Brazos River Authority

Application of HEFR at Brazos River at Richmond

Implementation and Suggested Improvements

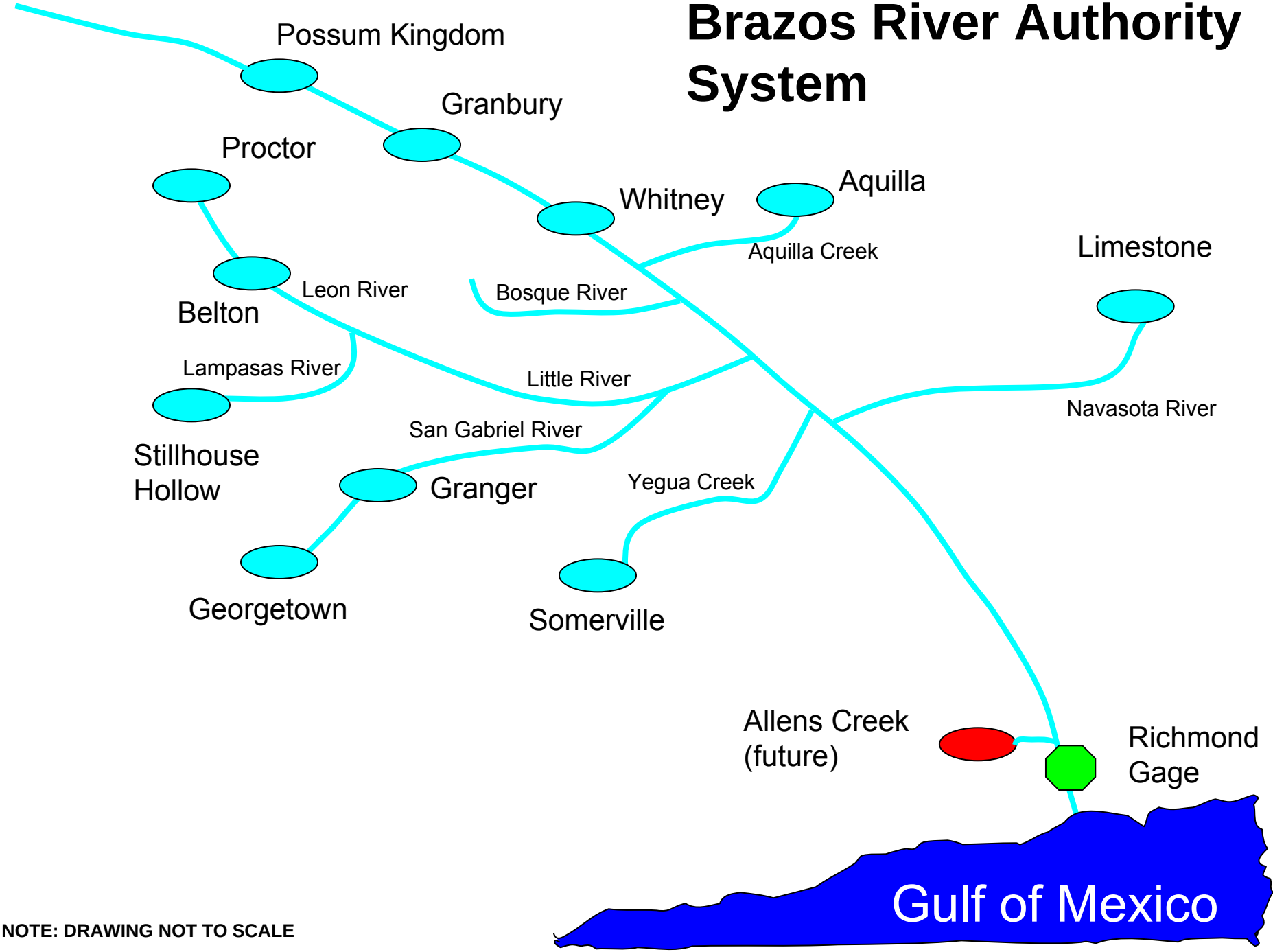
Presented to the Trinity and San Jacinto Rivers and Galveston Bay Basin and Bay Expert Science Team

April 8, 2009

Overview

- BRA system
- Development of instream flow regime statistics for the Brazos
- Application of HEFR
  - Qualifying high flow pulse events
  - Interaction of HFP events and water diversions
  - Frequency criteria
- Summary and recommendations

Brazos River Authority System



NOTE: DRAWING NOT TO SCALE

Flow Regime Statistics

- Statistics jointly developed by TPWD, TCEQ and BRA
- Consistent with flow regime approach of the TIFP
- Intended as a interim criteria until instream flow studies completed

