REGIONAL REGRESSION ANALYSIS LAKE TAHOE BASIN

US Army Corps of Engineers

Sacramento District

in cooperation with

Lake Tahoe SWQIC

ANALYSIS GOALS

- DEVELOP REGRESSION RELATIONSHIPS BETWEEN WATERSHED METEOROLOGIC/HYDROLOGIC CHARACTERISTICS AND FLOW FREQUENCY FOR NATURAL (OPEN) GAGED AREAS

Lake Tahoe Design Problem

- Precipitation Gage Information Limited
- Gaged Watersheds
  - Relatively Large > 0.5 sq mi
  - Natural
- Regression relationships
  - Based on gages with greater than 10 years of record
  - Drainage area average elevation greater than 7000ft

Regional Regression Summary

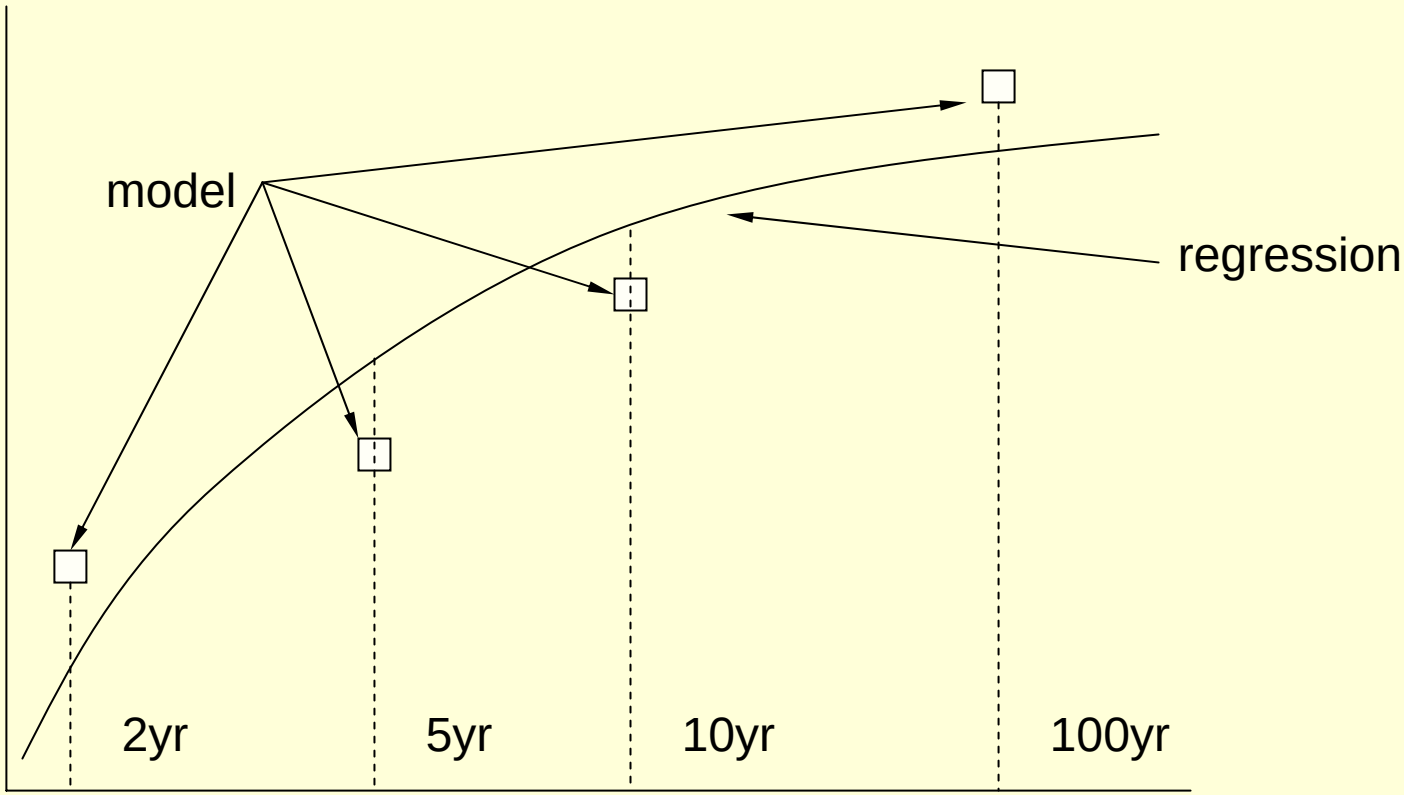
- Goal is to Relate Gage Flow Frequency to Basin Meteorologic and Hydrologic Characteristics
- Regressions can be used to Estimate Flow Frequencies for Ungaged Watersheds
- Basin Characteristics developed using GIS technology and results from PRISM
- Flow frequencies obtained from 20 gages

