

The Problem: Estimating Extreme Floods – Too Much Statistics . . . No Common Sense

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BIOGRAPHICAL SKETCH

Mr. Countryman worked for the U.S. Army Corps of Engineers from 1966 through 1988 (22 years). His duties included flood control hydrology, hydraulic design, water resources planning, and design of hydraulic structures. In addition, he was involved in the operation of flood control reservoirs in California, and Colorado. In 1988, he joined MBK Engineers and in 1992 became a partner in the firm and was president from 1992 to June 1, 2011. While at MBK he worked on a diverse array of flood control projects ranging from reservoir reoperation to the design of flood control facilities. He also served as an expert witness in numerous flood litigation cases.

EDUCATION:

California State University, San Jose
BS in Civil Engineering, 1966

PROFESSIONAL LICENSES, SOCIETIES AND HONORS:

Registered Civil Engineer, California, 20486
Registered Civil Engineer, Nevada, 8086
Member, American Society of Civil Engineers
Award of Distinction, San Jose State University, College of Engineering
ASCE Lifetime Achievement Award in March 2011

ABSTRACT

Over time the development of design floods for urban areas has shifted from a physically-based methodology (Standard Project Flood) to a statistical-based methodology (200-year flood). This presentation discusses the problems associated with estimating extreme floods from the statistical analysis of a single historic sample. It provides an example of a frequency curve extrapolation utilizing various Probability Distribution Functions (pdfs) and a graphical approach. The problems encountered when statistical extrapolations are done without regard to physical constraints are discussed. In addition, the basis for Confidence Bound calculations is discussed. The paper recommends abandoning the confidence bound calculation because it is theoretically incorrect and provides unusable information.

The Problem:
Estimating Extreme
Floods

Too Much Statistics - No Common Sense

Joseph D. Countryman, PE, D.WRE

2011 California Extreme Precipitation Symposium

June 28 at UC Davis

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**World Environmental and
Water Resources Conference
2007**

**500-Year Flood– Can it
be Reliably Estimated?**

By

Joseph D. Countryman PE, D. WRE

Presented May 17, 2007

Tampa, Florida

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Flood Frequency Confidence Bounds: Art, Science or **Guess!!**



Joseph D. Countryman PE, M. ASCE, D.WRE
and
Ben Tustison PE, M. ASCE

World Environmental & Water Resources Congress
2008
May 12-16, 2008 Honolulu, Hawaii

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Hydrologic Uncertainty

- Probability Density Function LP3
- **Extrapolation of Curve Fitting**
- Calculation of Uncertainty of the Estimate (Confidence Intervals)

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What is a pdf?

(Probability Density Function)

- Ordered Data – Assigned Exceedance Probability
- Mathematical Function
 - Curve Fitting of PDF to Data
 - Parameters to adjust PDF
 - Mean
 - Std Dev
 - Skew

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Show me a pdf!!!

Log Pearson Type III

$$f_{LP}(u) = k | \alpha | e^{-\alpha(\log_a u - m)} [\alpha(\log_a u - m)] / u \Gamma(\lambda); k = 1/\ln a$$

u , a and λ are function parameters that can be used to fit the distribution to the ordered data set

Source: The Gamma Family and Derived Distributions Applied in Hydrology
Bobee & Ashkar

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What Is Missing?

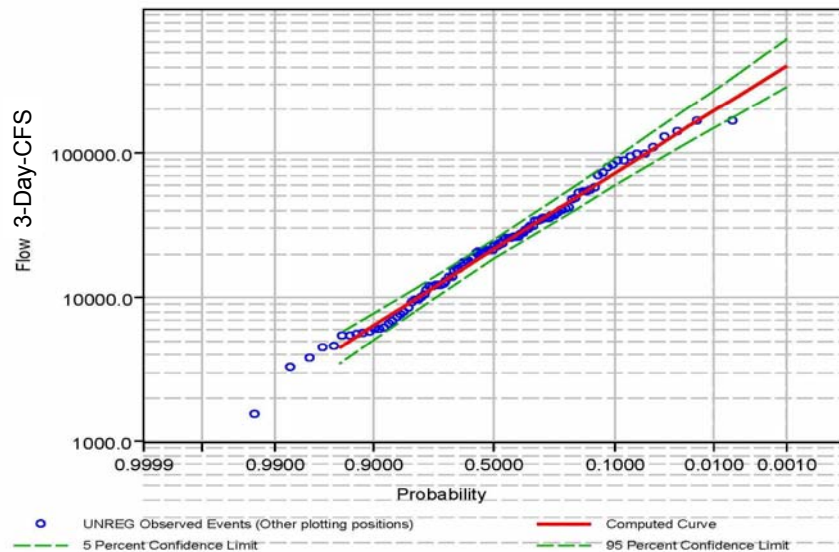
- Drainage Area?
- Elevation??
- Watershed Characteristics???
- Precipitation Potential????
- Any Physical Characteristic?????
- **Everything Pertaining to the Science of Hydrology!!!!!!!!!!!!!!**