HEFR Flow Regime Statistics

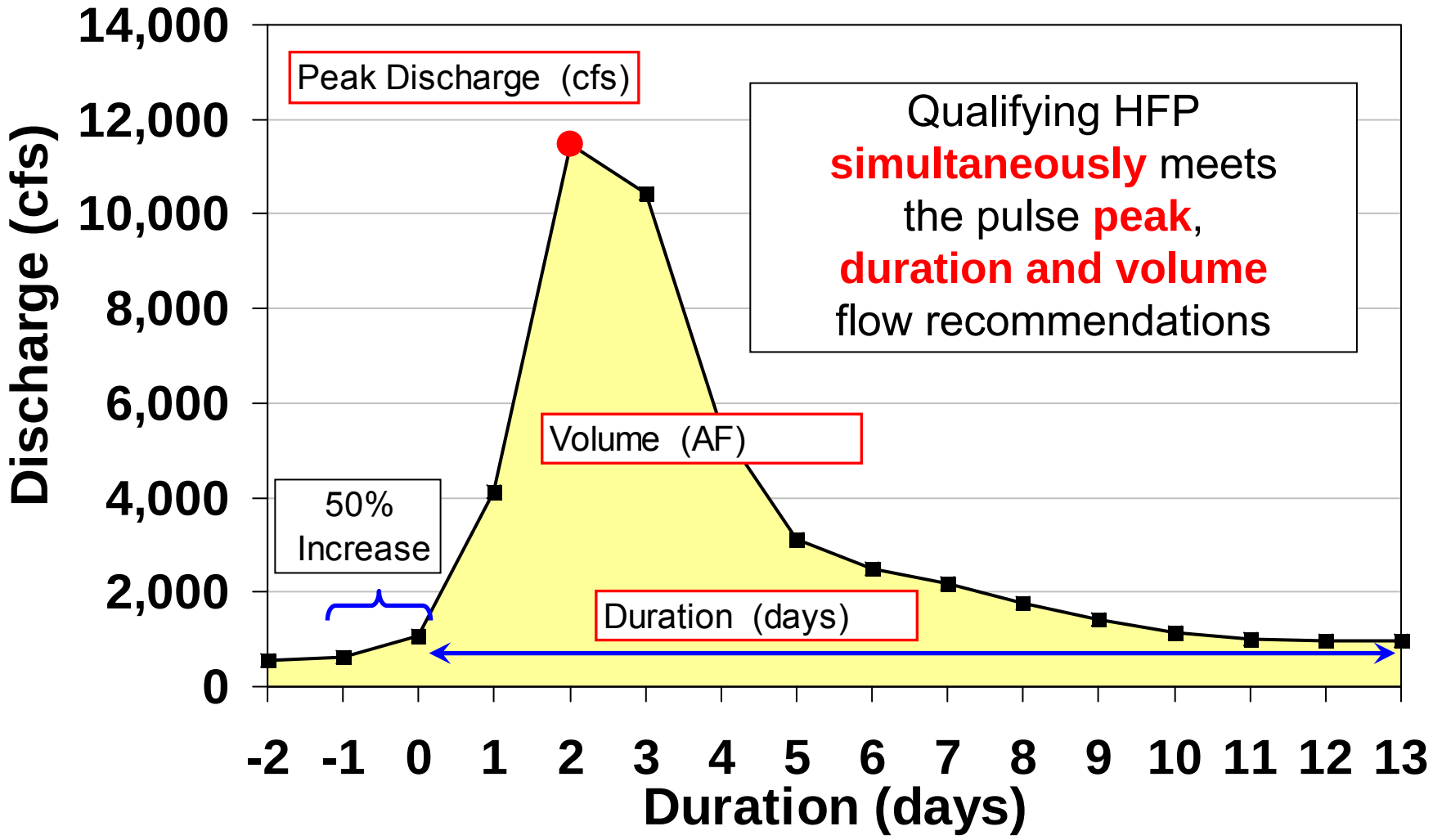
Brazos River at Richmond 1923-1959

Overbank Flows	Return Period (R) : 0.7 (years)						Duration (D) : 36 (days)					
	Volume (V) : 1,622,698 (ac-ft)						Peak Flow (Q) : 61,600 (cfs)					
High Flow Pulses	F: 1 D: 16			F: 1 D: 13			F: 1 D: 12			F: 1 D: 11		
	Q: 19,500 V: 297,551			Q: 19,150 V: 270,154			Q: 15,300 V: 166,116			Q: 13,175 V: 146,867		
	F: 1 D: 8			F: 1 D: 7			F: 1 D: 7			F: 1 D: 7		
	Q: 9670 V: 90,288			Q: 10200 V: 101,405			Q: 8830 V: 77,177			Q: 7730 V: 56,162		
	F: 1 D: 6			F: 1 D: 5			F: 1 D: 4			F: 1 D: 4		
	Q: 3748 V: 36,266			Q: 5640 V: 44,668			Q: 4880 V: 38,182			Q: 2500 V: 22,458		
Base Flows (cfs)	2,955			3,670			2,635			2,038		
	1,630			2,030			1,450			1,150		
	885			1,170			930			760		
Subsistence Flows (cfs)	460 (7Q2 743 cfs)			408 (7Q2 743 cfs)			359 (7Q2 743 cfs)			403 (7Q2 743 cfs)		
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
	Winter			Spring			Summer			Fall		

Hydrologic Conditions
Wet
Average
Dry
Subsistence

High Flow Pulse Characteristics
F = Frequency (per season)
D = Duration (days)
Q = Peak Flows (cfs)
V = Volume (ac-ft)

