Looking Toward an Urban Flood Standard

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BIOGRAPHICAL SKETCH

Ron has worked on Central Valley flood management issues for thirty years. In recent years he has worked with the Sacramento Flood Control Agency to fashion floodwater management approaches in the Sacramento Region that could garner strong community and environmental support. During that time he served as a member of the Lower American River Task Force and a liaison to the National Research Council's Committee on Flood Control Alternatives to the American River Basin.

In recent years, Ron served on the California Floodplain Management Task Force, on advisory committees of the Corps/Reclamation Board Sacramento & San Joaquin Basins Comprehensive Study, and continues to serve on the Yuba Feather Workgroup. Ron has been a determined proponent of recognizing the inherent long term dangers of vulnerable floodplain developments in the Central Valley's large regional floodplains — hoping to persuade the Federal, State and local governments to adopt more realistic floodplain management policies that recognize the area's status as a floodplain and to encourage planning to reduce or eliminate damages and loss of life when inevitable flooding occurs.

Ron is also a member of the Sacramento Area Water Forum, a group of community leaders working to fashion water development approaches that protect the area's riverine environments (including the American River Parkway) while helping to satisfy developing community water supply infrastructure needs.

Before beginning his work on the American River for Friends of the River, he had primary responsibility for dam licensing and permitting proceedings (and associated legal and legislative policy initiatives) before the Federal Energy Regulatory Commission, the State Water Resources Control Board, the U.S. Forest Service, and the Bureau of Land Management.

Ron received his Bachelor of Science degree from the School of Agriculture at the University of California at Davis in Plant Science. In his occasional spare time, Ron can be found ambling around mountain trails or floating western rivers with a hand lens and a large Flora in hand searching for rare wildflowers.

ABSTRACT

The California legislature and the Congress are considering the adoption of new approaches to size floodwater management projects and thresholds for floodplain management regulations. Current "level of protection" assessment techniques conflate a series of facts and assessments into one number, obscuring the important individual aspects of system performance or floodplain characteristics - or methodological uncertainties. Potential flood magnitudes faced by communities may be better addressed by methodologies designed to provide realistic estimates of potential worst-case floods rather than flood magnitude "prediction" based on flood-magnitude probability distributions that rely on extrapolating existing stream-gage data. Uncertainties in either system performance, hydraulics, hydrology, topography, or channel stability also need to be addressed by extending floodplain-management regulations to areas behind levees or that could be flooded by reasonably foreseeable floods. Scientific and governmental attention to refining both the "level of protection" and "worst-case" flood methodologies is long overdue.

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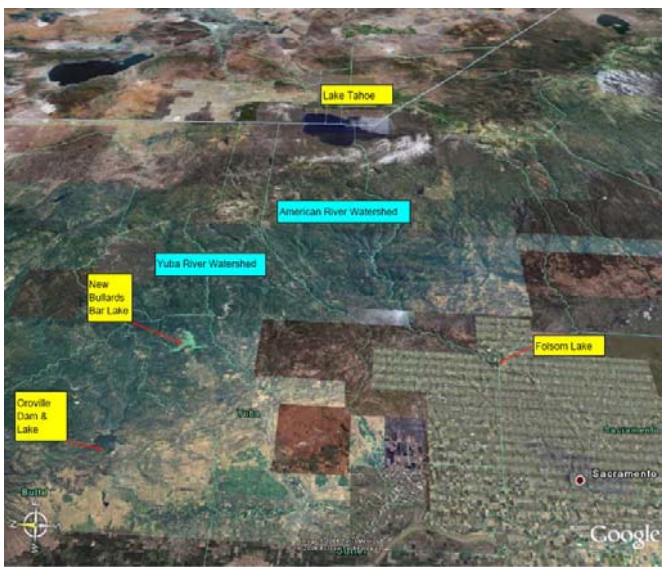
Friends of the River

April 13, 2007

With Examples From the Yuba & American River Watersheds



"Level of Protection" Methodologies

- Today's public depictions of project or floodplain-management performance measures focus on the ability to withstand a given (x)-year flood.
- The above is a mistranslation of the types of the actual performance measures used today -- the 1/x (such as 1/100) estimated annual chance of flooding.

