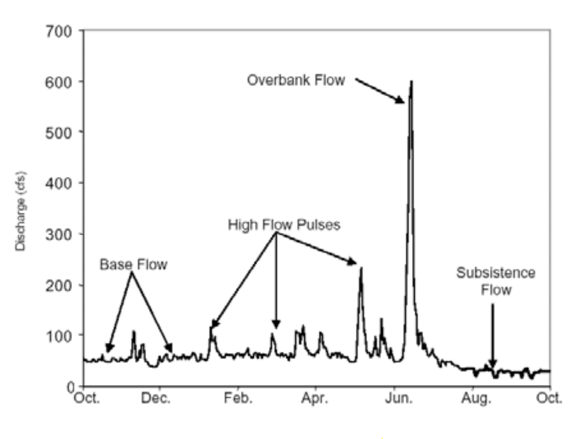
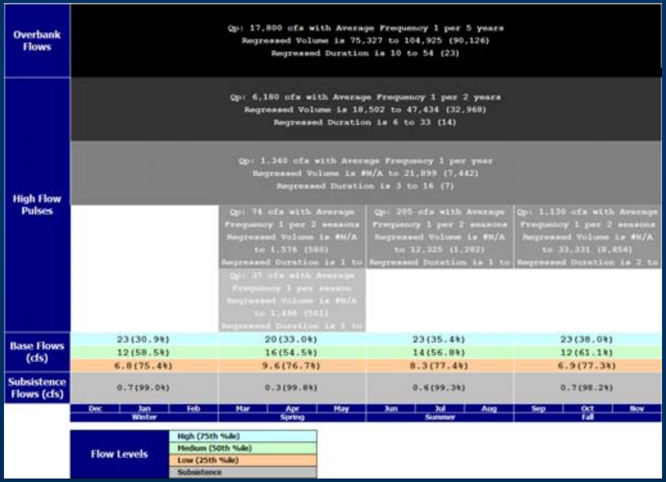
# Introduction to the Hydrology-based Environmental Flow Regime Method



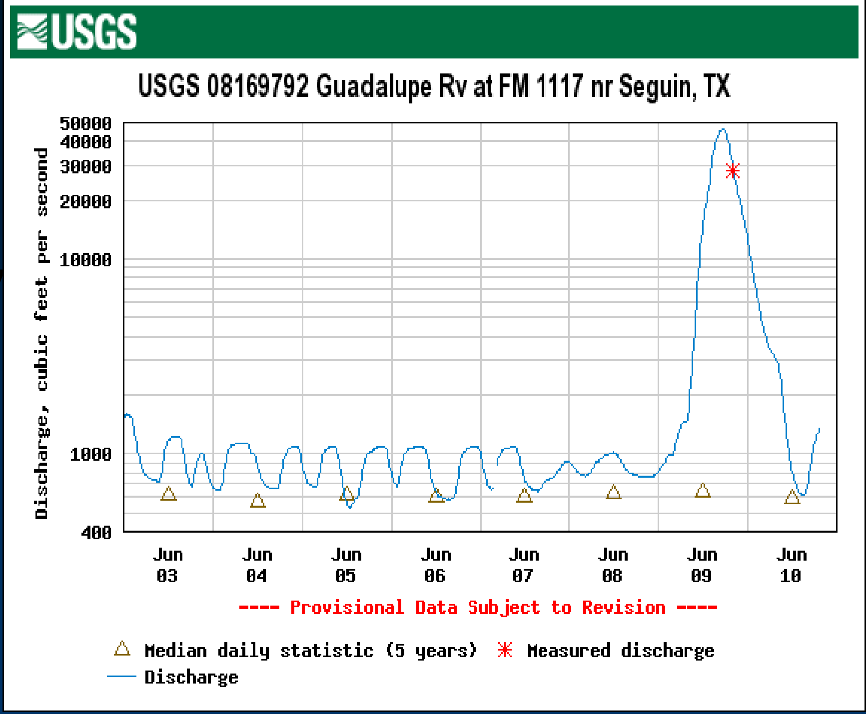

Dan Opdyke, TPWD

Presentation to Guadalupe-San Antonio BBEST

June 11, 2010

TEXAS PARKS & WILDLIFE

# Rationale for Using Hydrology




- SB 3 timelines are aggressive and budgets are tight
- Hydrology has been considered the "master variable" (Poff et al., 1997 as cited in NRC, 2005)
- Hydrologic data are
  - Widely available for a long period of time
  - Consistently measured
  - Fairly easy to work with
- Most appropriate in context of larger multidisciplinary effort

# SAC Hydrology Guidance

**Use of Hydrologic Data in the Development of Instream Flow Recommendations for the Environmental Flows Allocation Process and the Hydrology-Based Environmental Flow Regime (HEFR) Methodology**

- **From the cover letter:**
  - *Hydrologic data analysis is an important first step in developing an environmental flow regime, but it provides only an initial estimate of flow requirements.*
  - *The SAC believes that the HEFR methodology might prove useful as a first step in developing instream flow recommendations, and we recommend that the BBESTs consider its utility…*

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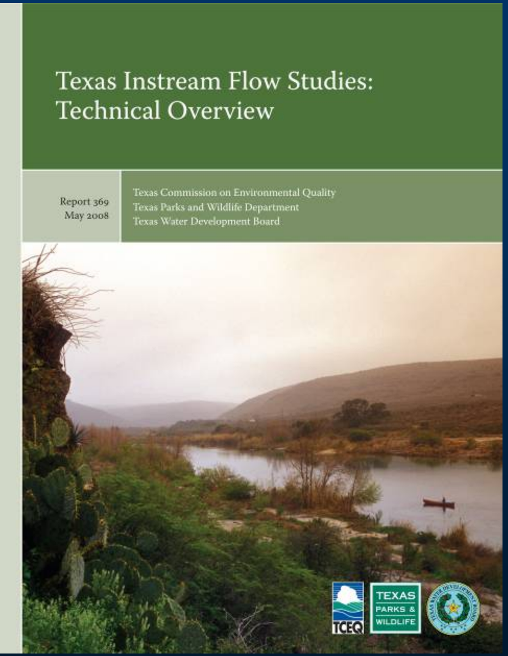
# Texas Instream Flow Program

http://www.twdb.state.tx.us/instreamflows/index.html

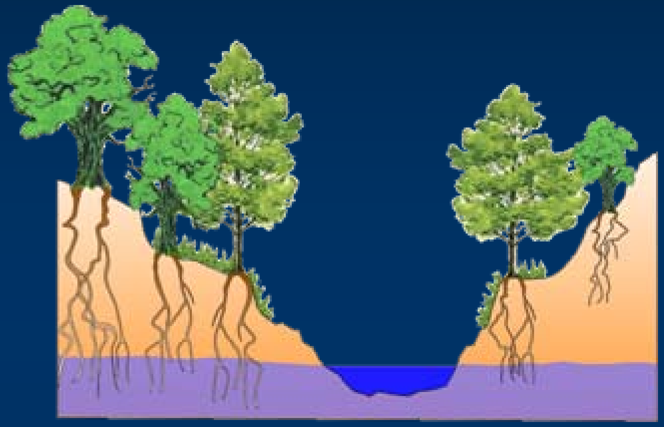
## Program reviewed by NAS

## Technical Overview Document

- Includes four flow components
  - Subsistence flows
  - Base flows
  - High Flow Pulses
  - Overbank Events



# Subsistence Flows



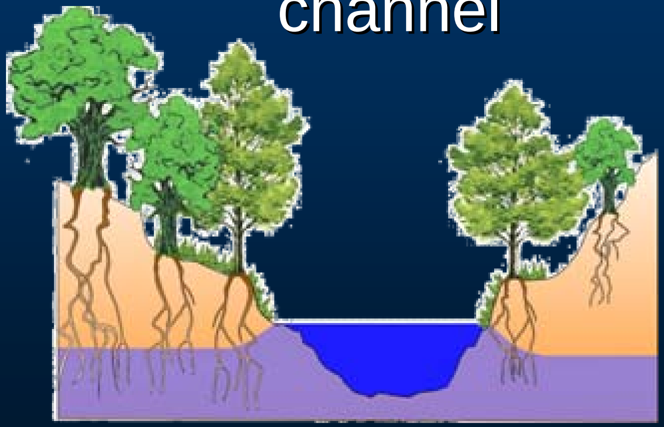
## Ecological Roles

- Protect water quality and critical habitat during very dry times
- Provides limited connectivity

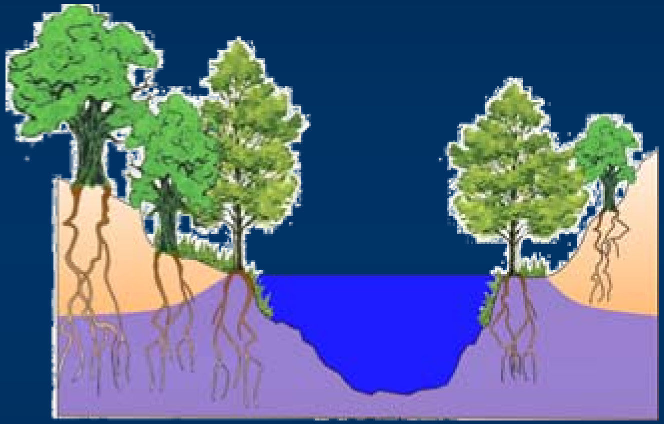
# Base Flows

## Ecological Roles

- Provide suitable habitat
- Maintain diversity
- Maintain water table for riparian vegetation
- Provide connectivity along channel