Qualifying High Flow Pulse Event Conceptual Description



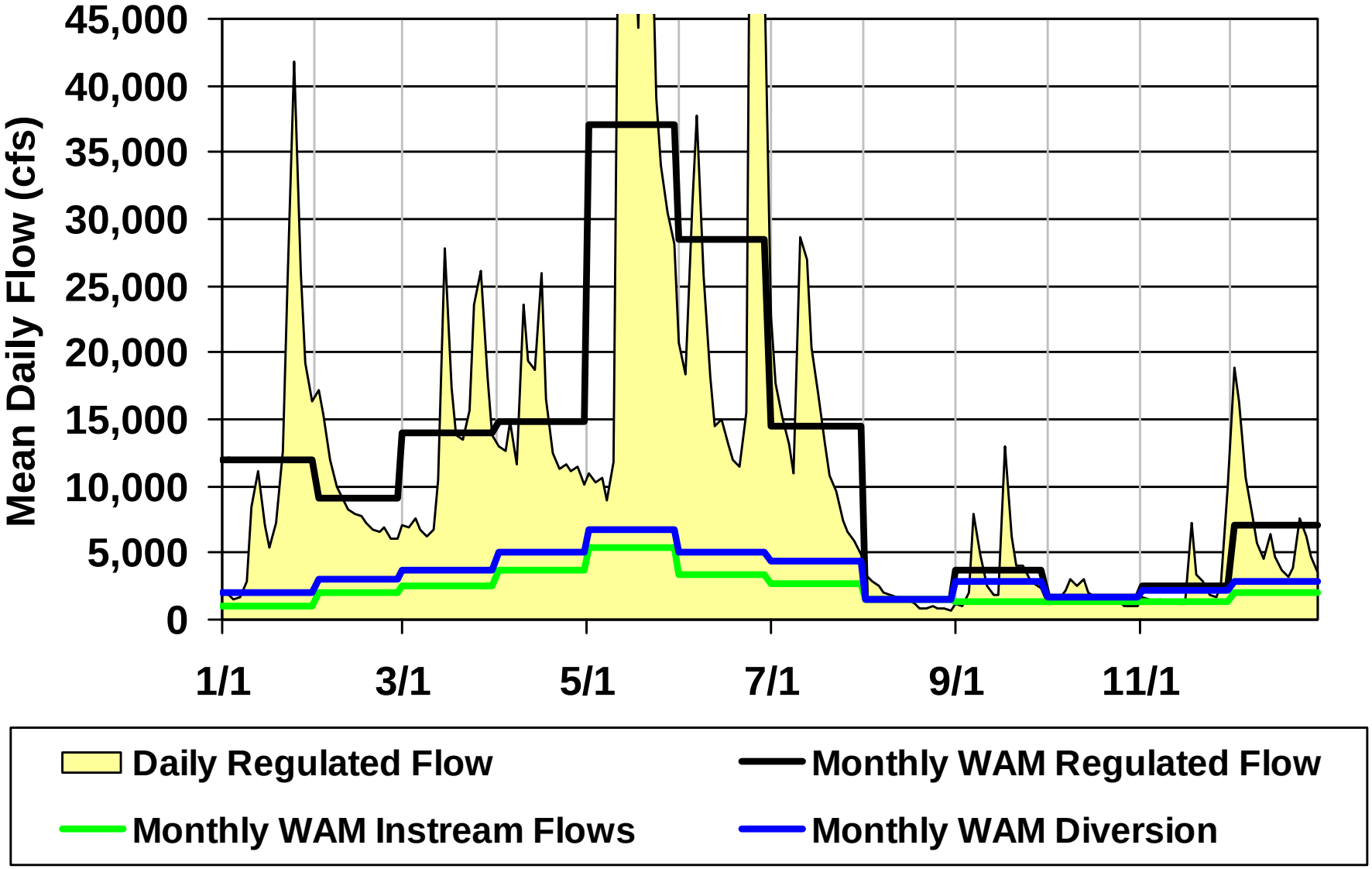
WAM Modeling

Brazos River at Richmond 1940 -1997

- Brazos WAM Run 3 modified to include
  - Return flows from BRA sources
  - System diversions at Richmond
    - 111,574 af/yr firm
    - 670,000 af/yr interruptible
- Daily flows
  - Regulated flows before system diversion
  - Distributed to daily using historical percentage of monthly flow
  - Appropriated flow reserved for senior rights

Regulated Flows at Brazos River at Richmond

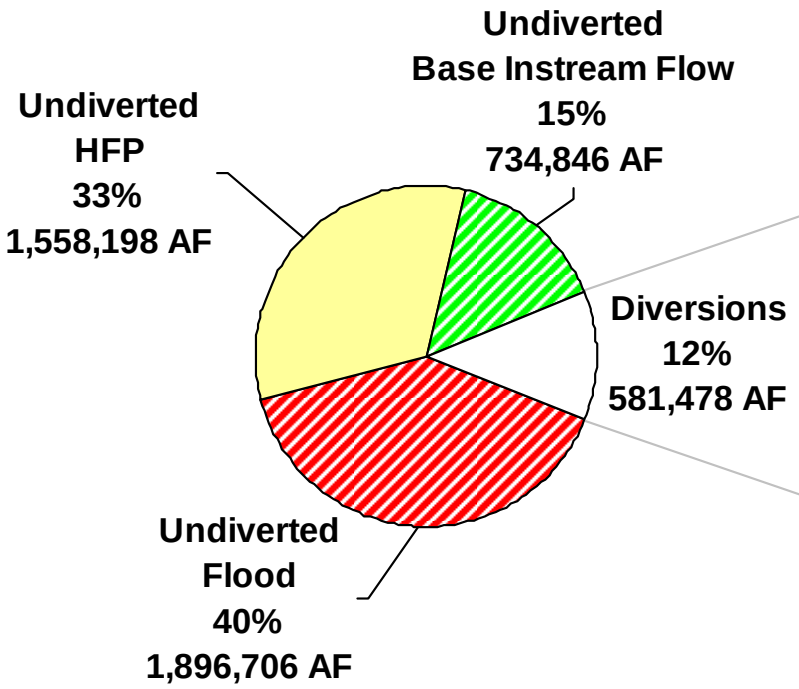
Calendar Year 1968



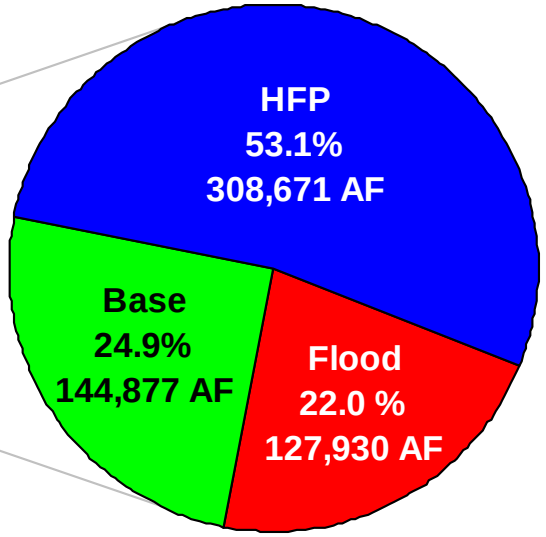
Average Annual Diversion of Run-of-River Streamflow