- Annual flood risk (chance of flooding) generally combines the following factors into a single measure-of-performance estimate:
  - Probability distribution of experienced and hypothetical flood flows (sometimes flows in cfs, sometimes x-year flows as in ACE R&U)
  - Stage/flow relationship (sometimes including an estimated probability distribution as in ACE R&U analysis)
  - Levee stability (sometimes including an estimated probability distribution of failures below and above design levee freeboard [R&U])
  - Channel stability

These factors are then usually combined mathematically into one of two different but similarly appearing measures of performance:

- Annual exceedance probability (estimated annual risk that critical events such as a levee-endangering flood stage will occur).
- Conditional exceedance probability (estimated reliability of the system for a specific frequency of storm – including the uncertainty of the "true" flow for that frequency).

Characteristics of "Level of Protection" Type Performance Estimates

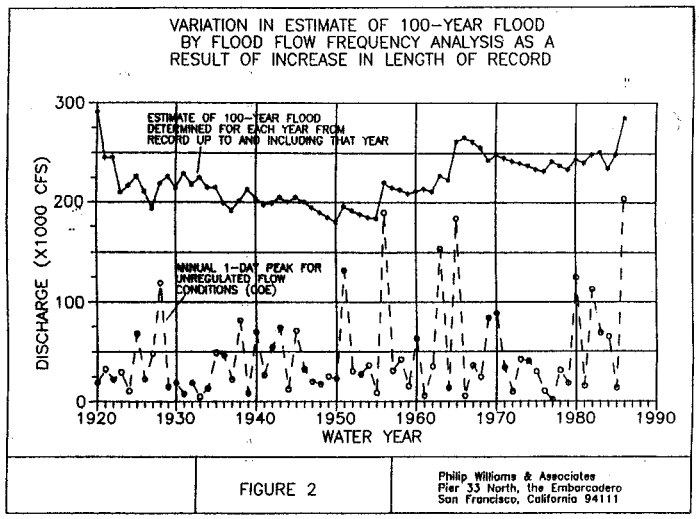
Desirable features of "Level of Protection" Methodologies

- Flow/Frequency estimates can be calculated with a standard statistical methodology.
- Such estimates support calculation of net annual flood-damage-reduction benefits or costs. (This economic-optimization calculation has established the performance goal for federal flood-damage-reduction projects for more than two decades.)

Difficulties with "Level of Protection" Methodologies

"Level of protection" estimates change every year as data accumulate. Estimates are based on past experience, not future conditions.

American River 100-year peak flood estimates



Probability estimates of floods that exceed known flows have increasingly poorer statistical justification at statistically less probable flows, the flows of most interest to flood-vulnerable communities.

"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."

Bulletin 17B, USDI, p.19. (The source of official U.S. WRC [Water Resources Council] flood estimation methodologies)

"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 sample data is only sufficient to provide estimates for the distribution parameters. The errors that are unavoidable in the parameter estimates become intolerable once the frequency curve is extrapolated." (emphasis added)

Flood Hydrology Manual, A Water Resources Technical Publication, by Arthur G. Cudworth, Jr., Surface Water Branch, Earth Sciences Division, First Edition, 1989, United States Department of the Interior, Bureau of Reclamation, Denver Office.

"Practical rule-of-thumb knowledge, which is supported by statistical calculations, indicates that frequency curves are reasonably reliable out to return periods of about the sample record length. The current Bureau practice is to limit the extrapolation of the curves to twice the length of record, or 100 years, whichever is longer. In cases where catastrophic loss, loss of life, or dam safety are involved, further extrapolations can be used as justified on a case-by-case basis."

Flood Hydrology Manual, A Water Resources Technical Publication, by Arthur G. Cudworth, Jr., Surface Water Branch, Earth Sciences Division, First Edition, 1989, United States Department of the Interior, Bureau of Reclamation, Denver Office.

The official U.S. flood frequency determination methodology is only for 100-year floods or more frequent floods.