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American River LP III

(Log Scale)

Exceedance Probability for American River



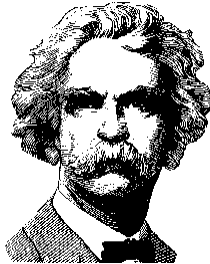
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HEC_SSP

Ex·trap·o·late

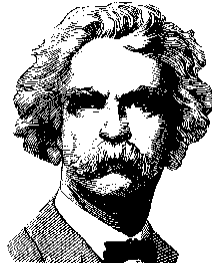
1. to **infer** (an **unknown**) from something that is known; conjecture.
2. Statistics. to **estimate** (the value of a variable) **outside** the tabulated or **observed range**.

Dictionary.com Unabridged (v 1.1)
Based on the *Random House Unabridged Dictionary*, © Random House, Inc. 2006. ⁹



Extrapolation Explained!

In the space of **176 years** the **Lower Mississippi** has **shortened** itself **242 miles**. This is an average of a trifle over **one mile and a third per year**. Therefore, any calm person, who is not blind or idiotic, can see that in..., just a million years ago next November, the Lower Mississippi River was upward of one million three hundred thousand miles long, and stuck out over the Gulf of Mexico like a fishing-rod.



Extrapolation Explained!

And by the same token any person can see that **742 years** from **now** the Lower Mississippi will be only a **mile and three-quarters long**, and Cairo and New Orleans will have joined their streets together, and be plodding comfortably along under a single mayor and a mutual board of aldermen. **There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact.**

Mark Twain, *Life on the Mississippi* 173-6 (1883)

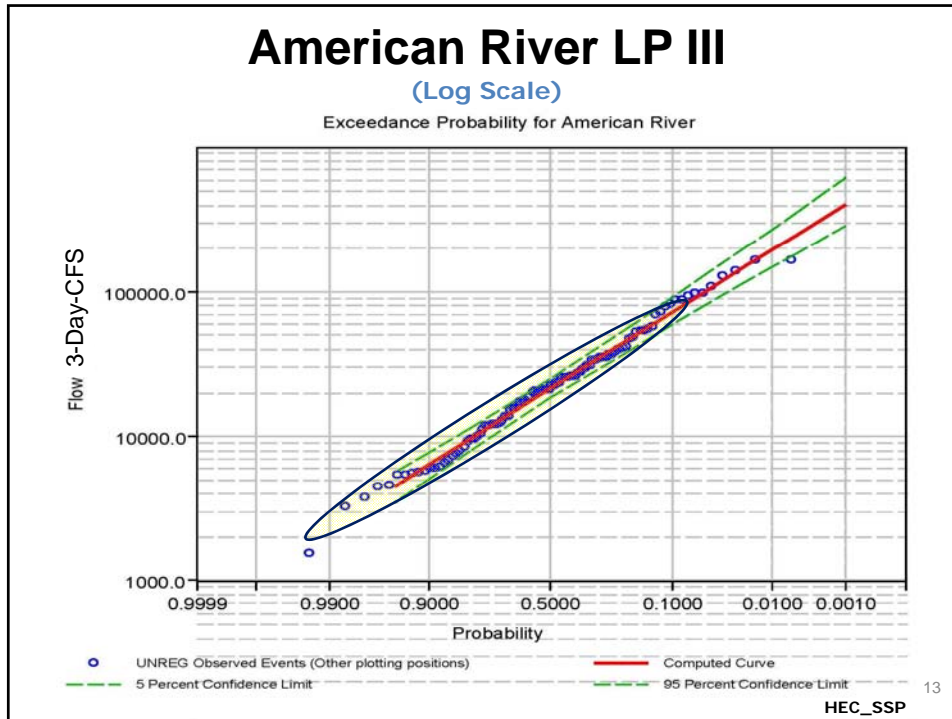
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Vit Klemes

Common Sense and Other Heresies

- “ ...from a hydrological point of view, very extreme floods and their causes tend to be outliers by definition, i.e., very little, if any, information about their likelihood is contained in the frequencies of relative small floods of which the bulk of a typical flood sample is composed. Extrapolating distribution models fitted to these samples is tantamount to extrapolating the small flood dynamics beyond the range it can physically function.”

