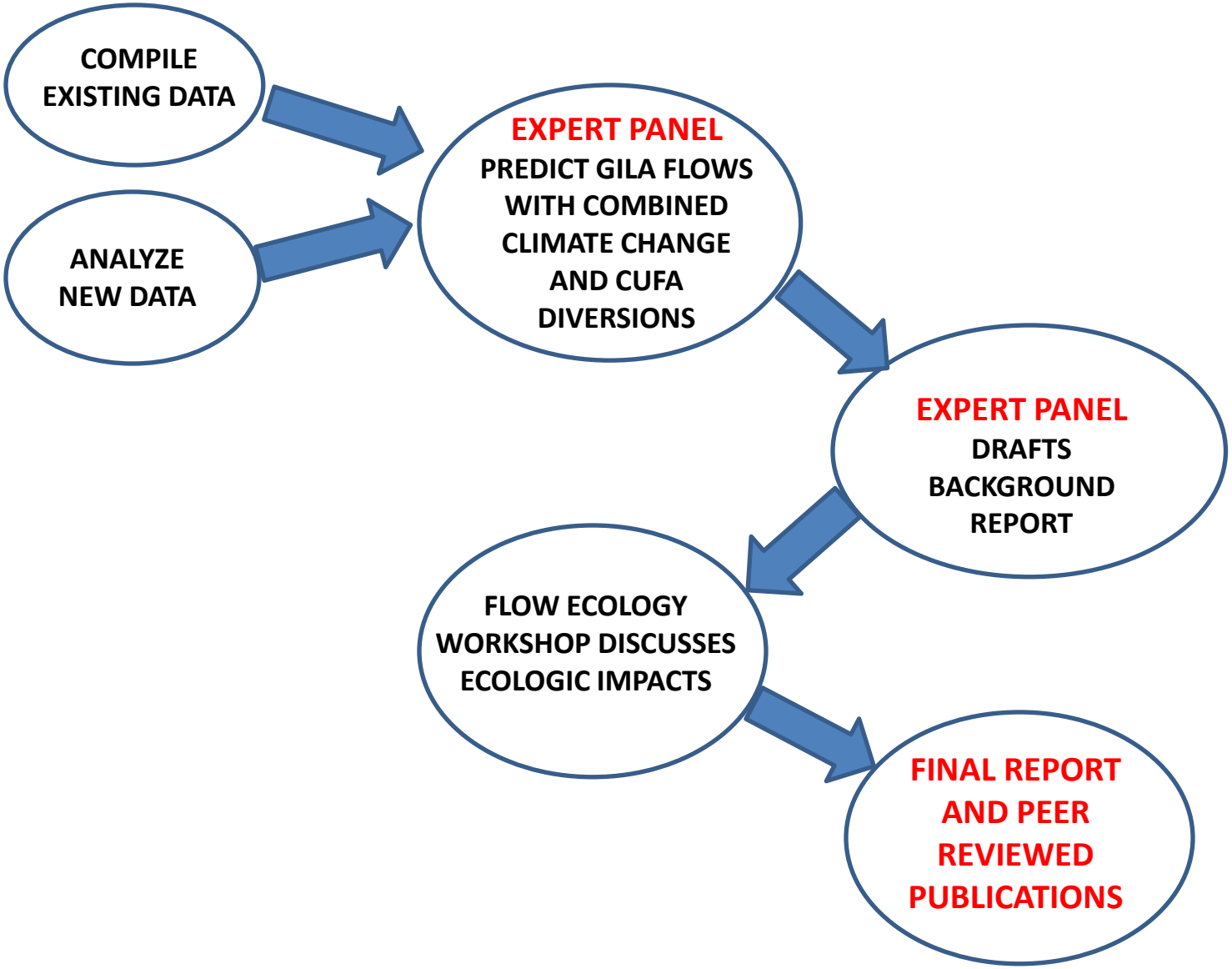


Figure 4.9. Decrease in Groundwater Elevations, Summer Dry Period, Scenario 3

ASSESSING THE ECOLOGIC IMPACT WITH IHA:



"As illustrated by our case study, the IHA method is extremely useful in drawing attention to aspects of a hydrologic regime altered by various types of human influence such as dams and ground water pumping. **Elucidation of hydrologic alterations alone, however, says little about the nature or degree to which biologic patterns and processes may degrade in response to such alterations. The tough work of interpreting and documenting species-or community-specific responses to hydrologic changes remains."**

— Richter et al. (1996)