Regression Results

- Regressions relations
  - Peak Annual Flow Frequency Curves
  - Maximum Annual 1,3,7,10,15, 30 Day Flow Frequency Curves
  - 7Day 10Year Low Flow Frequency Curves
  - Daily Annual Flow Duration Curves
- Drainage Area, Elevation and MAP important characteristics

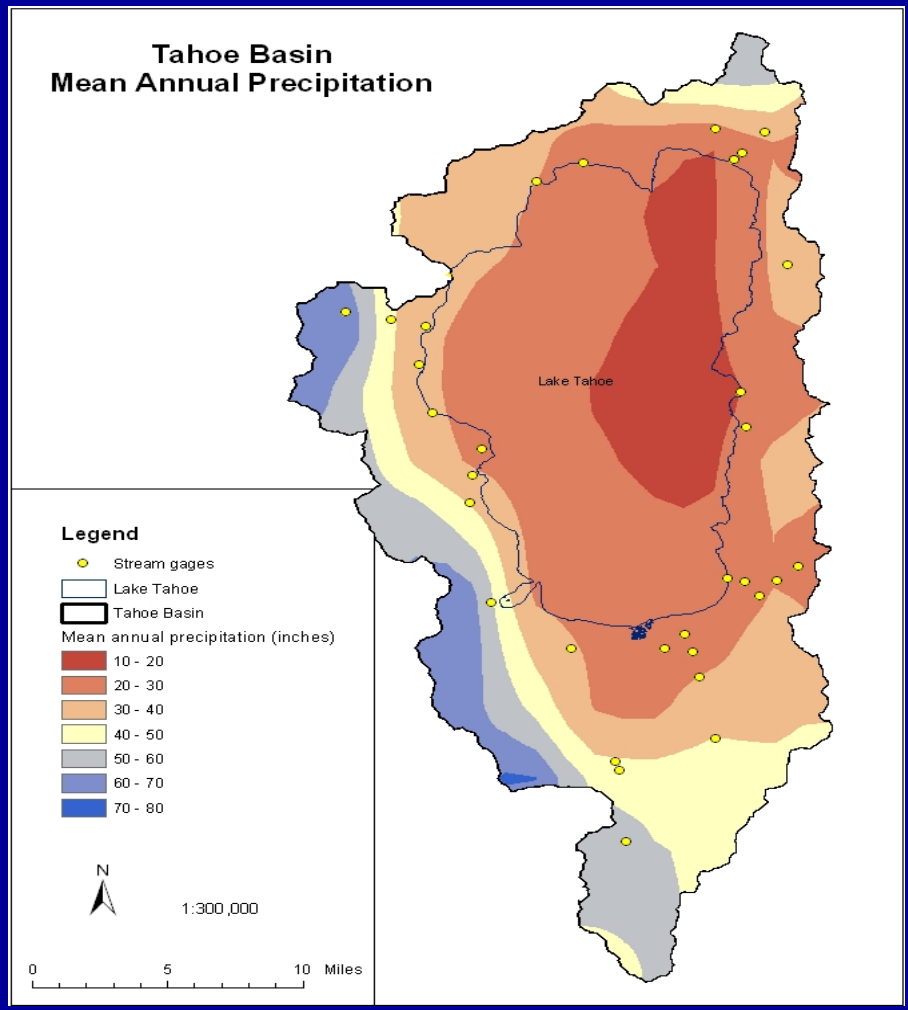
Application with Regional Regression Estimates

PEAK ANNUAL DISCHARGE



RETURN INTERVAL

PRISM – GIS MAP



Flow Frequency Analysis

- Develop regional regression relationships for high flow, low flow and flow duration frequency prediction
- Investigate gages in Lake Tahoe and other Sierra gages that are characteristic of stream flow in Tahoe Basin
- Investigate the significance in relationship between at-gage frequency characteristics and watershed characteristics & met variables

Application

- Ungaged natural basins, DA > 0.1 sq mi
- Provide estimates of flood risk for regulatory purposes for ungaged basins
- Q_7^{10} low flow estimates for water quality
- Flow duration estimates for computing annual average sediment load or other pollutants
- Calibration information for watershed models (runoff per square mile ?)