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The “Best Fit” is controlled by the vast majority of the floods smaller than a 10 year flood. We are saying that these floods tell us something about the Extreme Floods we wish to characterize???

Impact of Log’s

- **Log Statistics Emphasize Lower Flows.**
 - Real Numbers **100/10=10** with logs **2/1**
- **American River Mean Annual 3-Day Flow**
 - Real Numbers **33,056 CFS**
 - LN Numbers **21,705 CFS**

Bulletin 17B

- “The accuracy of flood probability estimates based upon statistical analysis of flood data deteriorates for probabilities more rare than those directly defined by the period of systematic record. This is partly because of the sampling error of the statistics from the station data and partly because the basic underlying distribution of flood data is not known exactly.” Pg. 19
- “**All types of analyses** should be incorporated when defining flood magnitudes for exceedence probabilities of less than 0.01 (larger than the 100-year)” Pg. 20

Guidelines for Determining Flood
Flow Frequency, 1982

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It would seem all means, precipitation history, types of storms, snow pack conditions, Paleohydrology, use of atmospheric models, ... None of this is being done by Federal Agencies!

Why is Bulletin 17B Ignored?

- Statistical Software allows for **Easy Extrapolation** of data, **Thinking** and **Evaluating** is a Problem!
- Many believe that **Statistical Extrapolation** is based on Science and that it can be reliably used. The ability to state with confidence limits an annual exceedance probability is proof. **(Ignorance is Bliss!!)**

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Bureau of Reclamation

- “An ultimate goal would be to arrive at a frequency curve that is valid over the entire range of possible flood flows. This of course **is not possible** because sufficient data do not exist to verify the **choice of base distribution.** ... The **errors** that are unavoidable in the parameter estimates become **intolerable** once the frequency curve is **extrapolated beyond a certain point.**” Pg. 204

Flood Hydrology Manual, 1992

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Bureau of Reclamation

- “**Practical rule-of-thumb knowledge**, which is supported by statistical calculation, indicated that **frequency curves** are reasonably **reliable** out to **return periods of about the sample record length** or even twice the sample length.” Pg. 204

Flood Hydrology Manual, 1992

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The American River

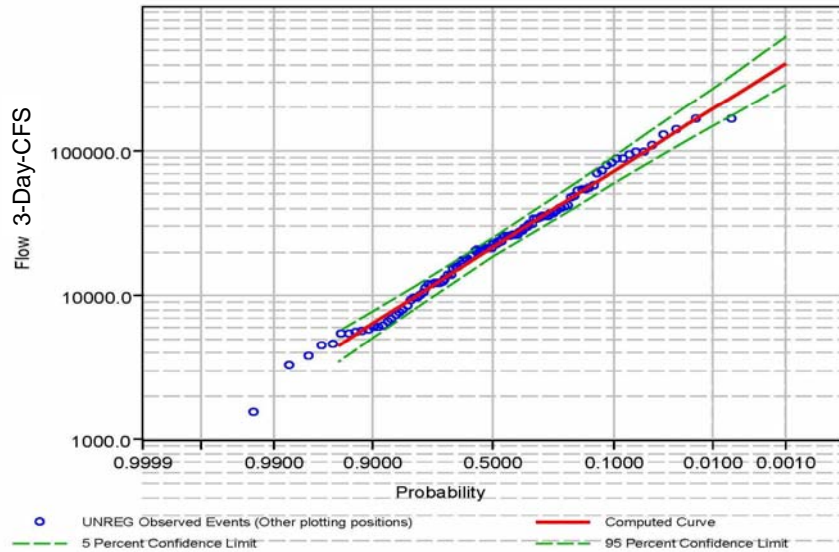
- The Extrapolation of the Annual Exceedance Probability for 3-Day Flows.
 - 104 years of record
 - Stationarity of data **Unknown**
 - Rain Flood Flows + Snowmelt Enhancement Variable