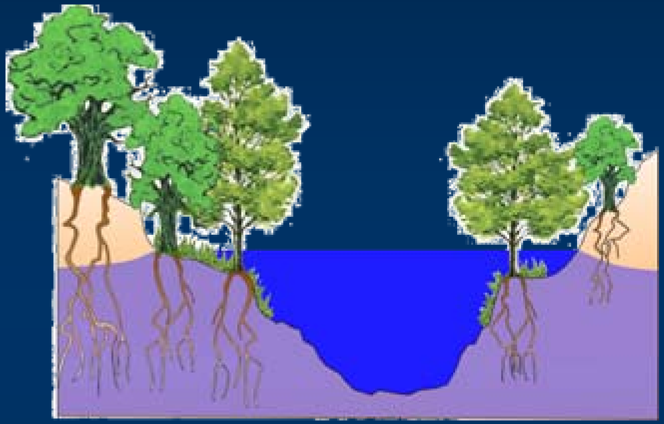
# High Flow Pulses



## Ecological Roles

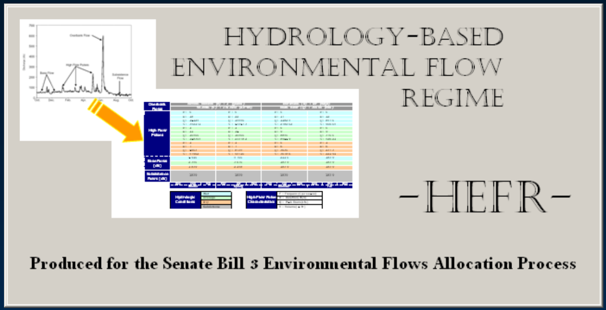
- Provide spawning cues
- Prevent riparian vegetation from encroaching into channel
- Restore water quality following drought

# Overbank Events



## Ecological Roles

- Shape physical habitats
- Provide migration and spawning cues
- Facilitate exchange of nutrients, sediments, woody debris




# HEFR Basics

- Uses hydrologic data
- Computations are rapid
- Populates a flow regime matrix

**A hydrological tool for an ecological purpose**

**(1) Select Flow Gage**

↓

**(2) Select Period of Record**

↓

**(3) Separate (parse) Hydrograph into Flow Components**

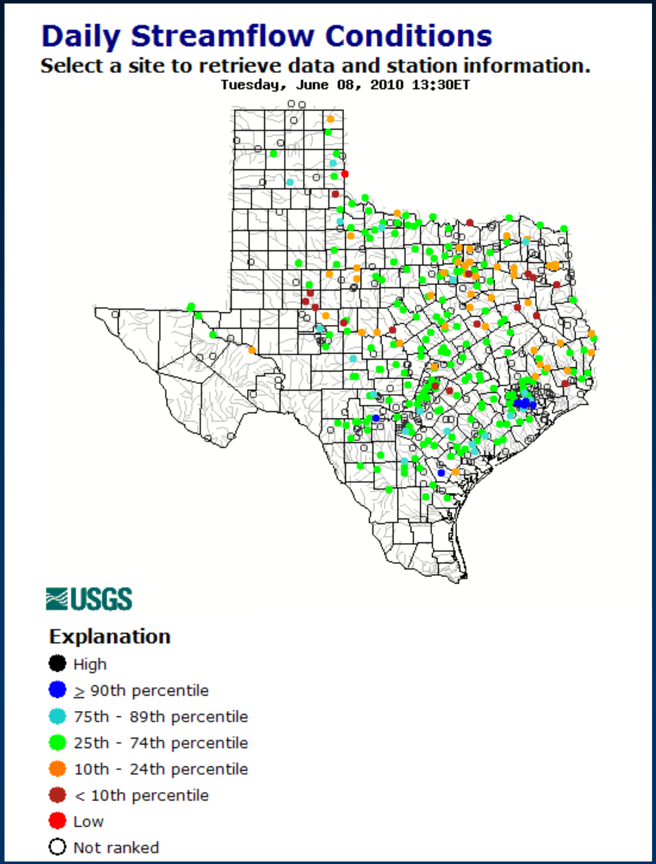
↓

**(4) Generate Statistical Summaries in Excel**

# (1) Select Flow Gage

- Many to choose from
- SAC has “Geographic Scope” guidance
- USGS TX “Core” Network documented here:

http://pubs.usgs.gov/wri/wri014155/




http://waterdata.usgs.gov/tx/nwis/rt

# (2) Select Period of Record

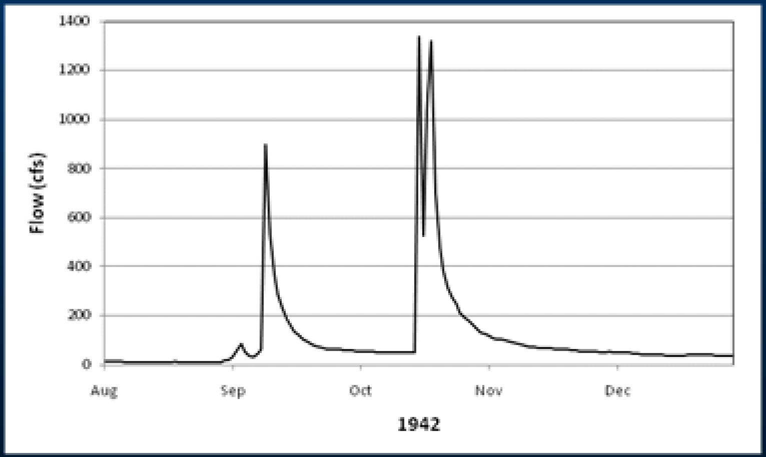

- May vary by gage
- Consider human influences and climate change
- Some discussion in Section 4 of Hydrologic Methods document, LSWP docs, etc.
- Many debates among older BBESTs

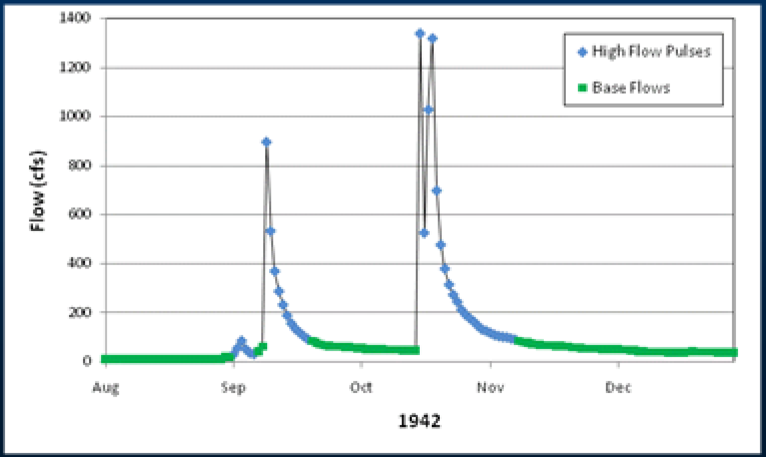
# (3) Separate (parse) Hydrograph

## Two Options

1. **Indicators of Hydrologic Alteration (IHA)**
   - Environmental Flow Components function
2. **Modified Base Flow Index with Threshold (MBFIT)**
   - Bureau of Reclamation method with modifications for SB 3

## Both split the hydrograph into IFCs



# (3) Separate (parse) Hydrograph

## Traditional Base Flow Separation

- Each day has both a base flow and runoff component
- Emphasis is on dominant source of water
  - Rate of change perhaps more important than flow magnitude

## Hydrographic Separation for Env Flows

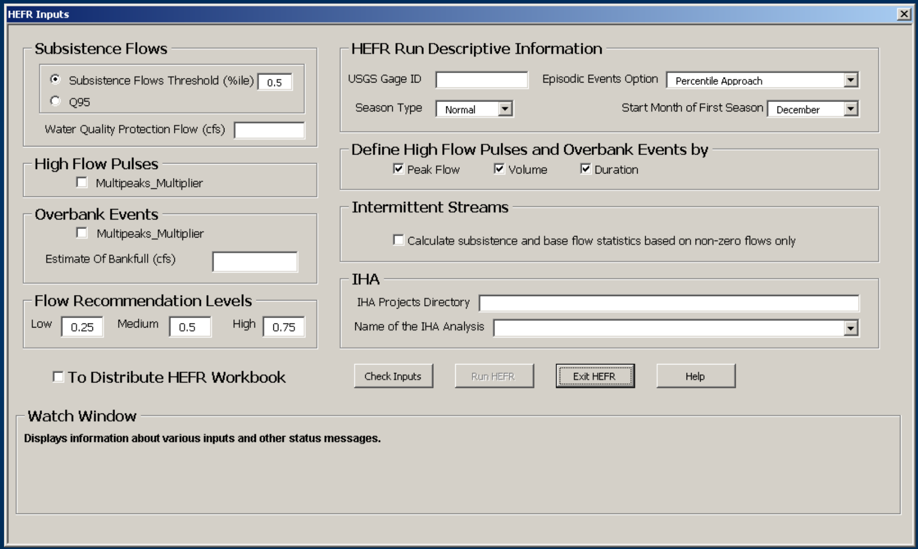
- Each day has only one component
- Emphasis is on dominant ecologic function
  - Instream habitat, spawning cues, sediment transport, etc.
  - Flow magnitude perhaps more important than rate of change