Regional regression analysis

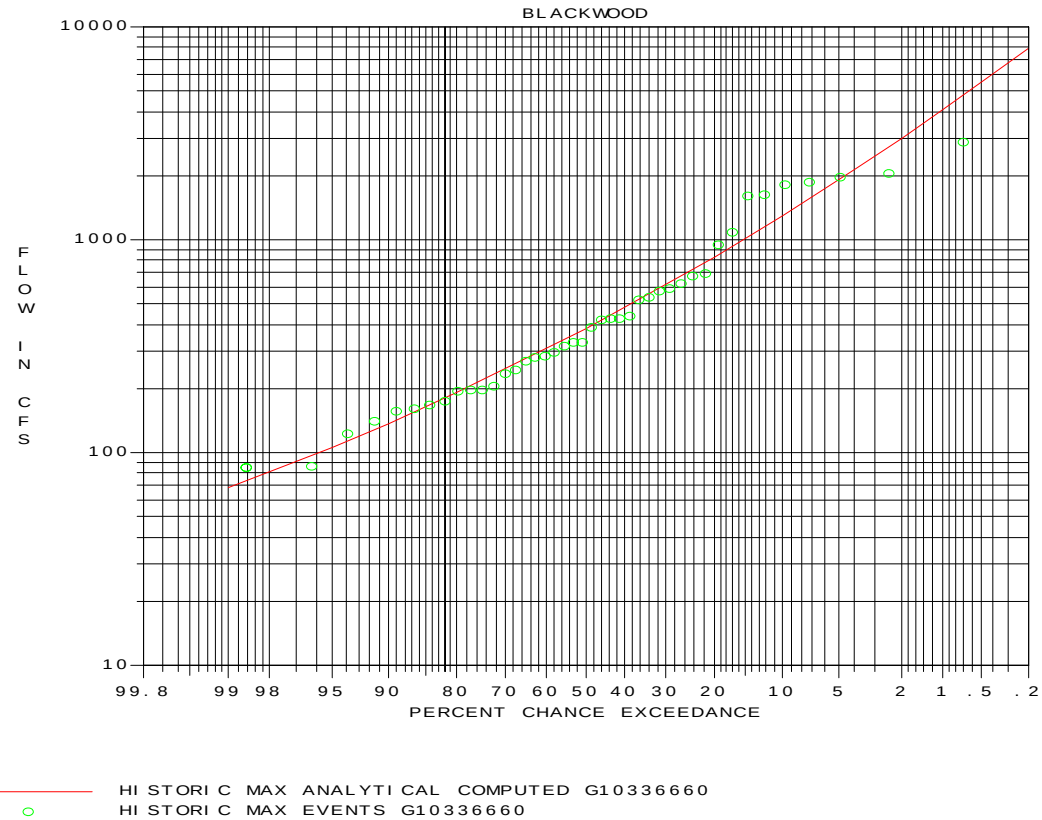
- Regional regression relate gage flow quantiles (e.g., the 100-year flood) to basin characteristic and meteorologic variables
- Applied Generalized Least Squares Regression to obtain relationships
- Standard technique used by USGS to obtain regional regression equations