"The analyses to include when determining the flood magnitudes with 0.01 exceedance probability vary with the length of systemic record…"

"All types of analyses should be incorporated when defining flood magnitudes for exceedance probabilities of less than 0.01."

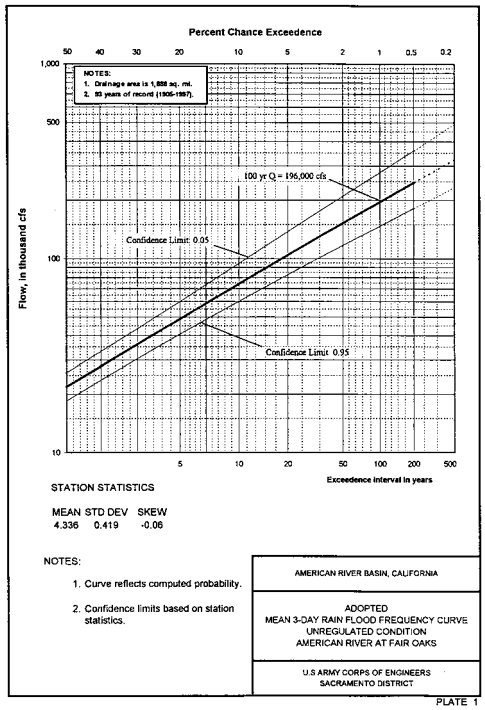
(Bulletin 17B, page 20)

However, there are no official methods to include the additional Bulletin 17B analyses into the standard statistical analysis.

Understanding of the limits of statistical extrapolations have consequences.

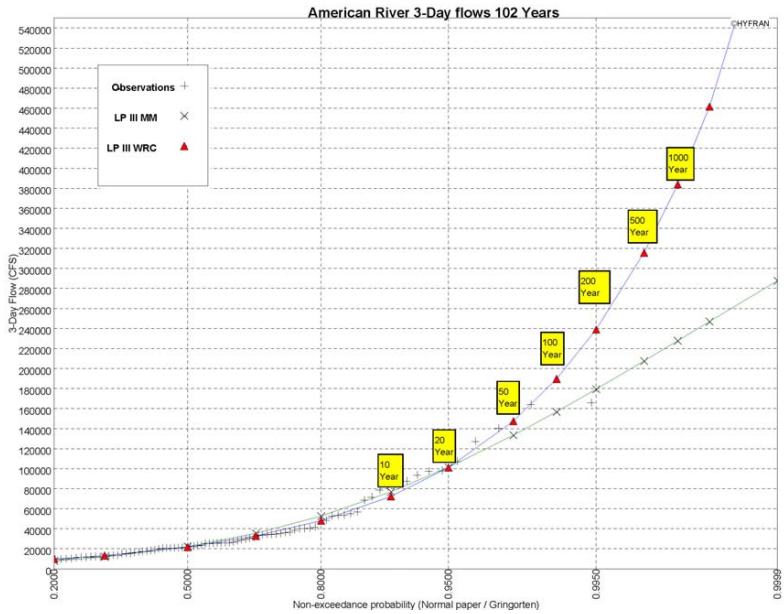
"Based on the evidence that the 'true' distribution flattens for very large floods, the [NRC Committee on American River Flood Frequencies] is hesitant to recommend the use of its selected distribution for annual exceedance probabilities of less than 1 in 200."

(National Research Council, Improving American River Flood Frequency Analyses, p. 66)

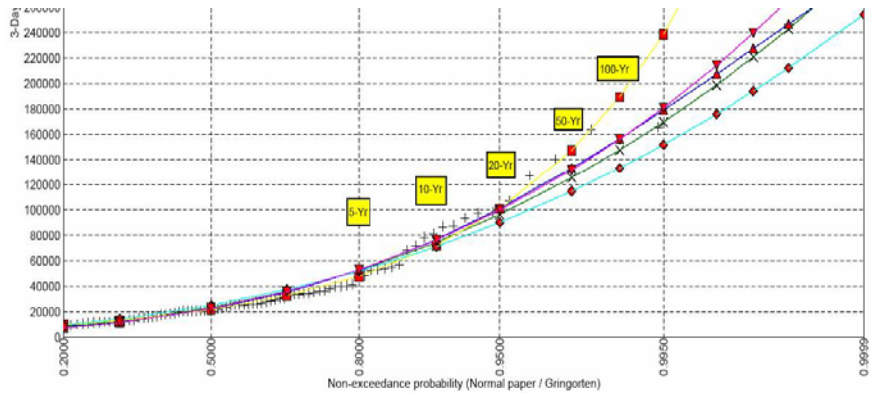


Flood Magnitude estimates for a given frequency are sensitive to the distribution selected – particularly for hypothetical floods exceeding the historic records.