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American River LP III

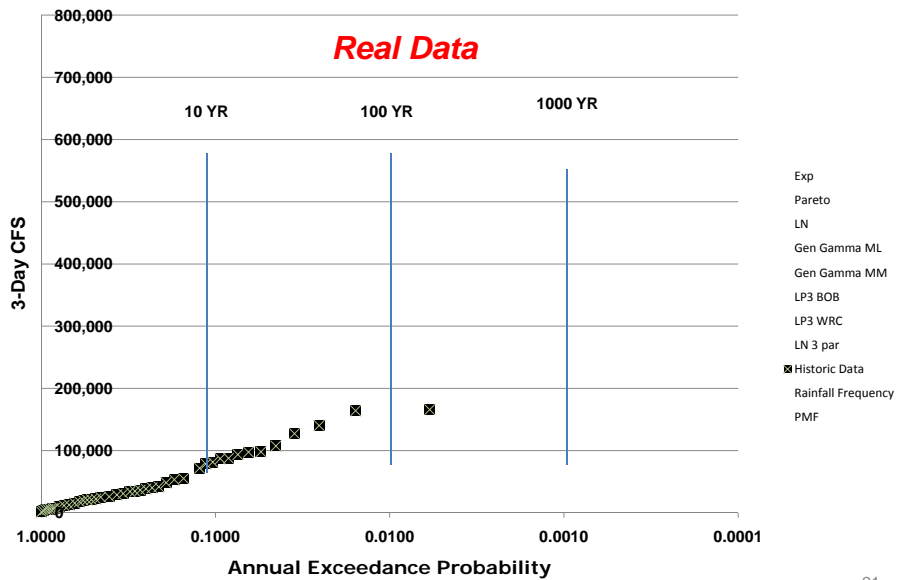
(Log Scale)

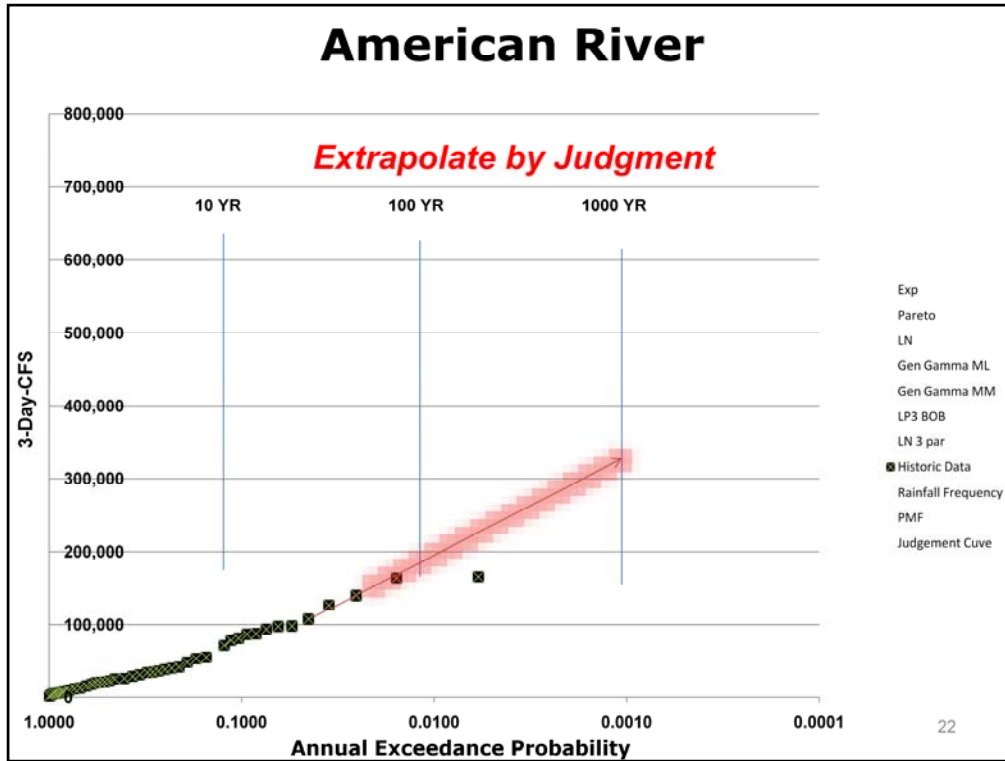
Exceedance Probability for American River