Regression High Flow Frequency Analysis

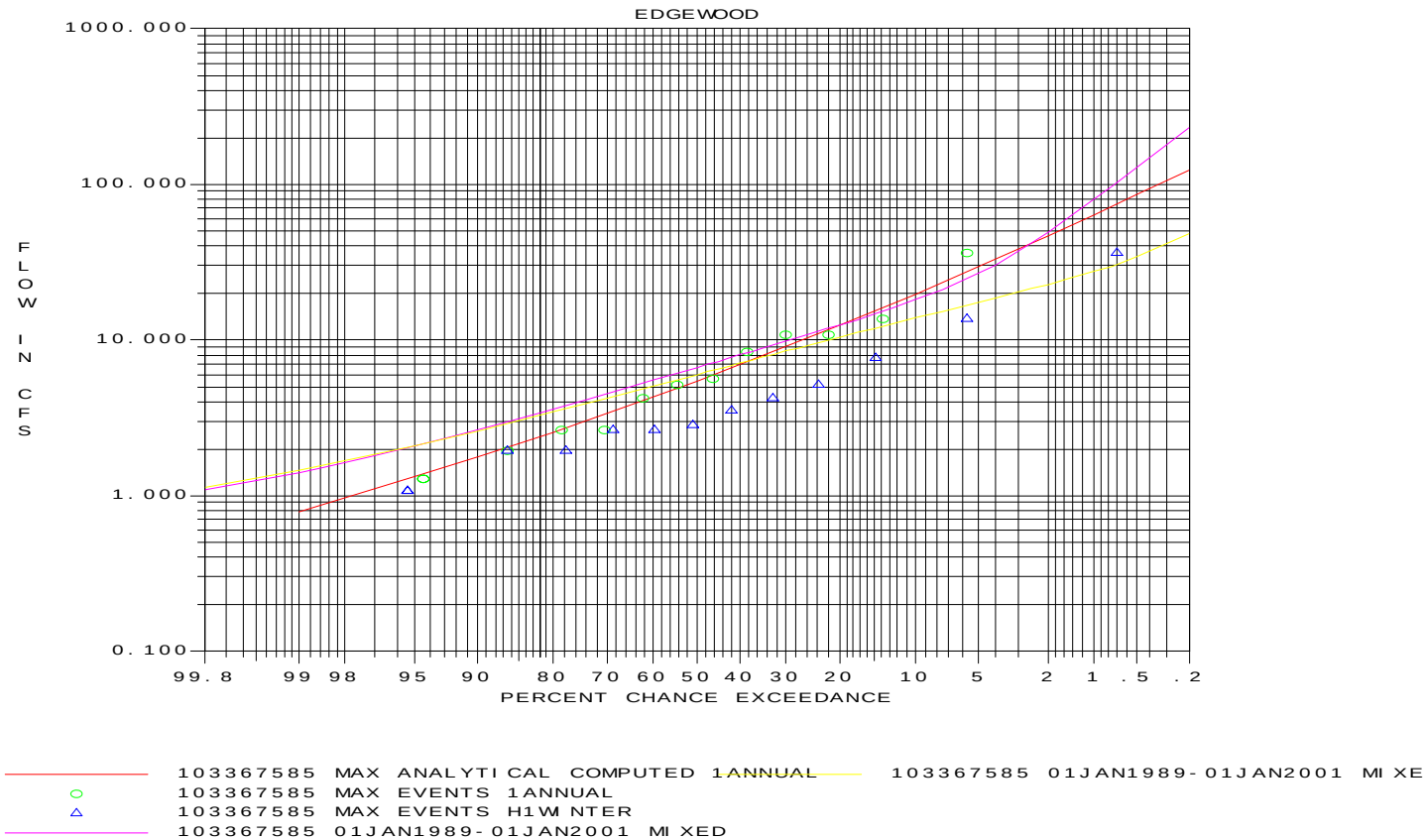
- Estimate flow-frequency from gage data
  - historic weighting of 1997 event
  - mixed distribution analysis
  - compute quantile MSE with historic information (effective record length)