# (4) Generate Statistical Summaries in Excel

**HEFR uses Excel to generate summary statistics of each IFC**

- Subsistence
- Base Flow
- High Flow Pulses
- Overbank Events

HEFR Input Window




**Outputs may include: flow, volume, duration, frequency**

# Brief Overview of Decision Points

## Seasons

- Highly flexible
- Consider flow patterns, spawning, temperature

## Non-Zero flows only

- Use to limit flow computations to days with measured flows
- Zero flow frequencies and durations handled separately

# Brief Overview of Decision Points

## Subsistence

- User-specified percentile of subsistence flow days
- Q95
- Water Quality Protection Flow

## Base Flows

- Up to three levels: low, medium, high
- Percentiles assigned by analyst

# Brief Overview of Decision Points

## High Flow Pulses and Overbank Events

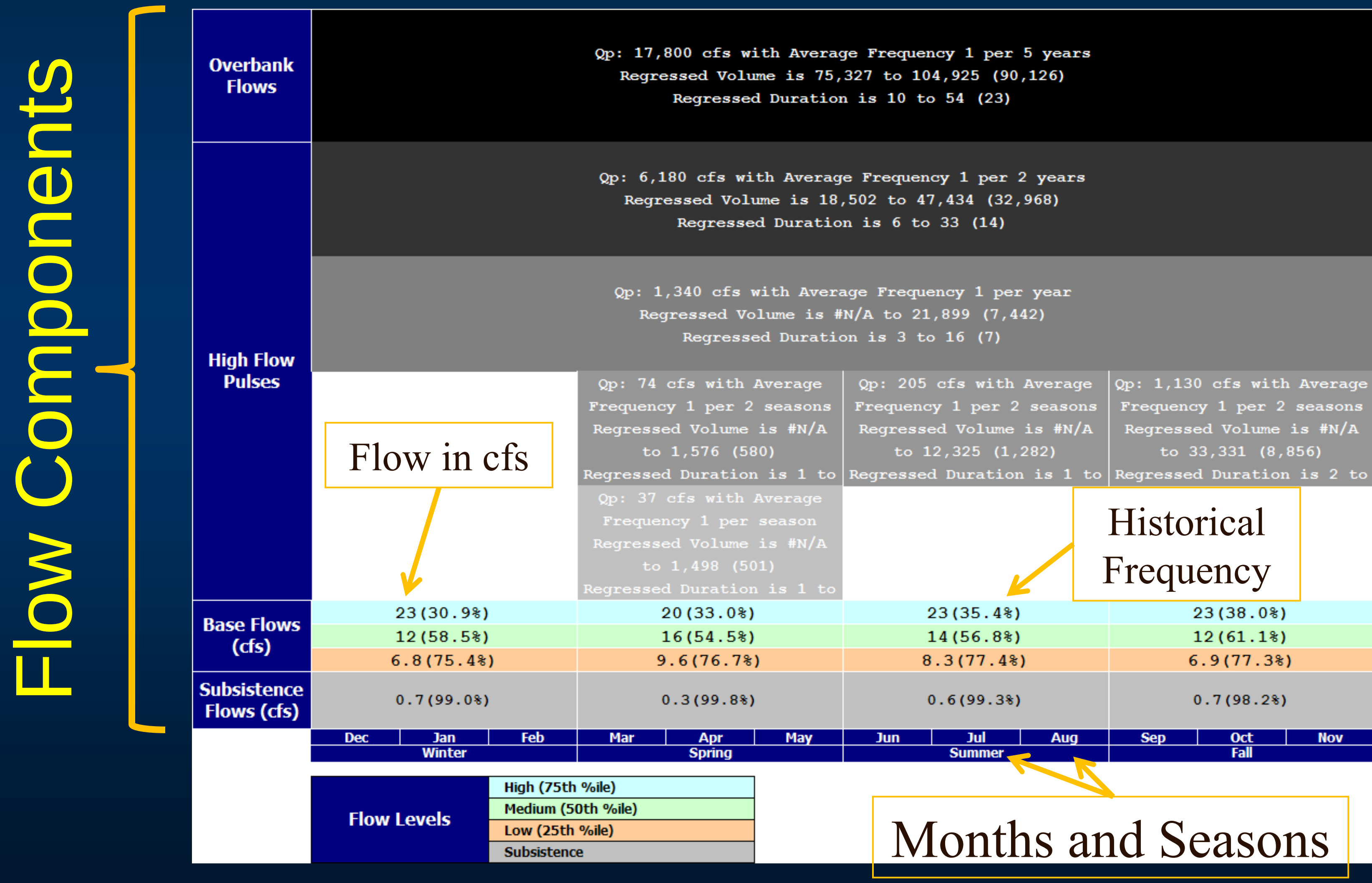
- Multipeaks_Multiplier
  - IHA will not identify discrete pulses or events unless separated by a base flow day
  - Using M_M, HEFR will identify discrete pulses and events
- Methodology
  - Percentile Approach
  - Frequency Approach

# Brief Overview of Decision Points

## Frequency Approach

- Tiers
  - For example, “one per two years” event
- Regression forms
  - For volume and duration characteristics
  - Log/Log or quadratic
  - Confidence level

# Illustrative HEFR Output



# How Does HEFR Compare to Other Methods?

# Hydrologic Methods used in Texas

## 7Q2

- lowest average stream flow for seven consecutive days with a recurrence interval of two years
- A water quality metric – generally not recommended for environmental flows

## Lyons

- 40% of monthly median Oct-Feb
- 60% of monthly median Mar-Sep
- Has been considered the “default” TCEQ approach

# Hydrologic Methods used in Texas - Continued

## Consensus (CCEFN)

- Direct Diversion:
  - 50th %ile, 25th %ile, 7Q2, all based on naturalized flows
- Often used in regional water planning

## HEFR

- Used by previous BBESTs
- A precursor of HEFR contributed to the BRA System Operations draft permit

# How Do These Compare

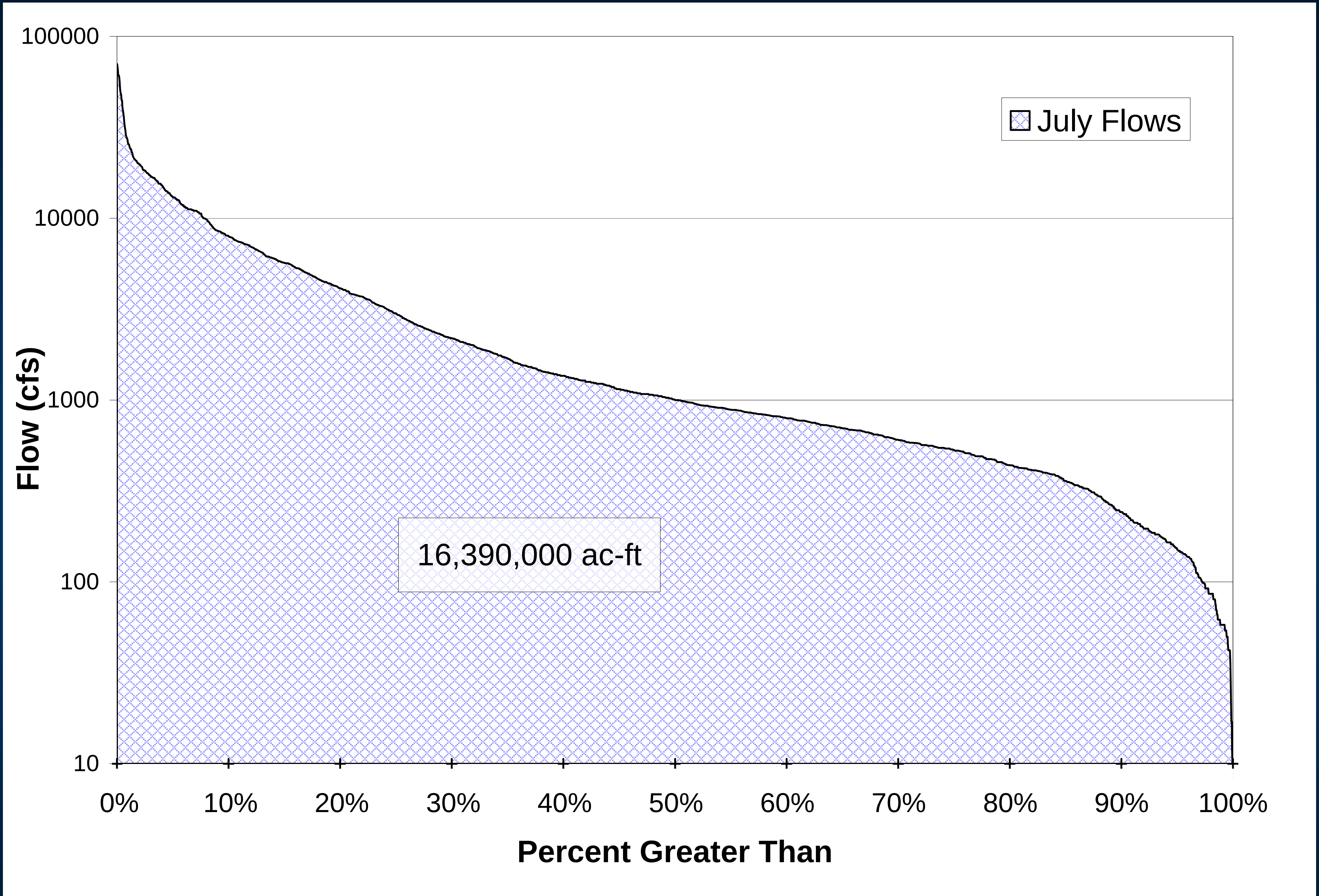
**7Q2, Lyons, and CCEFN calculations are prescriptive, i.e., no flexibility**