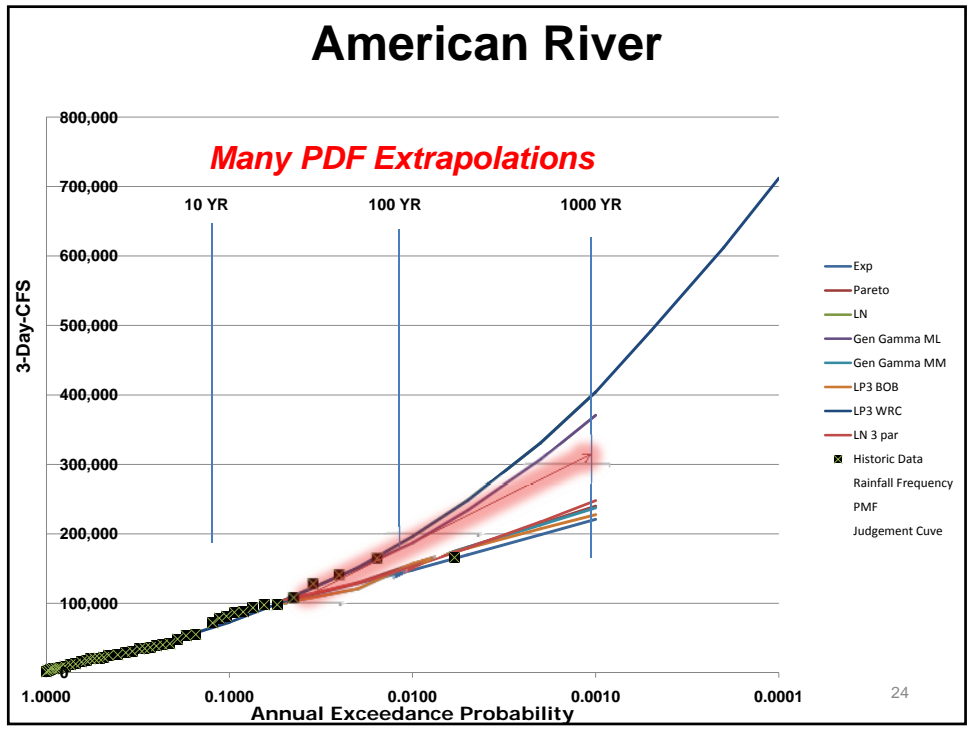
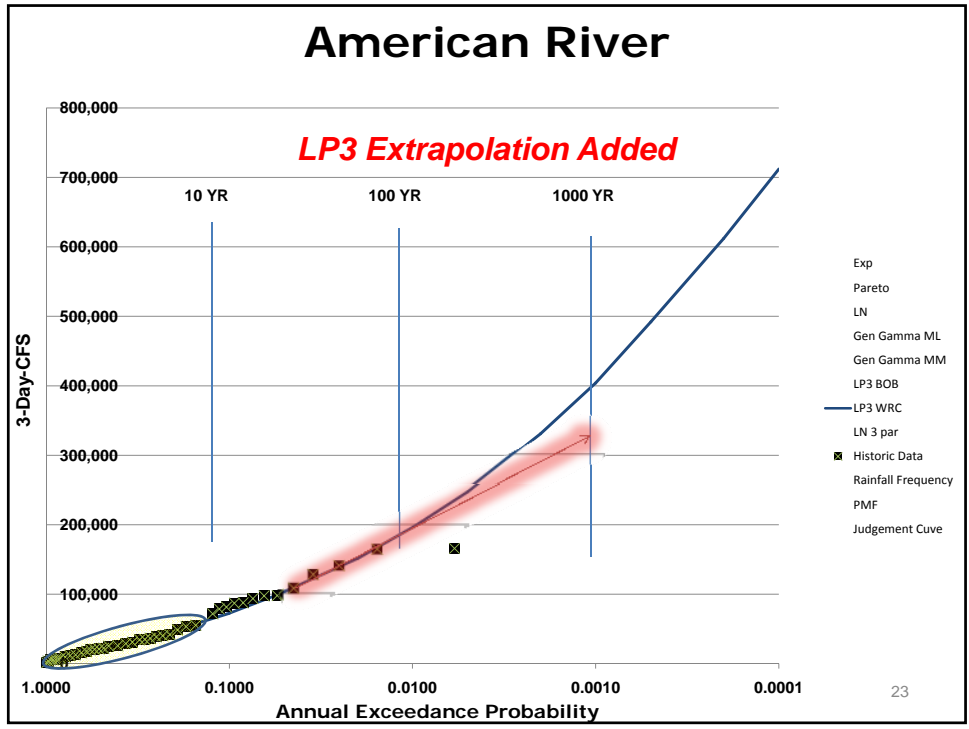
American River

