Development of Low-Flow Statistics From a Statewide Network

A cooperative program with the Kentucky Division of Water

Gary Martin, Hydrologist

U.S. Geological Survey
Department of the Interior

OVERVIEW

- Uses
- Definition
- Data collection
- Estimating equations

USES OF LOW-FLOW STATISTICS

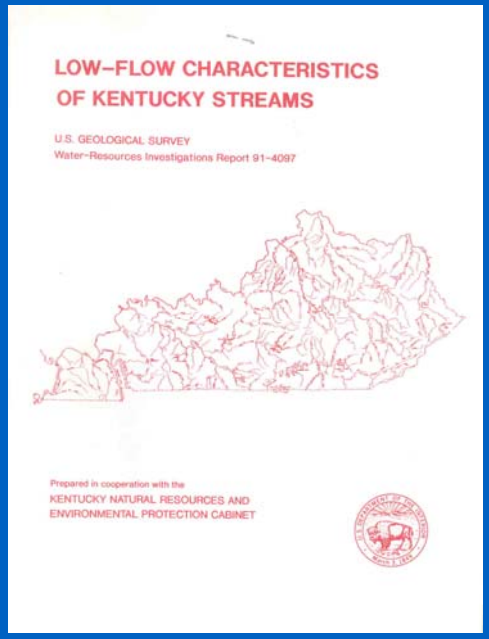
- Water-resources modeling, planning and management
- Waste load allocation to receiving streams for protection of aquatic and human life
- Assessment of surface-water availability to supply users

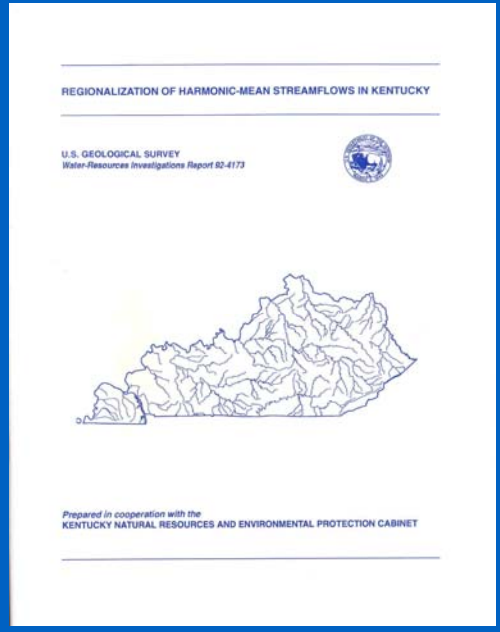
DEFINITIONS

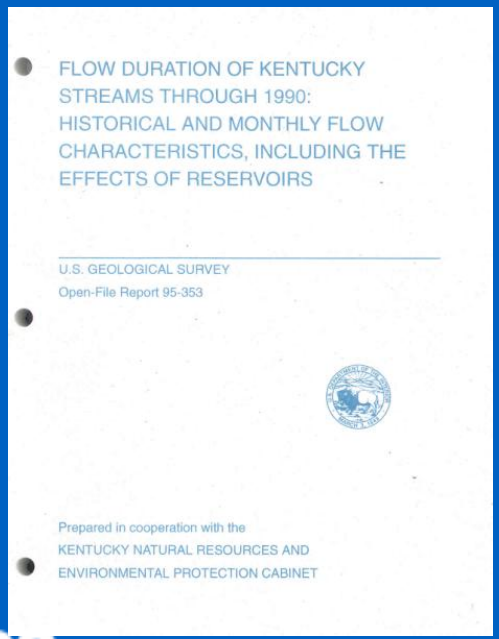
- N-day, T-year low flows: 7Q10, 30Q20

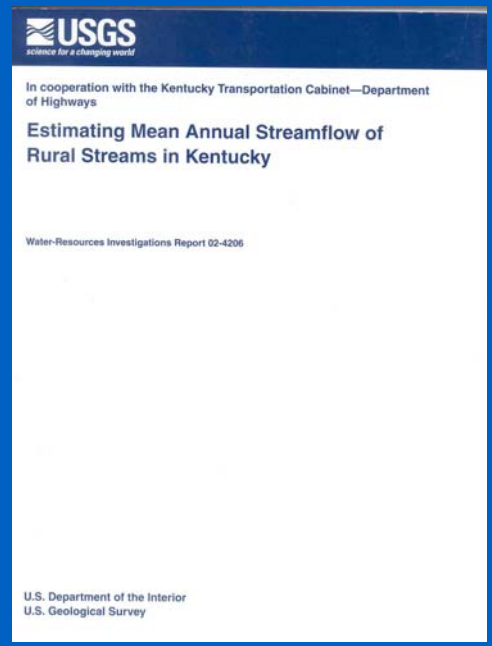
  Lowest mean flow for N consecutive days having a 1/T probability of not being exceeded in any given year