- Estimating regression for Lake Tahoe gages

Blackwood Creek Peak Flow Frequency



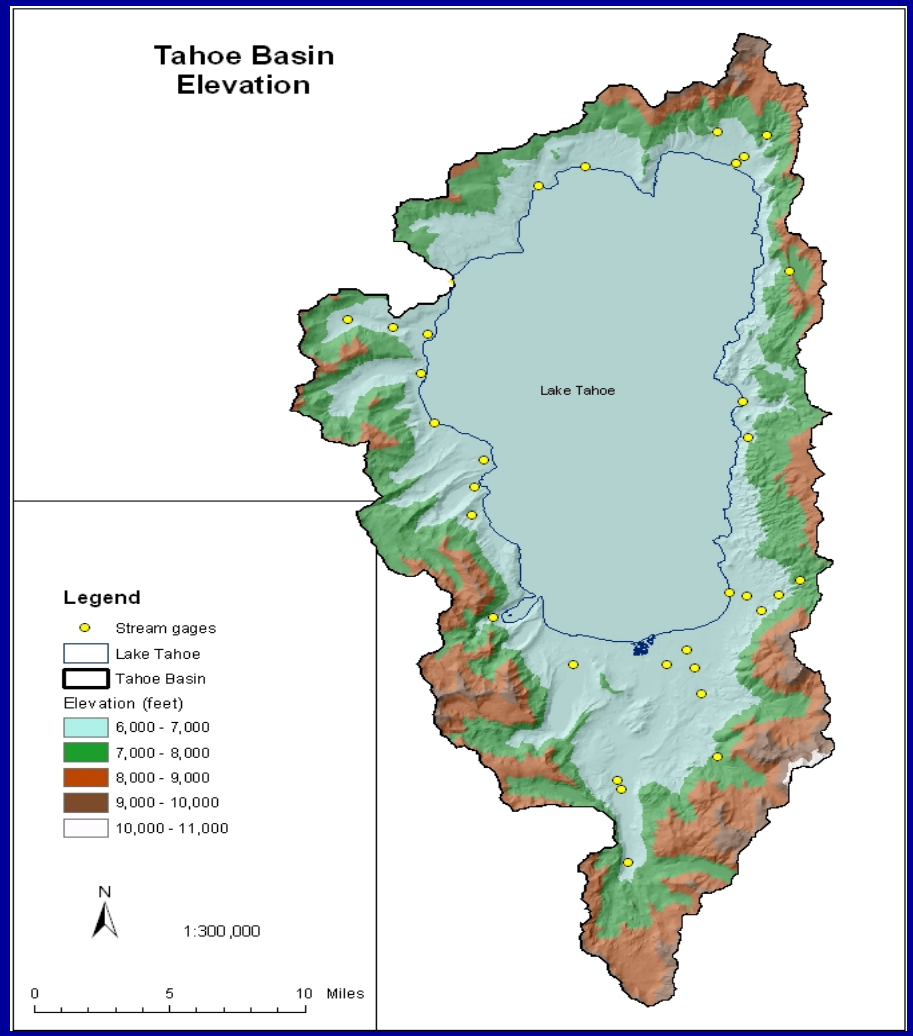
High Flow Frequency Analysis



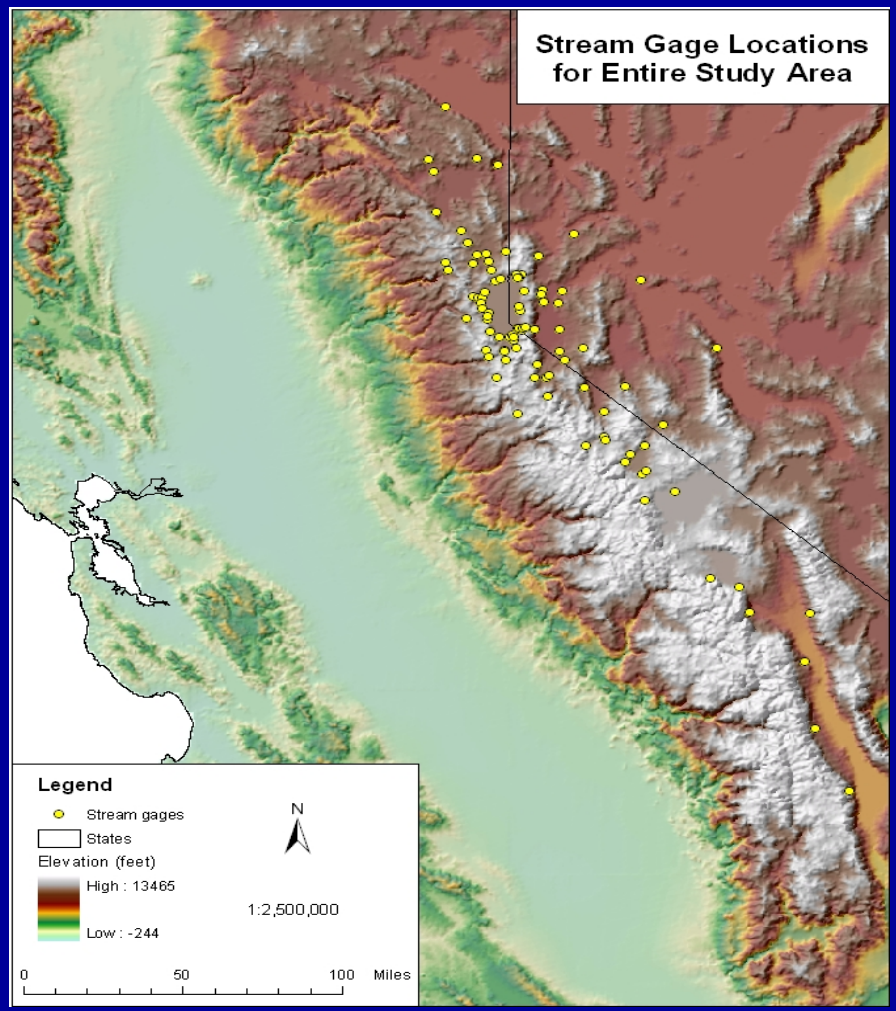
General Regression Relationship

- $\log(Q_p) = b_0 + b_1\log(x_1) + \ldots\ldots + ..e$

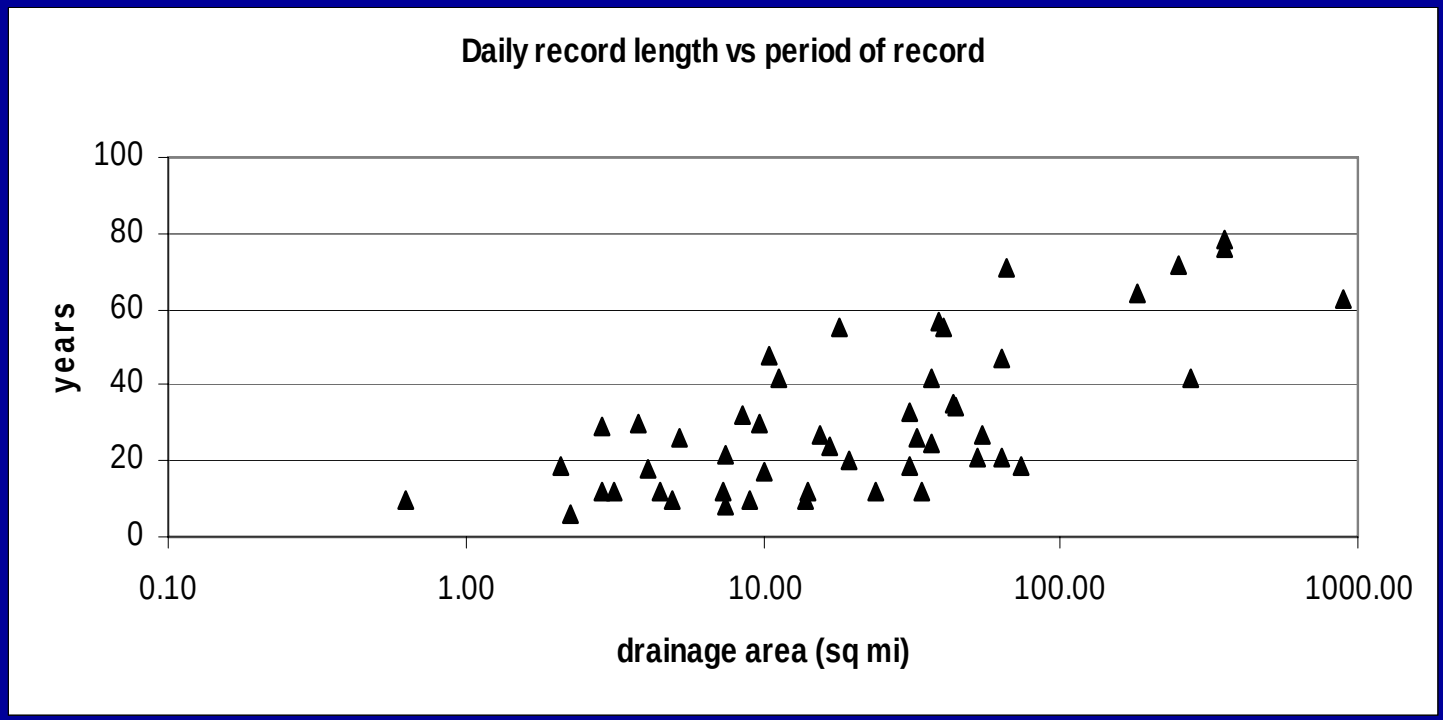
Lake Tahoe Gages



Regional Gages



REGIONAL GAGE RECORD LENGTH



Regression Results

- Regional gages grouped based on statistical tests of influence (leverage)

- Adding regional gages did not improve regression over those obtained for Lake Tahoe gages alone

Lake Tahoe Peak Regression Results

[7]probability	constant (b_0)	[1]area (b_1)	[2]map (b_2)	[3]elevation (b_3)	[4]se	[5]R^2	[6]avp
0.005	23.6472	1.1069	3.5522	-7.1149	0.1725	0.8417	0.0341
0.01	17.825	1.0701	3.5341	-5.6452	0.1078	0.8881	0.0196
0.02	15.6034	1.0548	3.567	-5.1023	0.0793	0.9135	0.0125
0.04	11.8335	1.0345	3.5743	-4.1559	0.0628	0.9281	0.0101
0.1	7.4608	1.0127	3.5824	-3.0633	0.0402	0.9515	0.0094
0.2	2.3416	0.9912	3.5848	-1.7786	0.031	0.9615	0.0106
0.50	-6.7992	0.9581	3.8036	0.4137	0.0246	0.9695	0.0124
0.80	-5.8306	0.9711	4.027		0.0255	0.9711	0.0136
0.90	-6.1263	0.9734	4.1252		0.0388	0.9593	0.0152
0.99	-7.0285	0.9679	4.4863		0.1278	0.896	0.0306