Brazos River at Richmond 1940 -1997

Average Annual Regulated Streamflow 4,771,228 AF

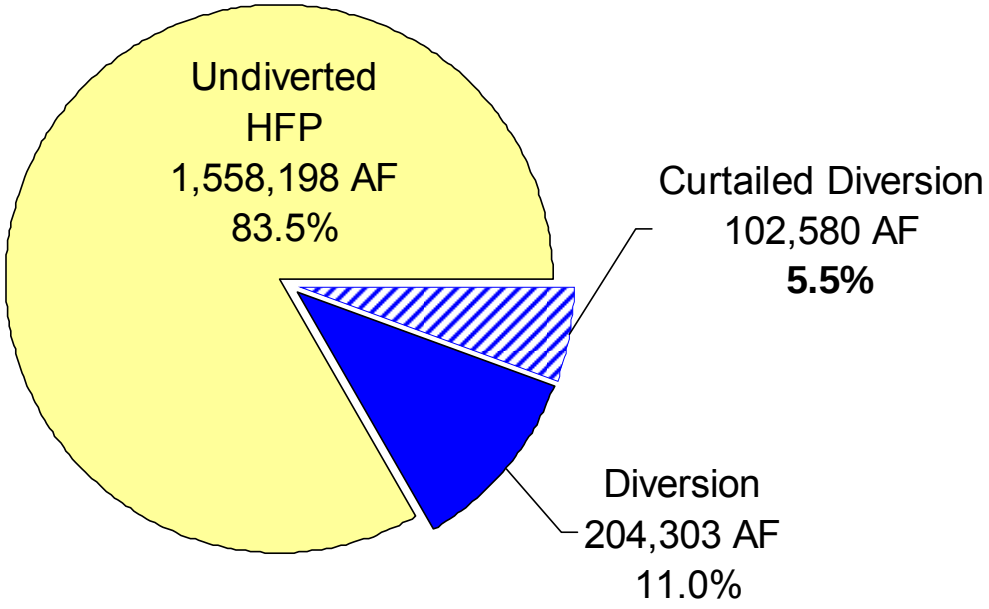


Average Annual Run-of-river Diversion 581,478 AF

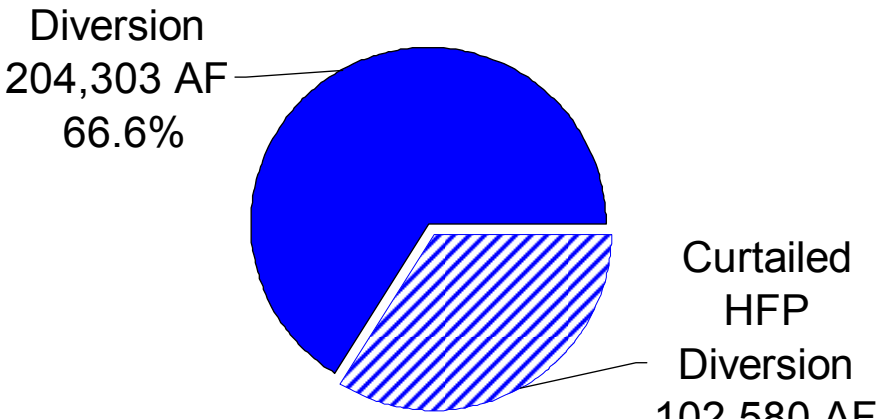


Average Annual Impacts of Diversions on HFP Volume

Brazos River at Richmond 1940 – 1997



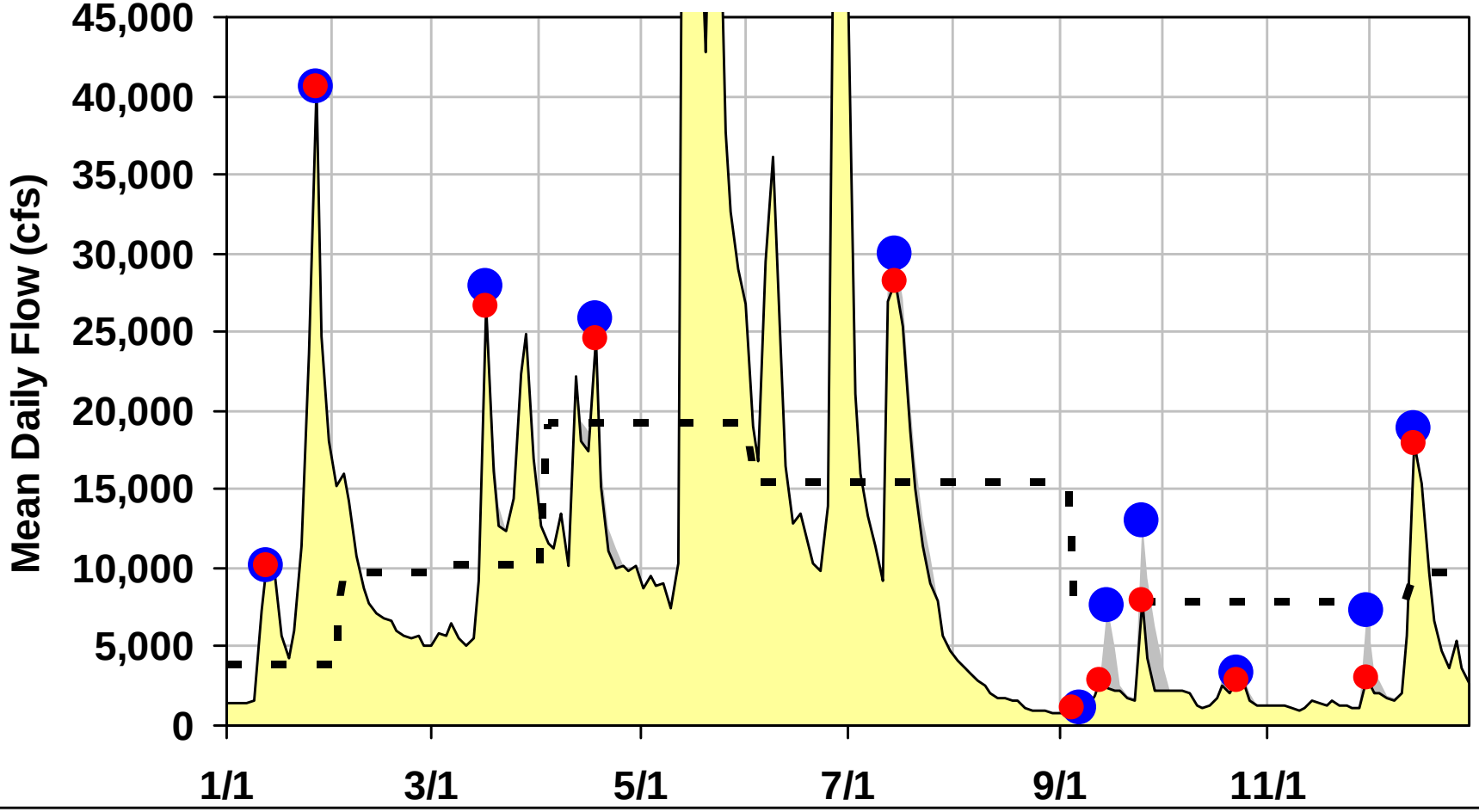
Continued diversion during HFP events impact pulse volume 5.5%.



Curtailment during HFP events impact diversions 33.4%.