**HEFR has multiple input parameters at the disposal of the analyst**

**All are based on historical (or naturalized) flows**

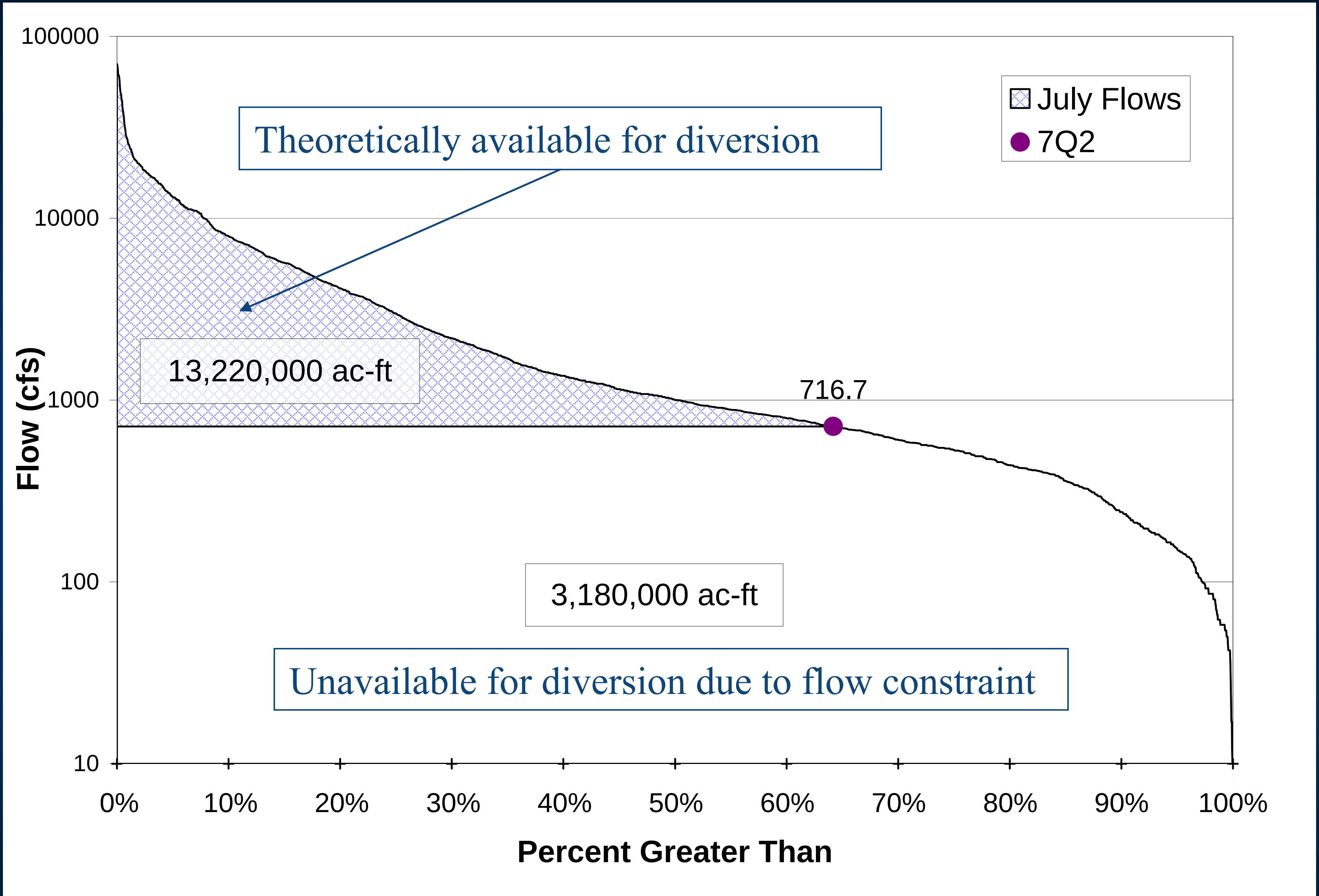
**The following slides have a visual comparison of these hydrologic calculations**

- Trinity River at Oakwood
- Full period of record (1924-2009, 86 years) July flows only