Differences in extrapolated flood frequencies – two LPIII distributions

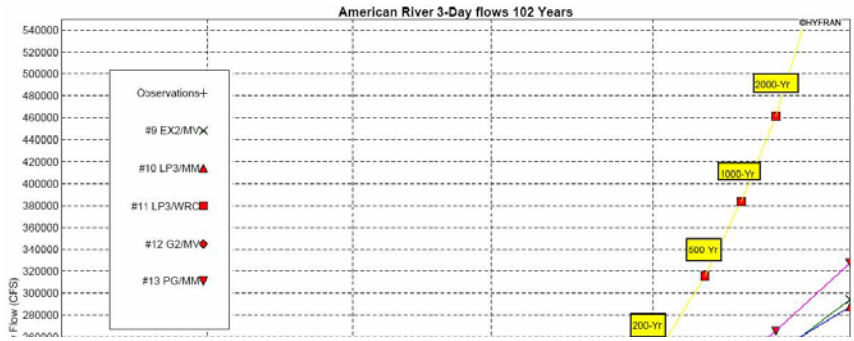


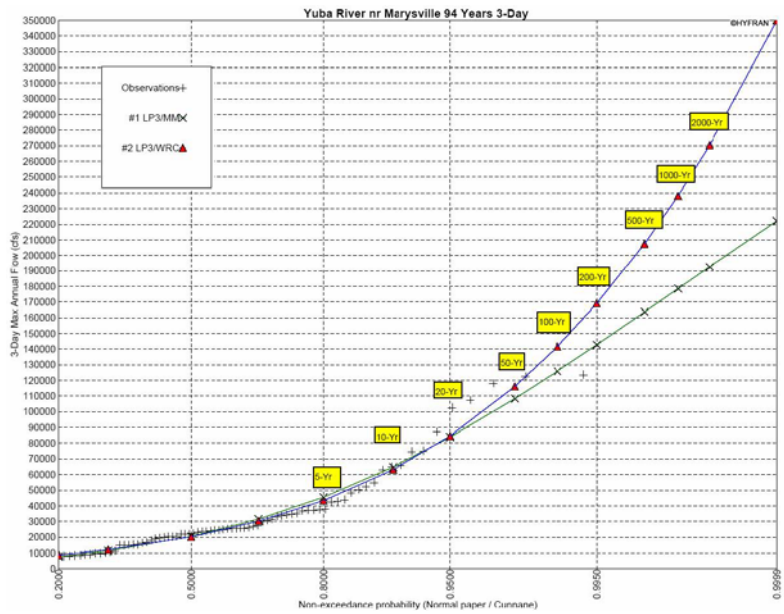
American River 1 to 200-year Flood Estimates
Effect of Distribution Choice
3-Day Flows, 102 Record Years



- 100-year WRC flood estimates exceed 100-year record flood by 10%.
- Distributions stay tight to about the 20-year flood estimate.
- Distributions are already obviously different by the 100-year flood estimate.
- 200-year WRC estimate exceeds 100/150 year record historic flood by 50%.
- WRC estimates are generally higher than other distributions for “rarer’ floods.