Impact of Diversions on HFP Peak

Calendar Year 1968



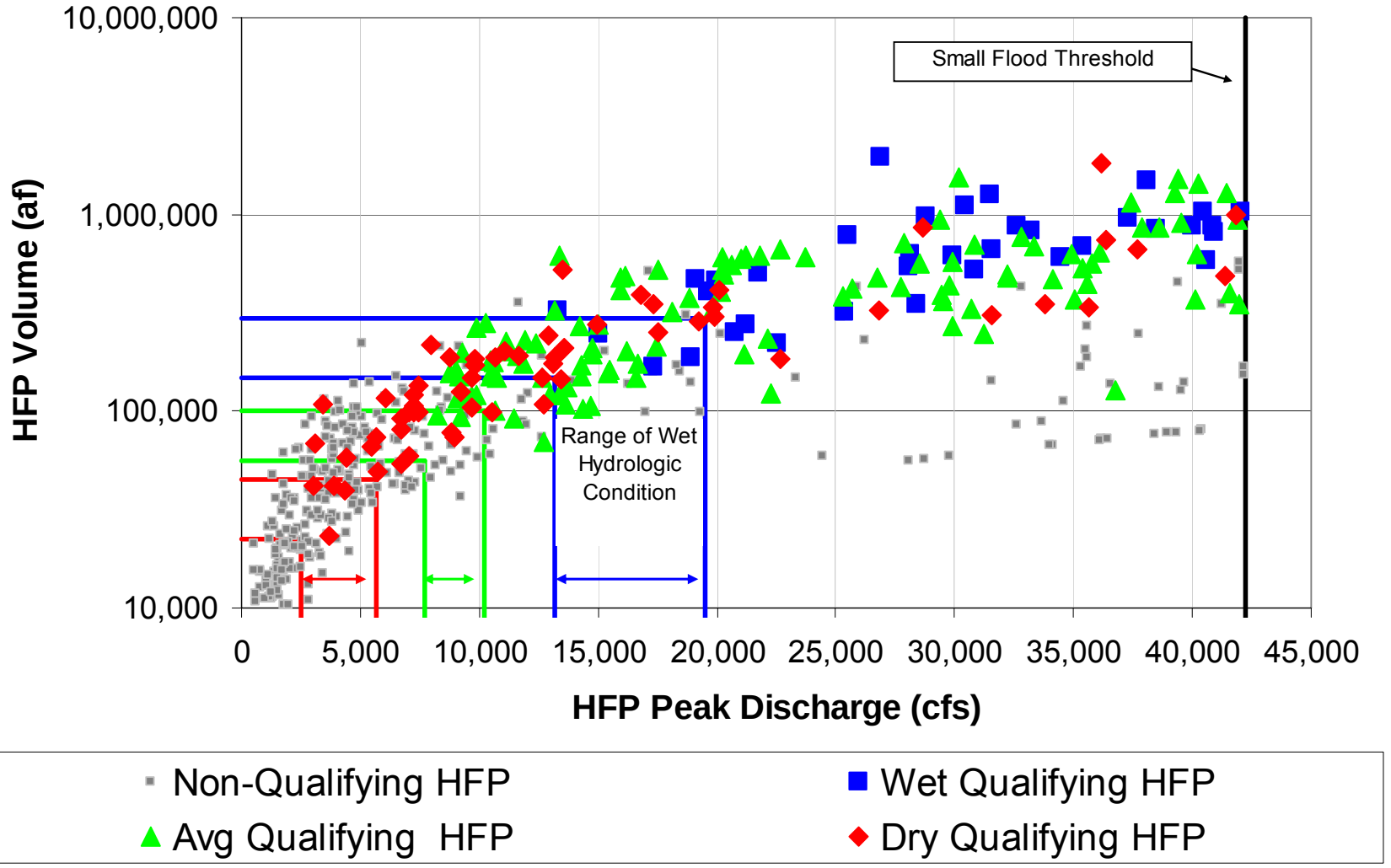
Impact of Diversions to Occurrence of HFP

Brazos River at Richmond 1940 - 1997

Diversion Rate Threshold (cfs)	HFP Events that Meet Peak Criteria	Total HFP Events	Flood Events
Curtailed HFP Diversion (number of events)	250	584	72
Continued HFP Diversion (number of events)	230	567	72
Impact to Occurrence (number of events)	20	17	0
Impact to Occurrence (%)	8%	2.9%	0%
Return Period of Impacts (years)	2.9	3.4	N/A