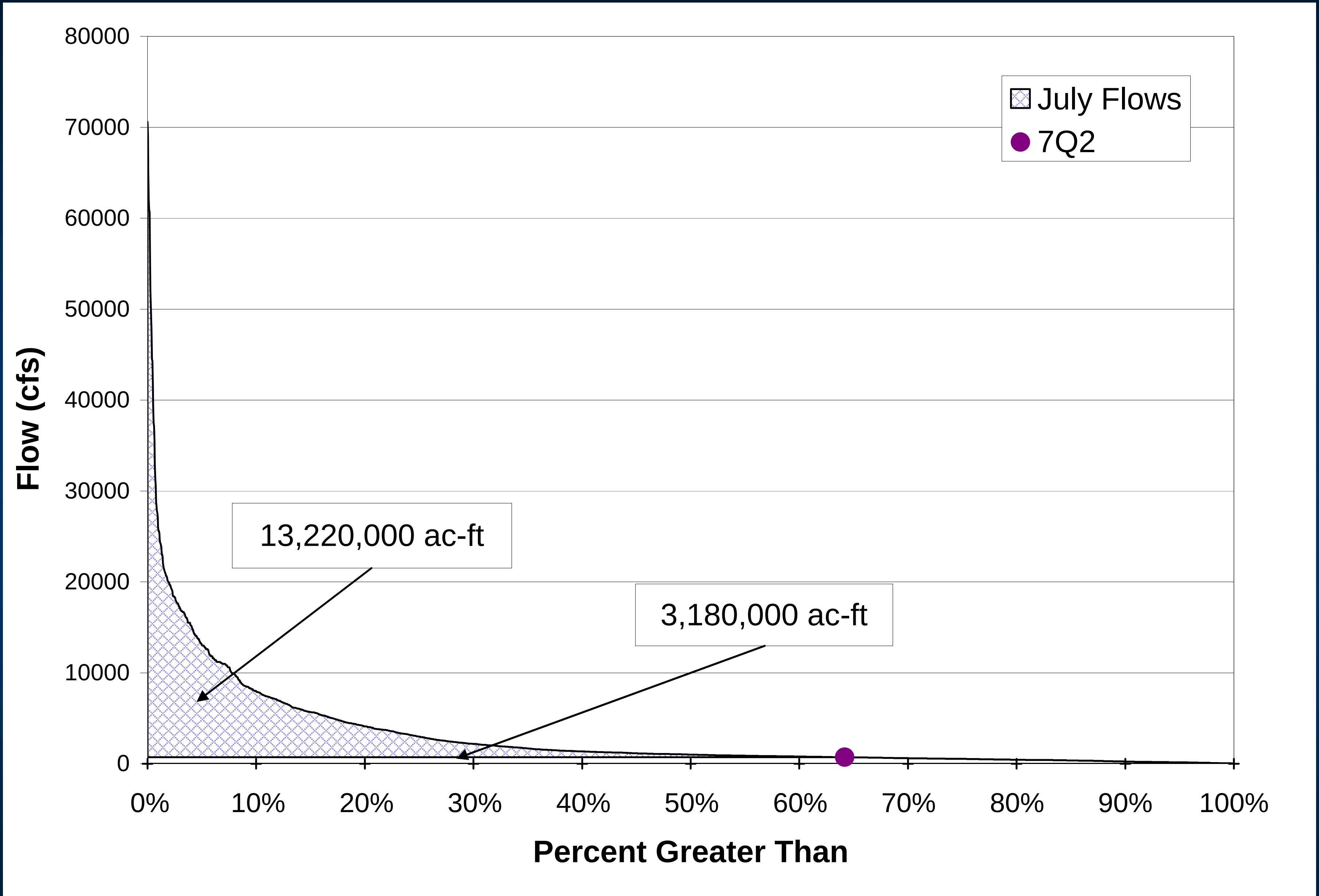



Note: Linear x axis, Log y axis

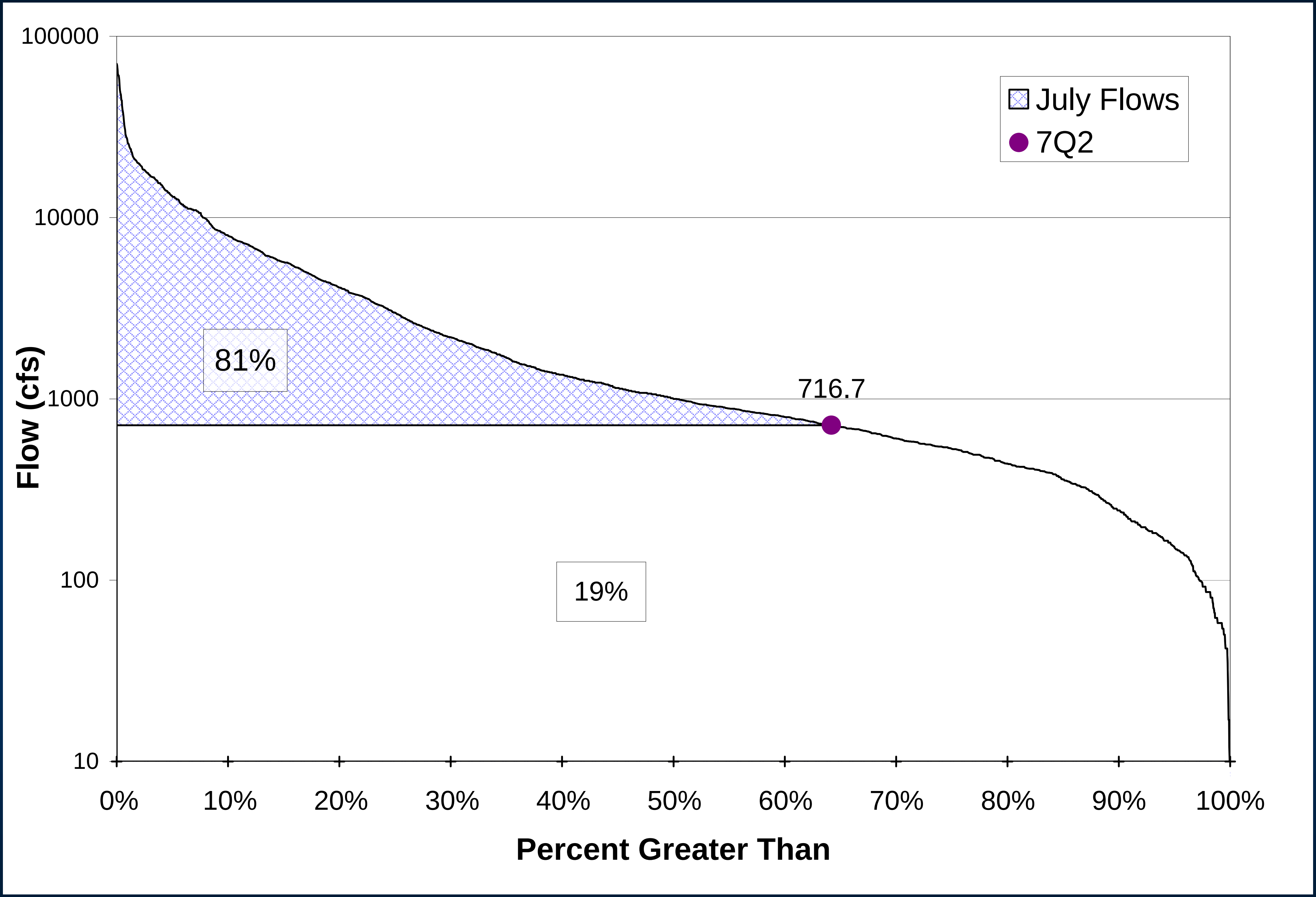
Approximately 16M ac-ft total volume over 86 years of Julys



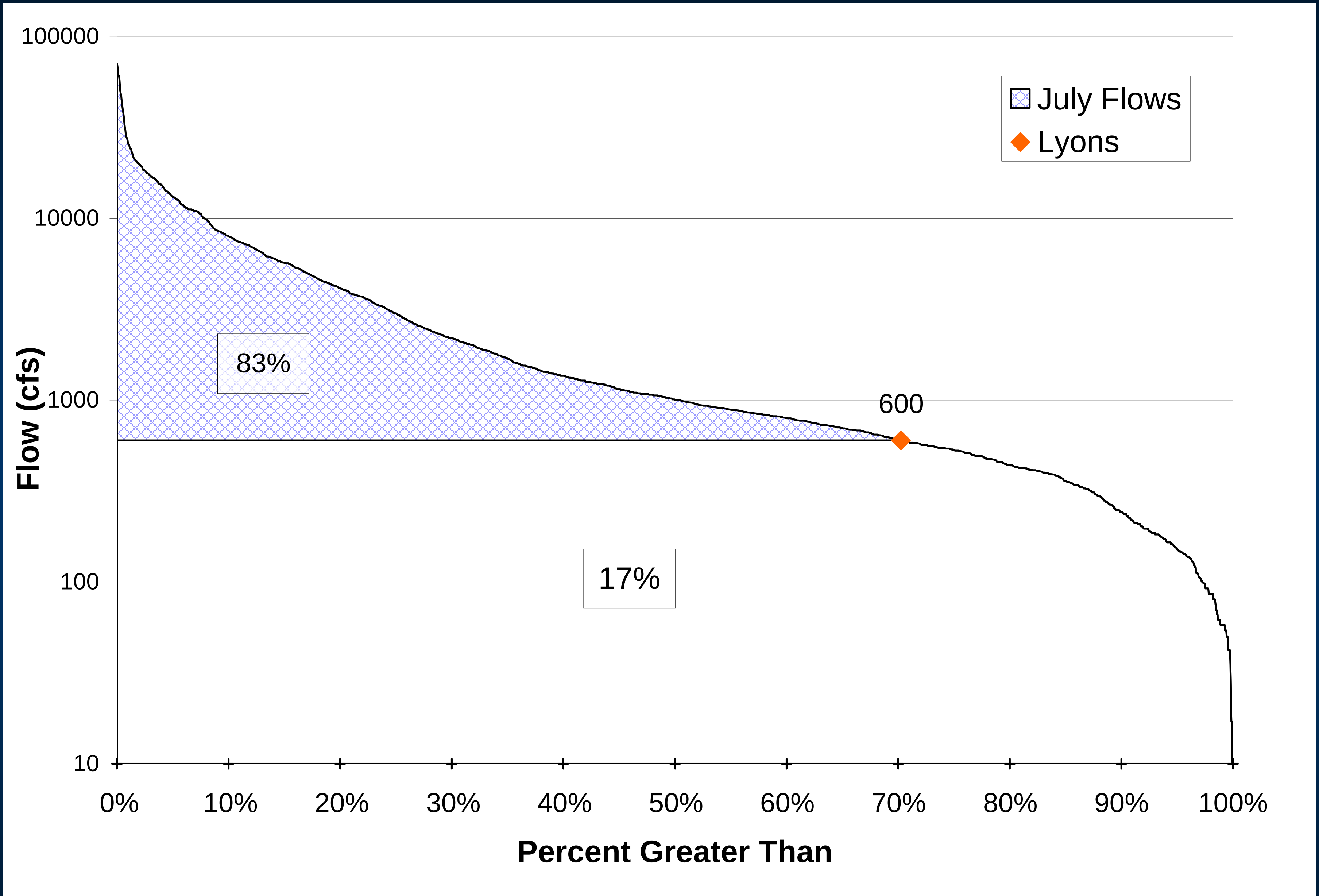

Note: 7Q2 from TCEQ website (1979-1996 only)