American River 2,000-year Flood Estimates – Effect of Distribution Choice

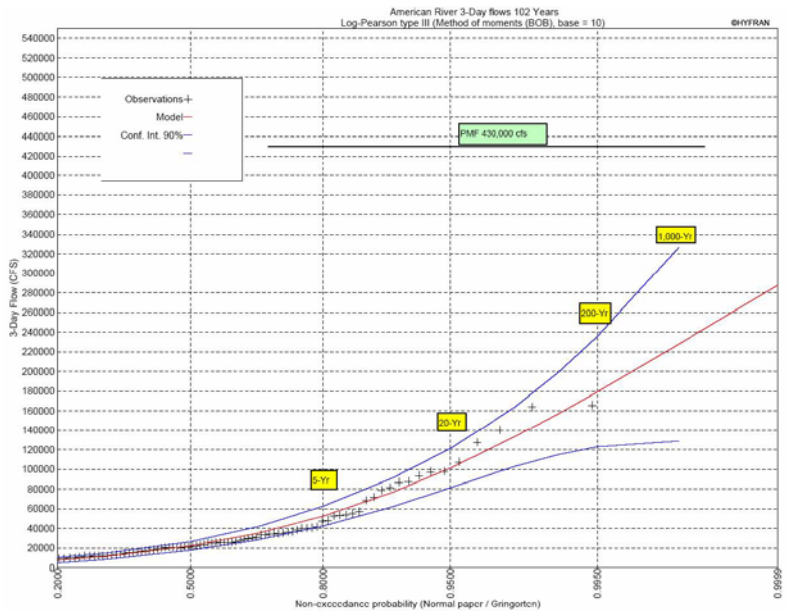




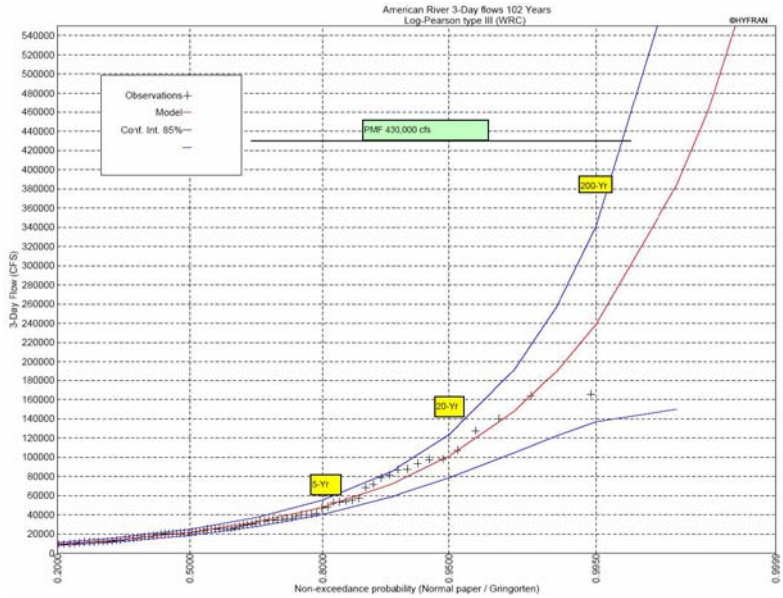
FEMA's Pending Adoption of Corps "Risk and Uncertainty" Methodology

Effects of including statistical confidence-bound uncertainty of "true" x-year flood

A surreal floodplain-management program threshold



"90% certainty" 200-year confidence-bound estimate at 240,000 cfs is 60,000 cfs and 1/3 higher than median LPIII methods of moments estimate.



WRC median estimate equals LPIII MM 90%-certainty confidence-bound estimate. The 85% WRC confidence-bound estimate is 100,000 cfs more & 40% higher than median value.

WRC 500-year-flood estimates exceed estimated maximum floods projected by non- “Level of Protection” methodologies

In the 1950s and 1960s, the standard of federal flood-control planning for high-valued urban property and where significant risks to human life existed was the Standard Project Flood (SPF). The SPF concept was the foundation of the California Floodplain Management Report planning concept called "the reasonably foreseeable flood."

"A hypothetical flood representing the most severe combination of meteorological and hydrological conditions that is considered reasonably characteristic of the watershed."