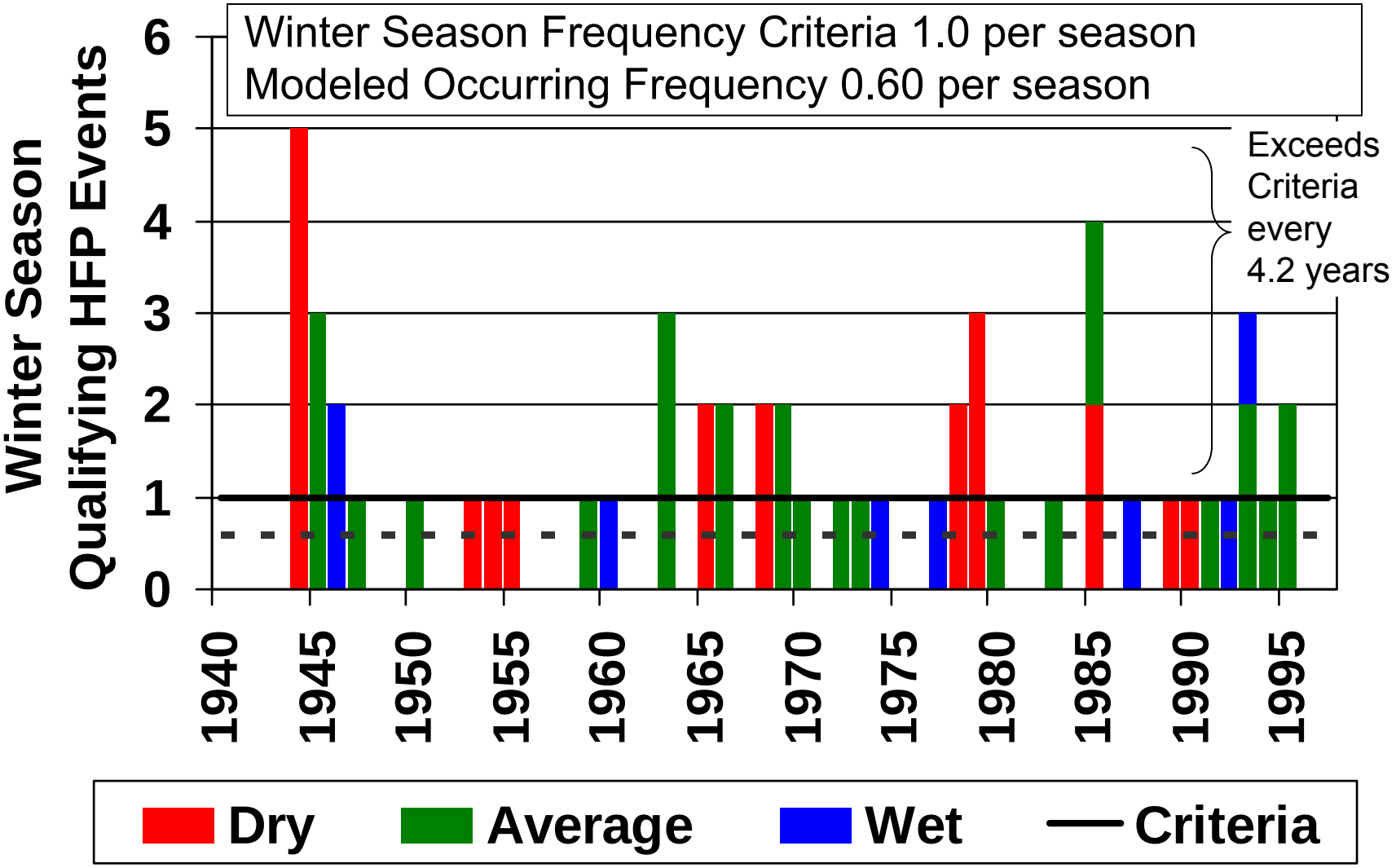
Qualifying HFP By Hydrologic Condition

Brazos River at Richmond 1940 – 1997



Winter Season Qualifying HFP Frequency

Brazos River at Richmond 1940 – 1997 (Regulated Flows)



Summary

- Methodology is complex – implementation even more so
- Aggregated criteria increase complexity of application with minimal benefit to the environment
- Pulses are a significant source of water

Recommendations

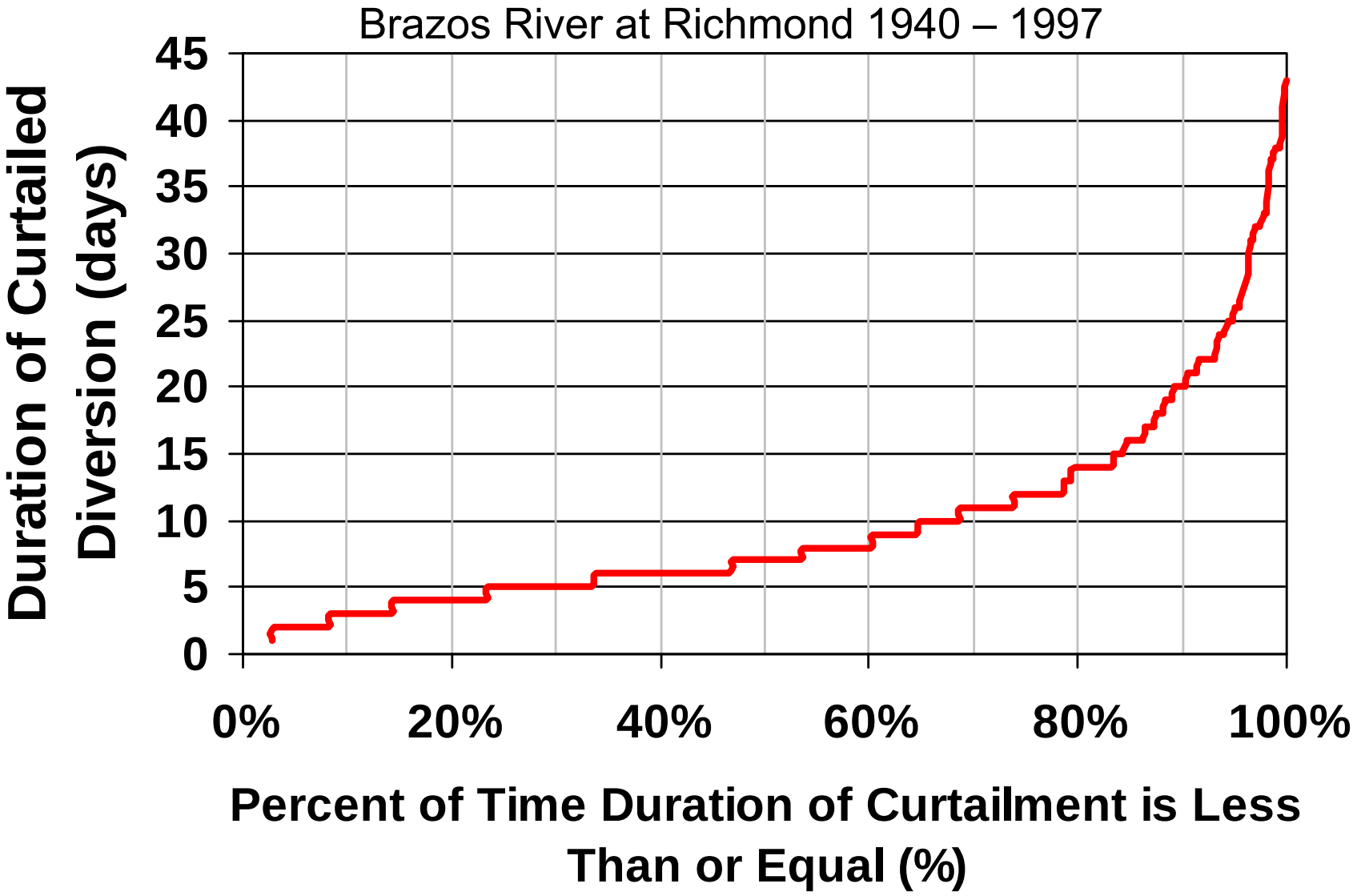
- Methodology is complex – implementation even more so
  - Consider simplifying; are hydrologic conditions (wet, average, dry) needed to characterize HFP criteria?

Recommendations

- Over-constraining criteria increase complexity of implementation with minimal benefit to the environment
  - Consider relaxing criteria, such as meeting one of the three criteria to qualify
- Pulses are a significant source of water
  - Consider a diversion rate threshold, below which the Qualifying HFP criteria do not apply
  - The frequency distribution should incorporate multi-year variability (return period) and the corresponding accounting

Questions?