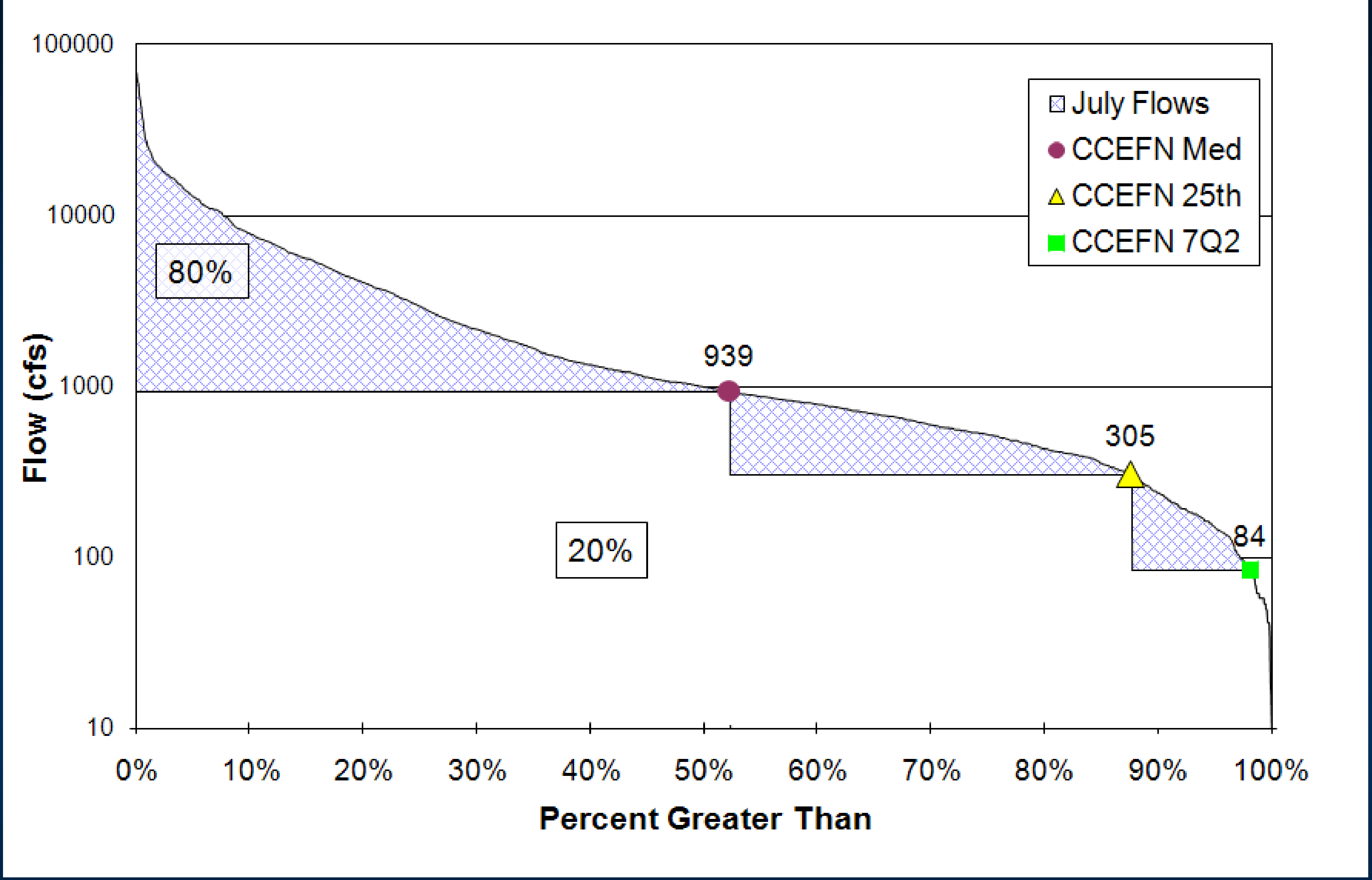

Note: Same plot as previous slide, except linear y axis.
Blue area can be visually compared to white area in this plot



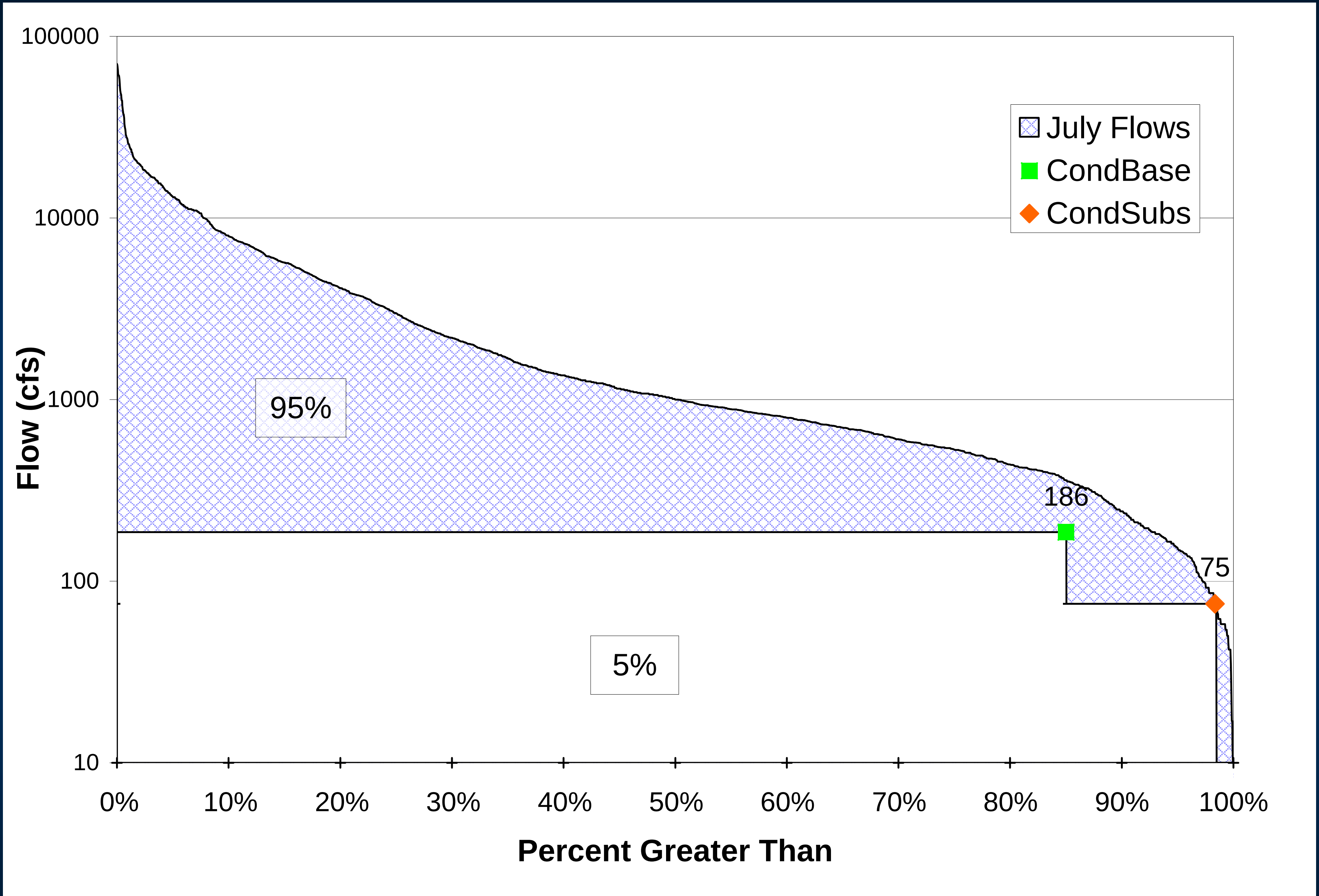

Note: Same plot as previous two slides, except back to log y axis and showing percentages of total water instead of volumes.