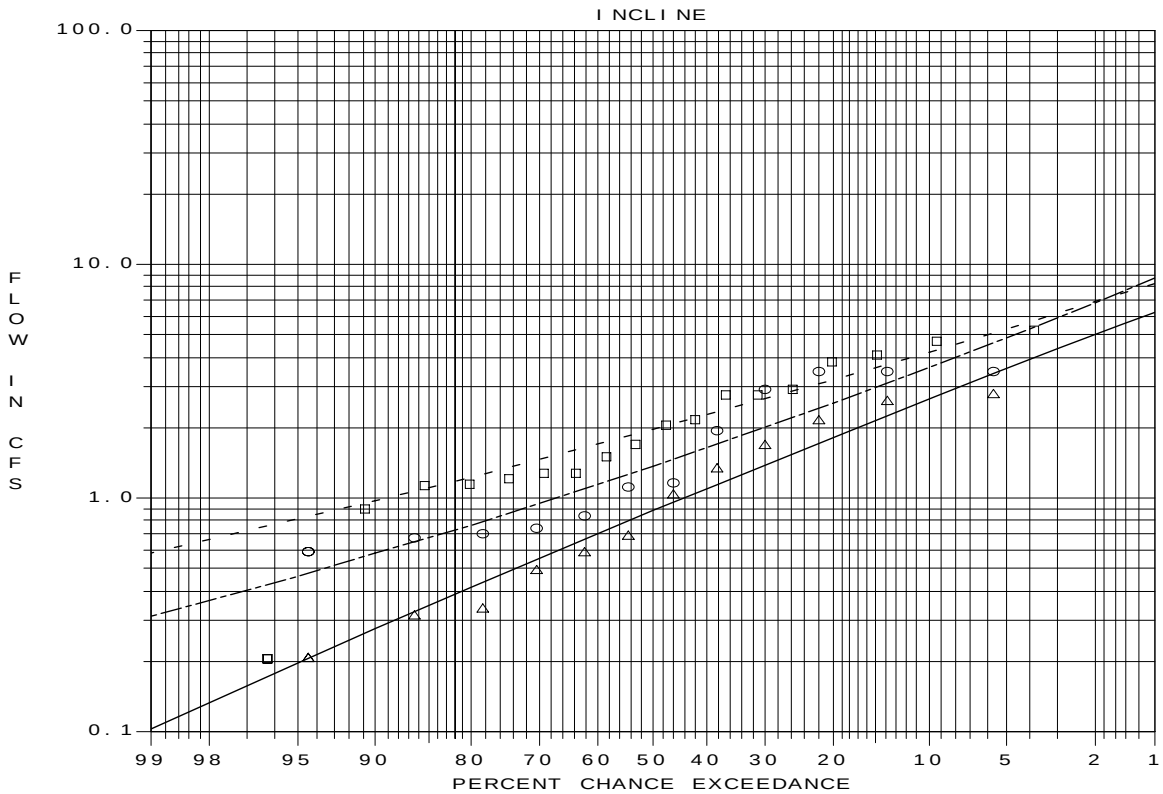
High Volume Duration Frequency Regression

- Obtained Volume Duration Frequency Curves for Lake Tahoe Basin Gages
- 1,3,7,15,30 day annual maximum curves estimated from daily records
- Obtained regression relationships between peak and 1-day, 1-day and other durations
- R^2 values exceed 0.9

Low Flow and Flow Duration Issues

- Low Flow and Flow Duration Frequency Curves non-linear
- Flow Duration curves generally not described by an analytic probability distribution
- Diversions make data non-homogenous (poor records)
- Regional gages were not useable because of diversions
- Sufficient number of Lake Tahoe gages unaffected by diversions