Duration of Curtailed Diversion During HFP



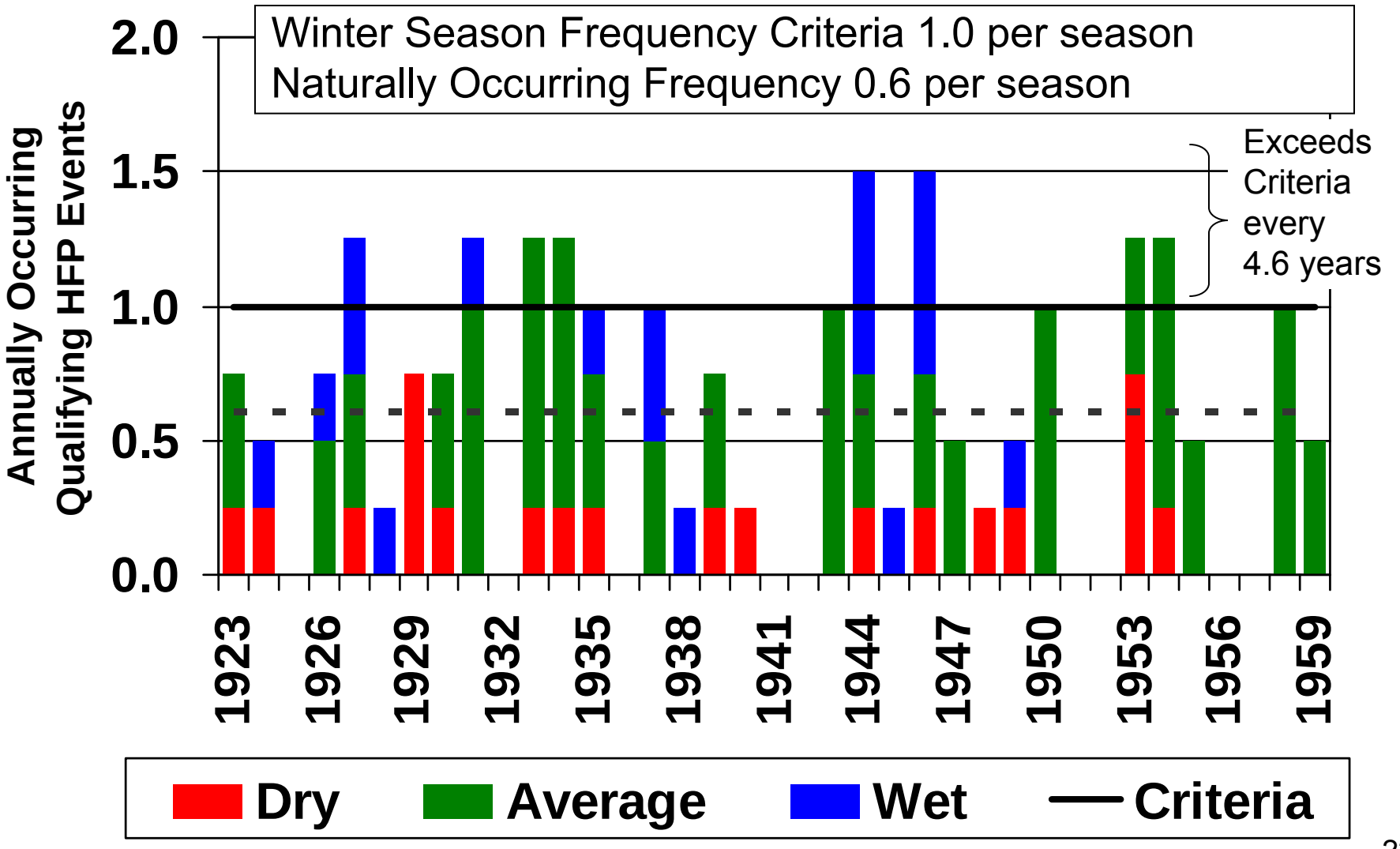
Qualifying HFP Frequency

Brazos River at Richmond 1940 – 1997 (Regulated Flows)

	Winter	Spring	Summer	Fall
Frequency Criteria (per season)	1.00	1.00	1.00	1.00
Frequency of Occurrence (per season)	0.60	0.66	0.50	0.71
Return Period of Occurrence (years)	1.66	1.45	2.00	1.41
Return Period of Exceeding Criteria (years)	4.46	3.41	6.44	3.22

Winter Season Qualifying HFP Frequency

Brazos River at Richmond 1923 – 1959 (Pre-Dam)