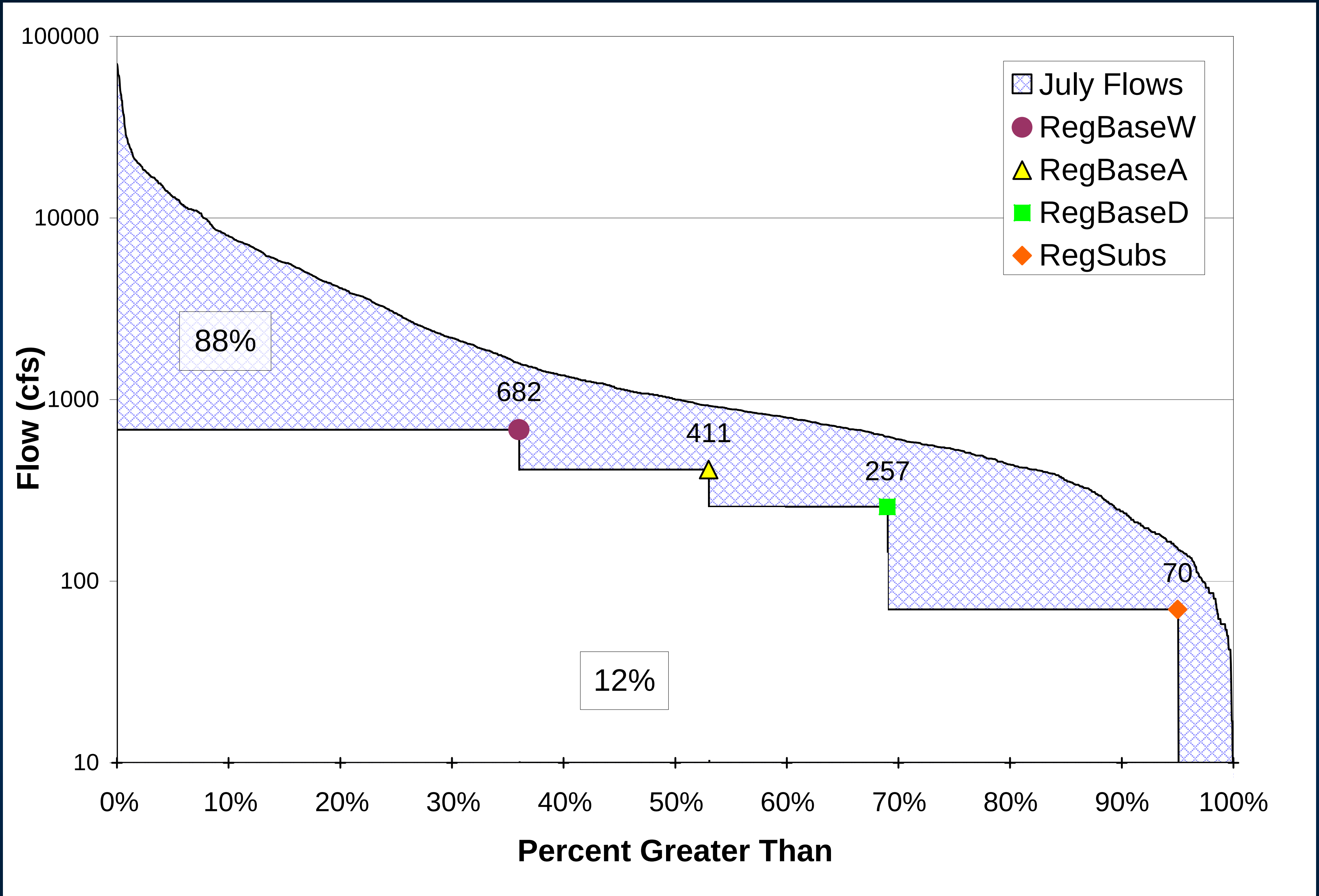

Note: Lyons flow conditions with percentages of total volume.
Lyons calculation using entire gaged period of record (1924-2009)



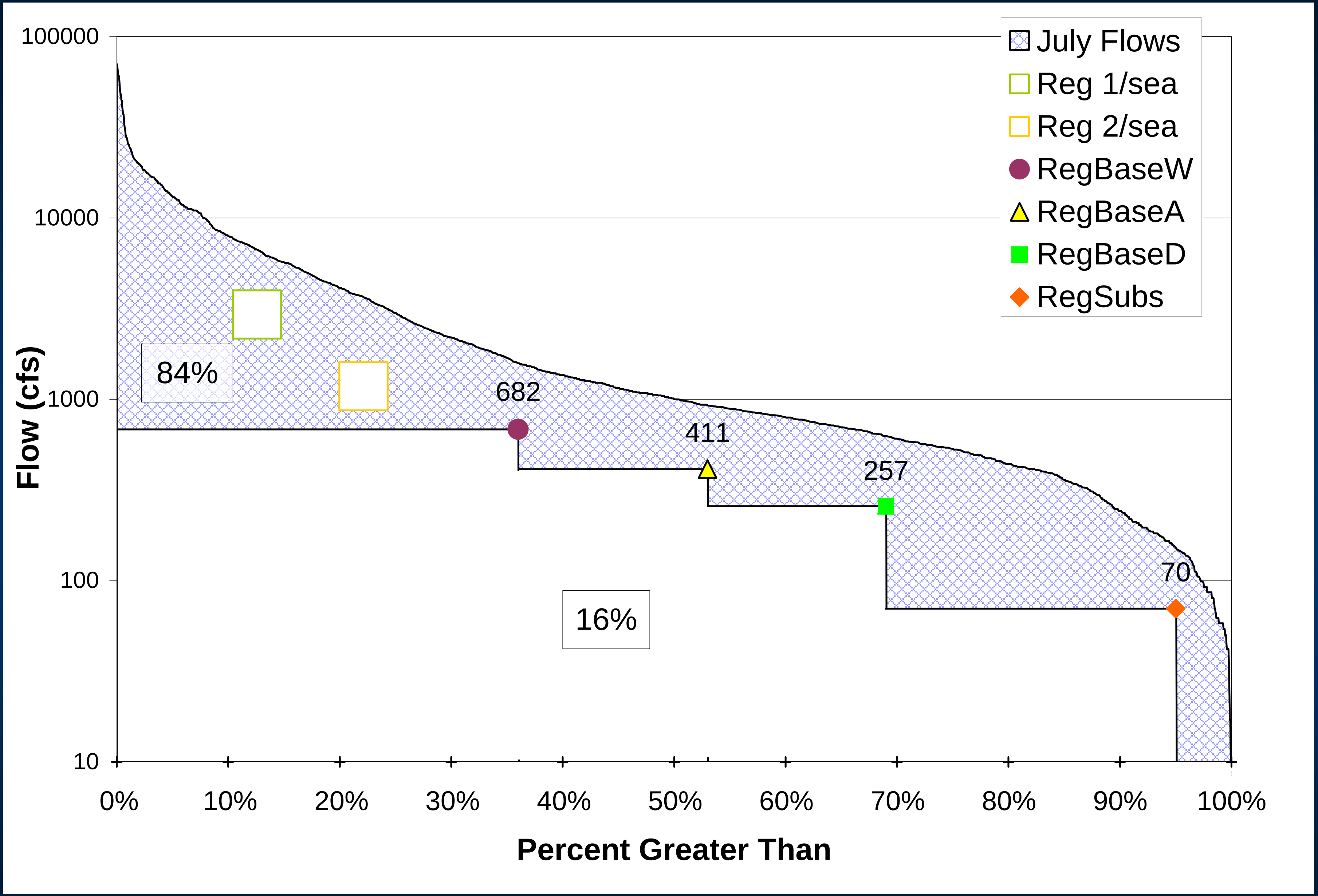

Note: Consensus Criteria for Environmental Flow Needs (CCEFN).
Assuming a direct diversion project, 1940-1996 naturalized flows.
Median and 25th %ile based on daily July flows, 7Q2 based on all daily flows.
TCEQ may use published 7Q2 (716.7cfs) as floor. I did not in this chart.



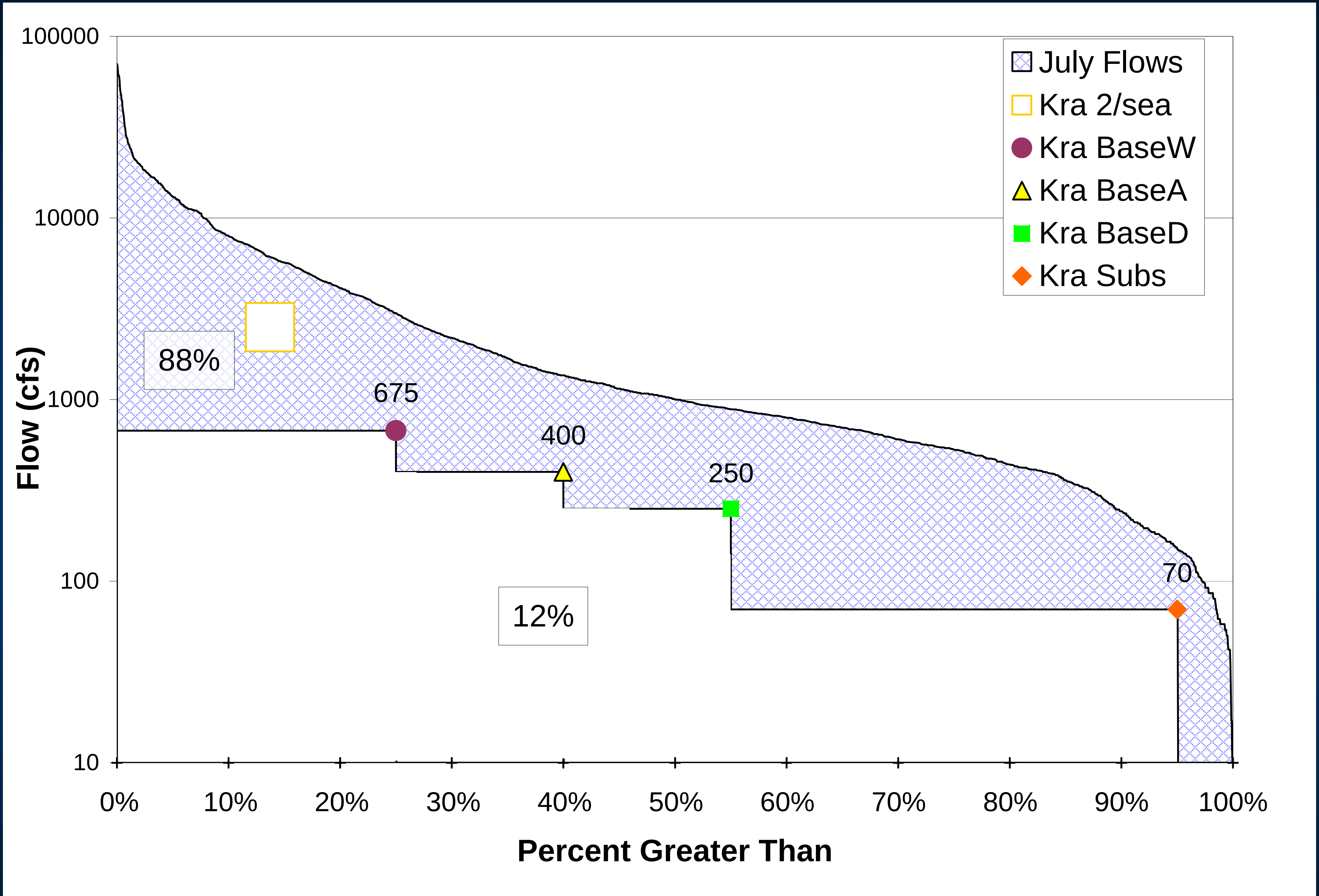

Note: Trinity-San Jacinto BBEST Conditional Phased Group.
Flow recommendations based on 1924-1964 gaged flows.