USACE, ER 1105-2-101, 1952 revised 1965

Final Recommendations Report, California Floodplain Management Task Force, December 2002, p. 58

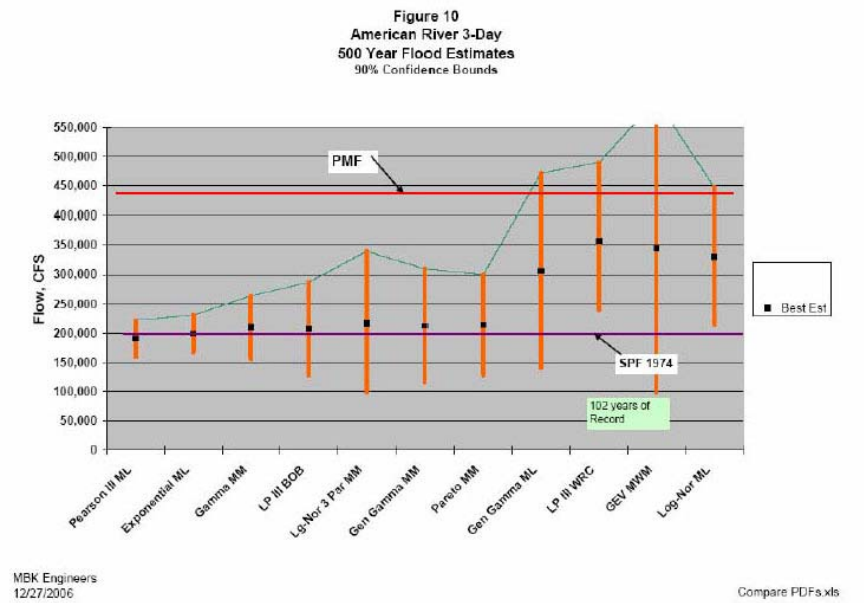
Purpose of SPF

"The SPF is intended as a practicable expression of the degree of protection to be considered for situations where protection of human life and high-valued property is required, such as an urban flood levee or floodwall. It also provides a basis of comparison with the recommended protection for a given project. Although a specific frequency cannot be assigned to the SPF, a return period of a few hundred to a few thousand years is commonly associated with it."

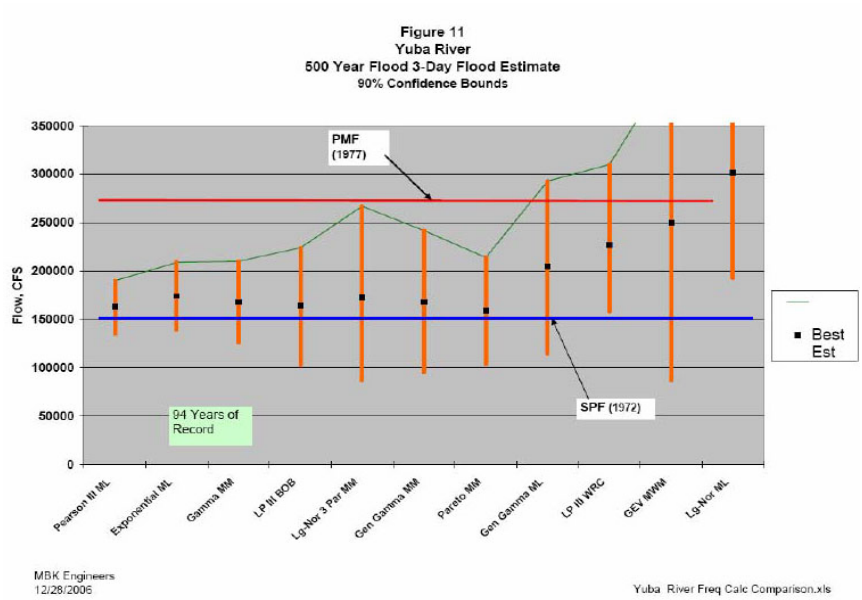
U.S. Army Corps of Engineers Engineering Manual EM 1110-2-1417, Flood Run-off Analysis, 31 Aug 94, p. 13-7

Nature of SPF Methodology

- It is not a statistical-extrapolation methodology. But it is based on either of two approaches.
- Physical models of maximum rain and watershed runnoff potentials.
- Or based on extreme regional-storm experience that is then modeled to be centered over the watershed in question.