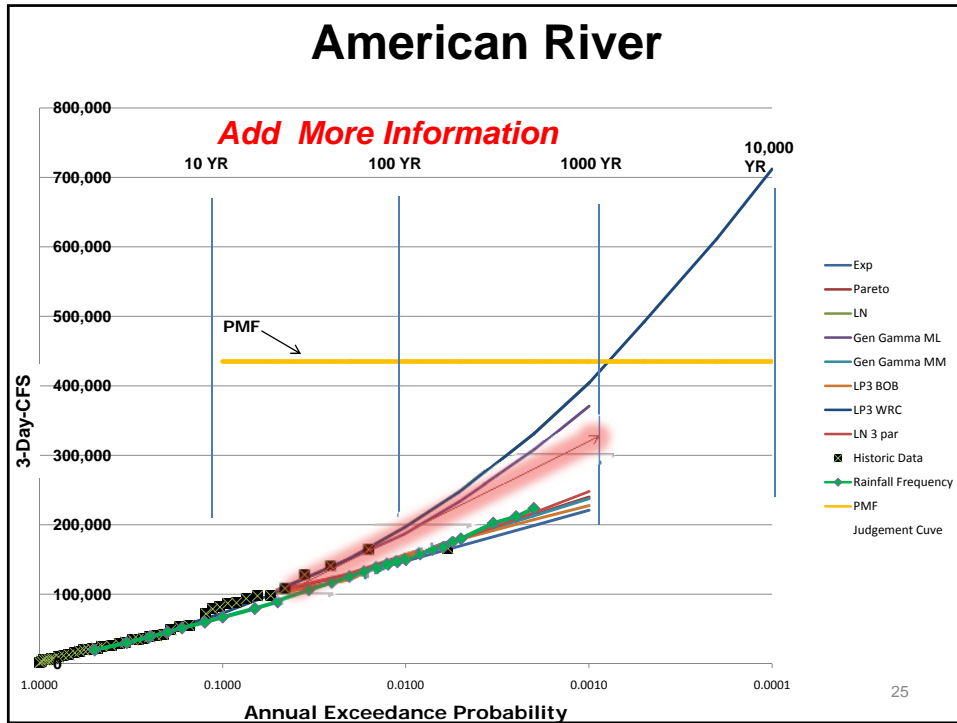
Real Data





Ignore the largest event and project a line through the 2 thru 4th largest.





Remember This!!!

- **LP3 is JUST curve fitting**
- No information about the basic factors of the meteorology or Hydrology of the Watershed is included in the LP3 parameters!
- Extrapolation of curves is an Estimate. Statistics based on primarily small events do not help make a better extrapolation estimate!

Questions That Need to be Asked & Answered

- Is there a relationship between Rainfall and Streamflow?
- Shouldn't the Extrapolation of Flow Frequency Curves be consistent with Rainfall experience and potential?

The answer is **YES!!!!**

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Confidence Intervals

- A way to estimate the Uncertainty of the estimate based on sampling error
- Assumes the pdf chosen is a true representation of the Flood Data population
- *Validity cannot be Proven for Real Flood Data– **NEVER!!!!!!***