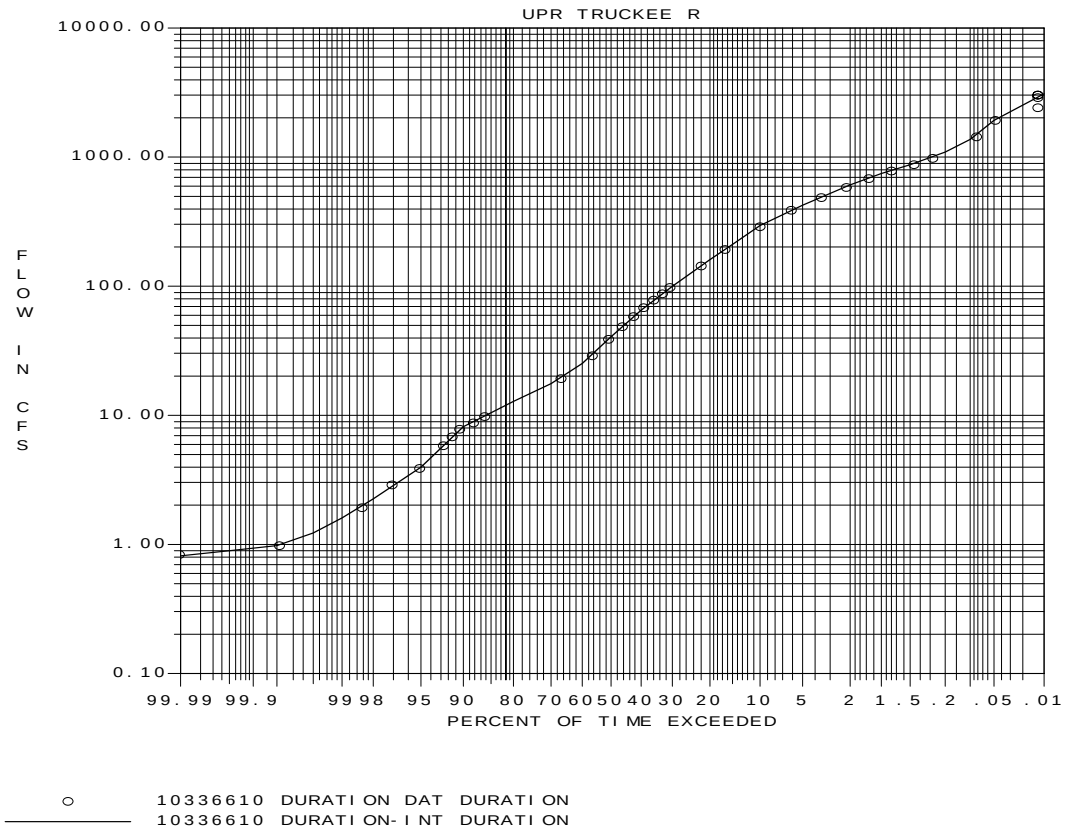
Low Flow Frequency Analysis



Low flow regression 7day duration

[2]Probability	b_0	[3]area (b_1)	[4]snowfall (b_2)	[5]temperature (b_3)	[6]R^2	[7]SE
0.01	133.84415	0.68033	-83.20121		0.77	0.46
0.05	107.53622	0.58155	-66.80492		0.80	0.35
0.10	106.50728	0.57185	-66.10442		0.82	0.32
0.20	111.07000	0.68248	-0.86005	-67.65282	0.86	0.26
0.50	92.88154	0.67949	-1.12005	-55.91357	0.90	0.18
0.80	80.95735	0.69295	-1.42008	-47.99028	0.89	0.16
0.90	76.48834	0.70488	-1.60545	-44.89824	0.88	0.16

Flow Duration Analysis



Flow Duration Regression (Tahoe Gages)

[5]Frequency exceeded (f)	b_0	[1]area (sq mi)	[2]elevation (ft)	[3]MAT (F)	[4]MAP (inches)
99%	-43.8641	0.927195	11.04962		
95%	-38.8409	0.945971	9.789445		
90%	-32.7125	0.970529	8.235106		
50%	32.85813	0.80133		-20.24583805	
[7]50%	-1.64067	0.89692			0.942848
10%	-4.21429	0.85337			3.011556
5%	-4.11273	0.889998			3.038292
1%	-3.97303	0.965017			3.042417

[1]Frequency exceeded	[2]Adjusted R^2	[3] standard error
99%	0.86	0.18
95%	0.87	0.18
90%	0.90	0.15
50%	0.91	0.15
	[4]0.87	0.18
10%	0.96	0.13
5%	0.96	0.13
1%	0.95	0.15

Questions?