WRC 500-year median flood estimates exceed SPF estimates by 75% and the 90% WRC confidence-bound uncertainty estimate exceeds the SPF by 150%



WRC 500-year median flood estimates exceed SPF estimates by 50% and the 90% WRC confidence-bound uncertainty estimate exceeds the SPF by 100%

SPFs and the Comp-Study 200-year flood estimates. Major watersheds

- SPF estimates developed for decades-old Corps Reservoir Regulation Manuals in California have not been exceeded by either historic or subsequent floods.
- The Corps/DWR Comprehensive Study's 200-year flow estimates are generally fairly similar to these SPF estimates.

Table 4
Compare Historic Floods with SPF and Comp Study 200-year Floods

River	Drainage Area SQ Miles	Maximum 3-Day Flow CFS Unregulated	Year of Max Flow (Water Yr)	SPF 3-Day CFS	Max Flow % of SPF	Comp Study [38] 200-year CFS	Historic Max Flow % of 200-year	Year SPF Calculated
Sacramento River								
Shasta Dam	6,421	168,000	1997	180,000	93	180,000	93	1963
Cottonwood Creek								
Nr Cottonwood	927	38,000	1983	54,000	70	55,000	69	1977
Stony Creek								
Black Butte Dam	741	31,000	1995	46,000	67	55,000	56	1958
Feather River								
Oroville Dam	3,611	244,000	1997	286,000	85	295,000	83	1958
Yuba River								
Nr Marysville	489	123,000	1997	153,000	80	170,000	72	1972
American River								
Folsom Dam	1,888	166,000	1986	193,000	86	237,000	70	1974
Mokelumne River								
Camanche Cam	627	39,000	1997	55,000	71	62,000	63	1961
Calaveras River								
New Hogan Dam	363	18,000	1956	33,000	55	28,000	64	1958
Stanislaus River								
New Melones Dam	904	50,000	1997	58,000	86	82,000	61	1958
Tuolumne River								
Don Pedro Dam	1,533	92,000	1997	122,000	75	115,000	80	1961
Merced River								
New Exchequer Dam	1,037	44,000	1997	66,000	67	67,000	66	1959
Chowchilla River								
Buchanan Dam	235	9,600	1956	17,000	56	13,000	74	1964
Fresno River								
Hidden Dam	234	6,900	1956	17,000	41	14,000	49	1958
Sacramento River								
Latitude Verona	21,251	545,624	1997	N/A	N/A	680,000	80	N/A

[38] USACE and Reclamation Board, Sacramento and San Joaquin River Basins Comprehensive Study, Appendix B, Dec 2002.

Reflections

- Defining the hydrologic challenge for flood-vulnerable communities is probably most meaningfully addressed by methodologies that ask that question rather than those that develop statistical relationships defining hypothetical floods based on extrapolation of flood frequencies of historical storms.

- Planning for floodwater and floodplain management projects and programs should be informed by an assessment of the size of reasonably foreseeable hydrologic challenge.
- The threshold for floodplain-management programs should be tied to an assessment of whether flooding is reasonably foreseeable, an assessment that should include vulnerabilities to hydraulic, stage, channel-path, or structural-performance uncertainties, as well as future conditions.

- For projects and programs that rely on structural floodwater management, the uncertain reliability of these structural features is also essential to understand. Failures of structural elements are particularly devastating if the structural elements have been used to avoid floodplain management programs.
- Communities protected by dams that cannot regulate reasonably foreseeable floods or protected by levees or floodwalls subject to failure should undertake floodplain management programs that minimize flood damages and loss of life, as well as insure against financial losses from such floods.

An illustration from

The Times-Picayune

"Corps Team Blames Poor Levees March 27, 2007"

"The Corps already is using information in the report to begin designing improvements necessary to provide protection from hurricanes with a 1 in 100 chance of hitting the city every year."

Although this is just a press account, notice how pervasive the statistical-fiction "level of protection" mindset is. The more important question of what measures would be necessary to protect New Orleans from the reasonably foreseeable hurricane (a category 5) did not appear in the press account, and perhaps the report itself. That conversation should be happening in New Orleans, as well as with California and National policy makers of our state's and the country's floodwater and floodplain management programs.