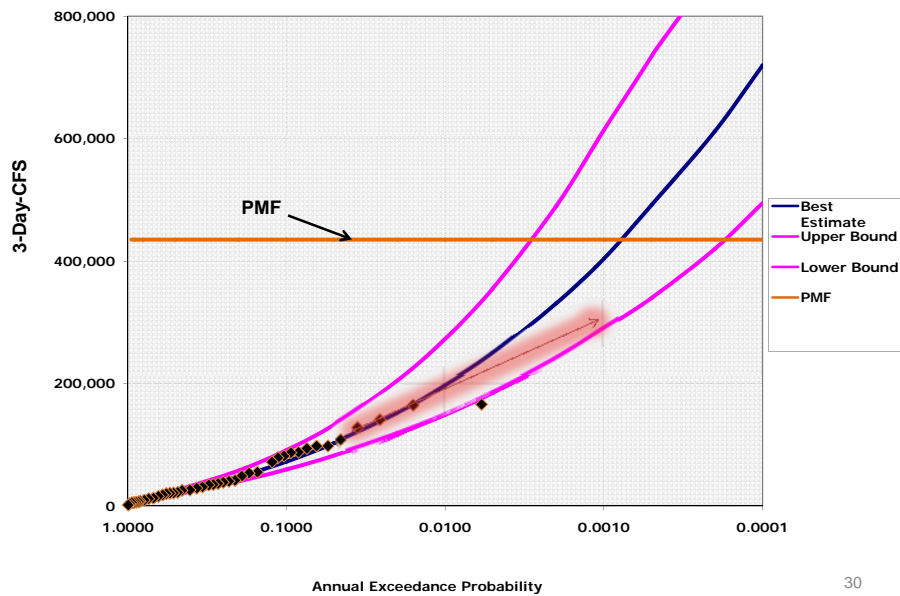
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What do Confidence Bounds Look Like?

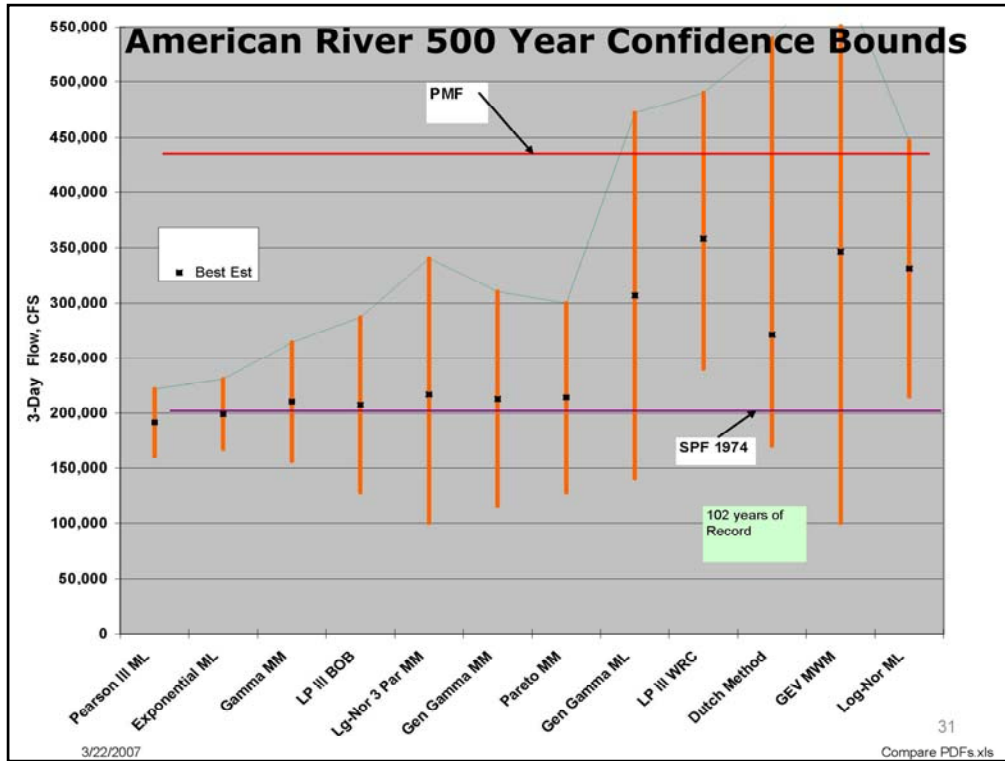
- Very Impressive!!!
- Impossible to verify

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American River



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Why not use the PDF with the narrowest confidence intervals (CI)? Wrong pdf?????

What is Next?

- **Bulletin 17B is not doing the job for Extreme Flood Events**
 - **Bul 17B** guidance on **extrapolation** is being **ignored**
- **Integrate Precipitation Frequency, Storm Potential, Paleo-Flood estimates and PMF information when making Extreme Flood estimates**

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What to do about Uncertainty?

- **Stop Pretending** that the Confident Limit Calculations provides useful information!!!
- Use experience and expertise to establish uncertainty bounds
 - Suggest a fixed percentage for flows greater than the 10 year flood
 - Above all make sure the limits are compatible with Precipitation Estimates!!

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