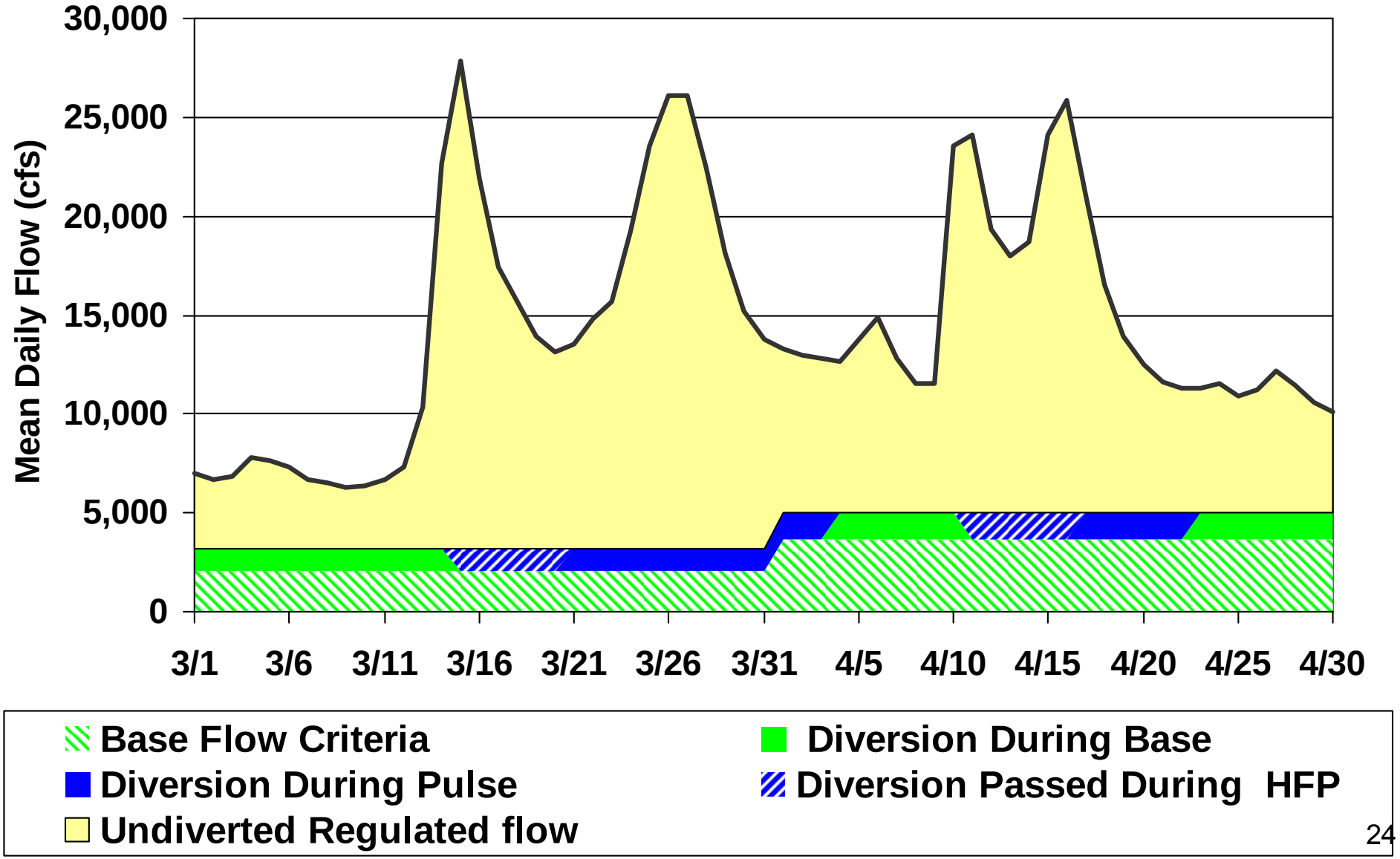
Qualifying HFP Frequency

Brazos River at Richmond 1923 – 1959 (Pre-Dam)

	Winter	Spring	Summer	Fall
Frequency Criteria (per season)	1.00	1.0	1.0	1.0
Frequency of Occurrence (per season)	0.6	0.6	0.5	0.5
Return Period of Occurrence (years)	1.6	1.6	2.0	2.0
Return Period of Exceeding Criteria (years)	4.6	5.3	9.3	7.4

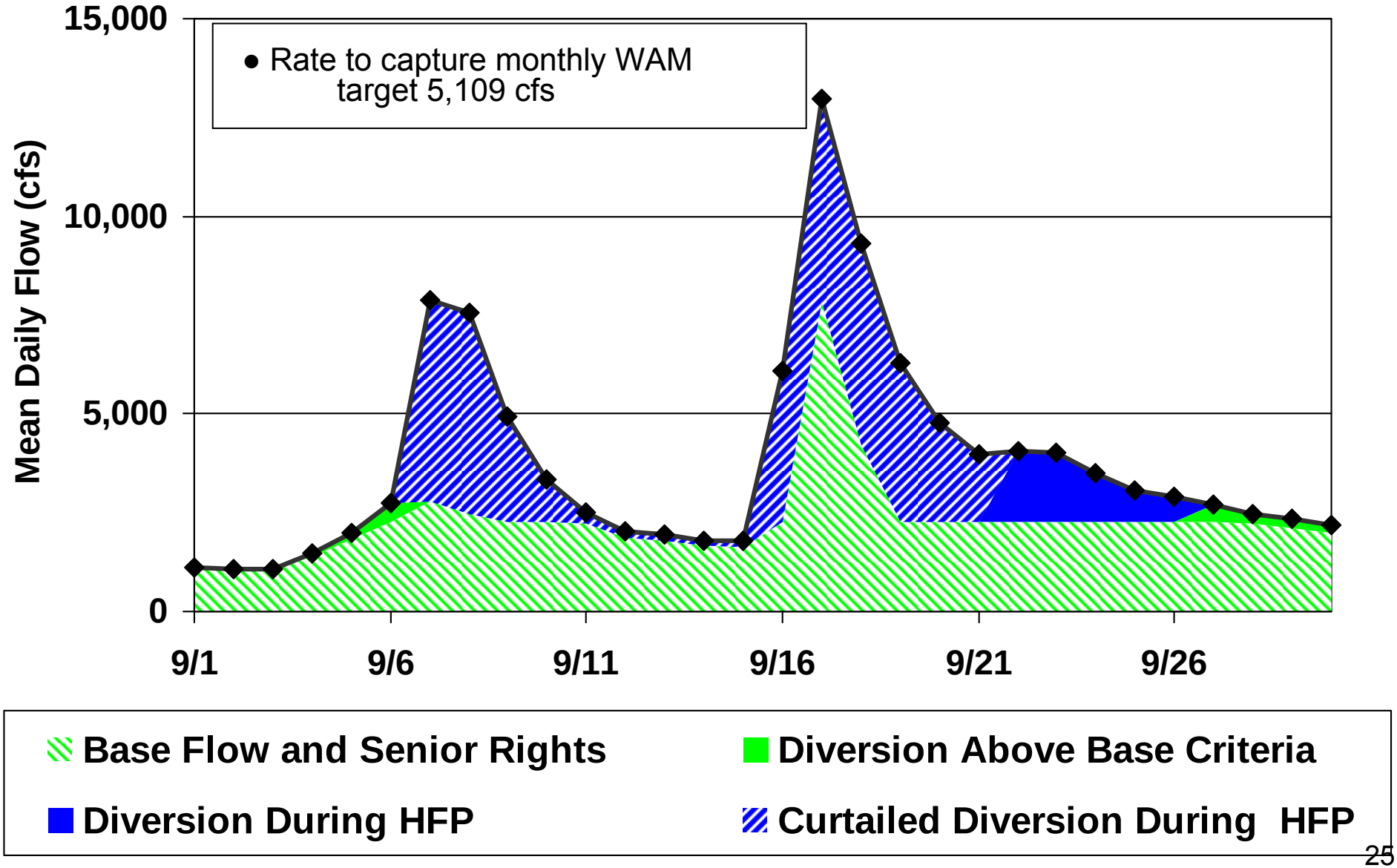
Daily Diversion to Capture Monthly Appropriation

Brazos River at Richmond March thru April 1968



Daily Diversion to Capture Monthly Appropriation

Brazos River at Richmond September 1968



Overview

- Focus on pulse data
- System can be operated so that diversion during pulses has minimal impact on environment
- Curtailment of diversion during pulse flows increases complexity of operation and impacts water supply without significant benefit to environment
- Multi-year variability cam be easily incorporated into the frequency recommendations