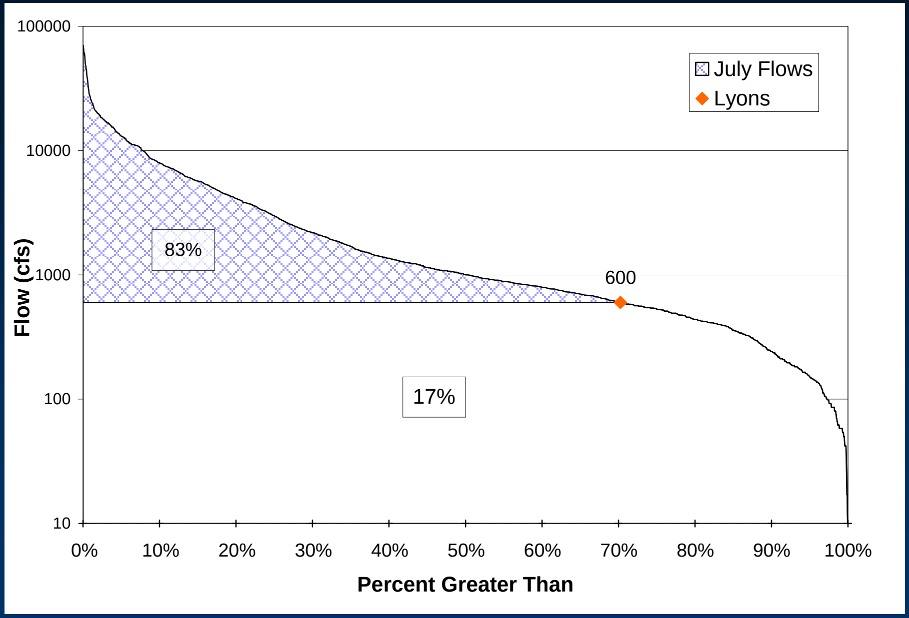

Note: Trinity-San Jacinto BBEST Flow Regime Group without High Flow Pulses.
Flow recommendations based on 1924-1964 gaged flows.

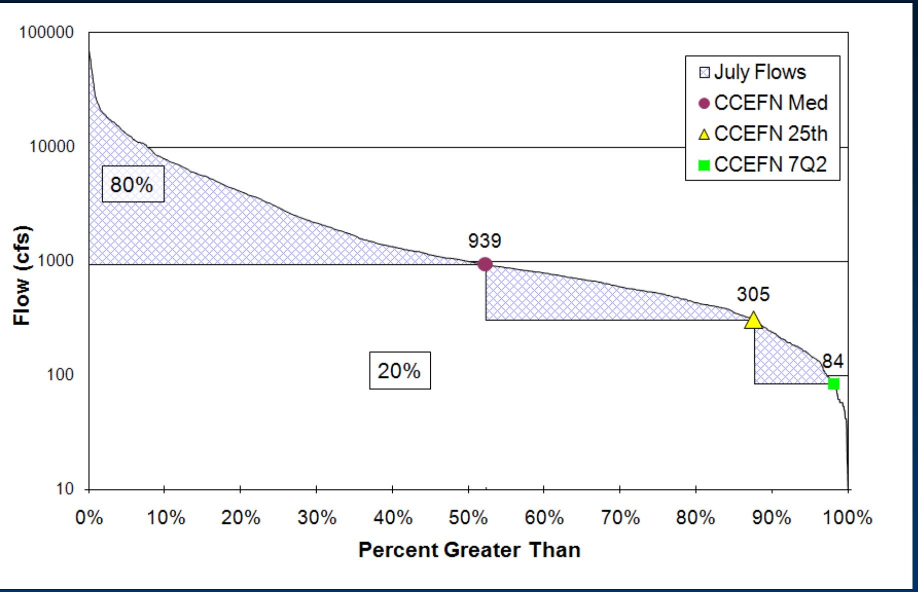


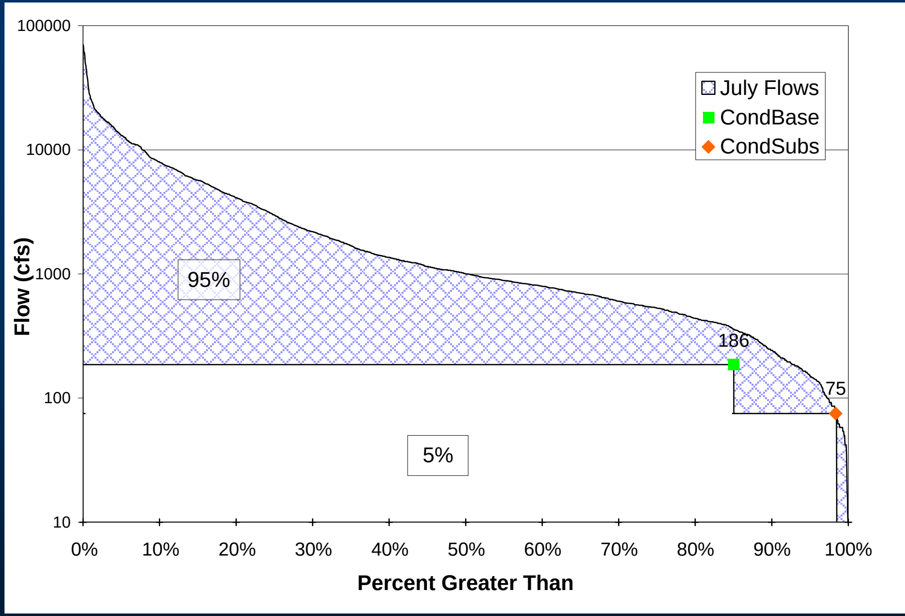

Note: Flow Regime Group with seasonal High Flow Pulses.
Flow recommendations based on 1924-1964 gaged flows.

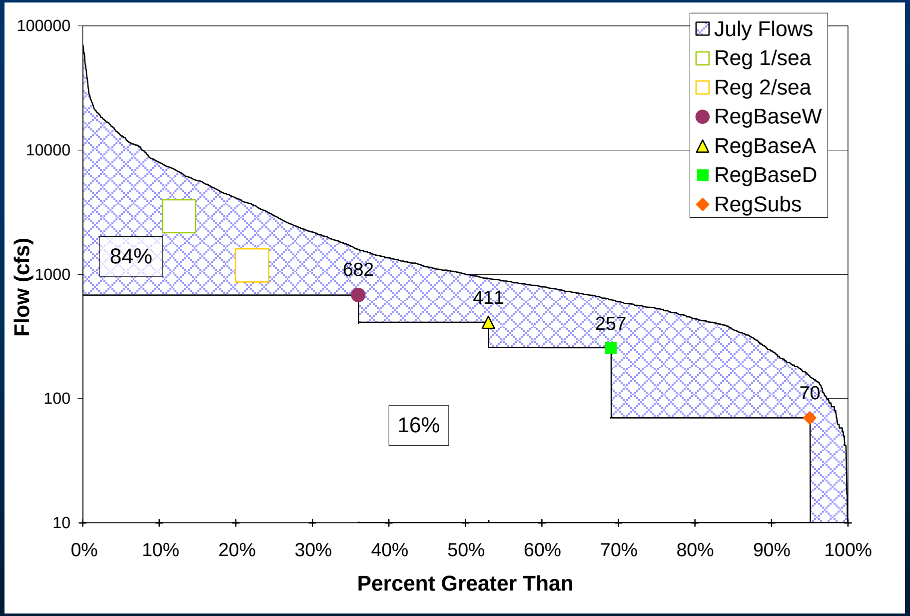



Note: Trinity-San Jacinto BBASC Kramer et al proposal.




Note: Lyons % numerically ≈ Reg
but note that Reg allows diversions at lower flows.

# Caveats

- 7Q2 is not seasonal, therefore the flow conditions are high relative to July flows
- Much of "blue hatched" water is either already appropriated or may not be permittable (e.g., too unreliable)
- Different periods of record among calculations are important
- Different months will have different results

# Conclusions

- While HEFR is based on historical flows, it does not attempt to protect all historical flows.
- Flexibility = Decisions Required
- Need to keep ecological goals front and center
- HEFR can efficiently populate a flow matrix to generate a first cut
- Other disciplines are necessary before reaching a final instream flow recommendation
  - Biology – SAC guidance released September 1, 2009
  - Geomorphology – SAC guidance released May 29, 2009
  - Water Quality – SAC guidance released November 3, 2009
- These disciplines can be used to guide HEFR parameter selection or as direct replacement of HEFR-generated flow recommendations.