- Harmonic-mean flow
- Flow-duration percentiles







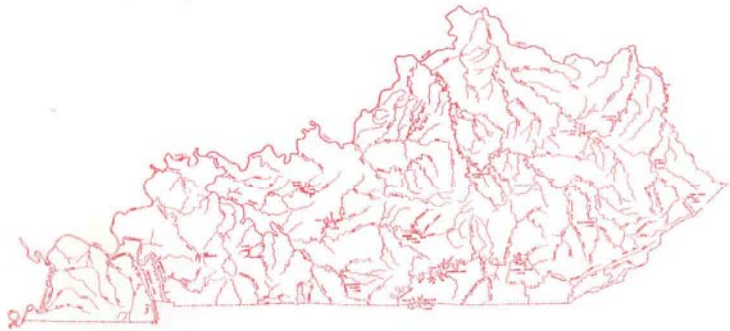


USGS

Low-Flow Network and Statistics

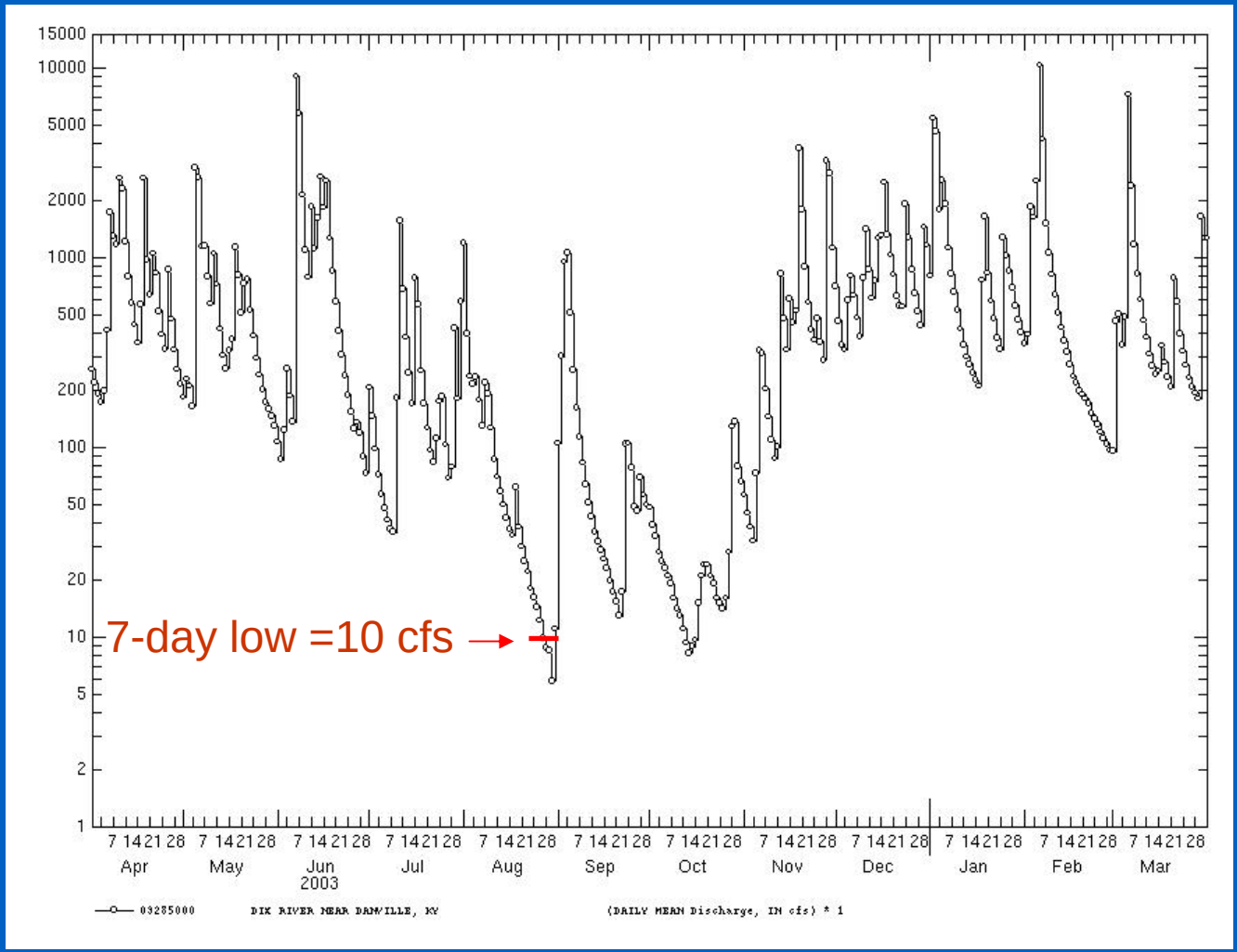
LOW-FLOW CHARACTERISTICS OF KENTUCKY STREAMS

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 91-4097

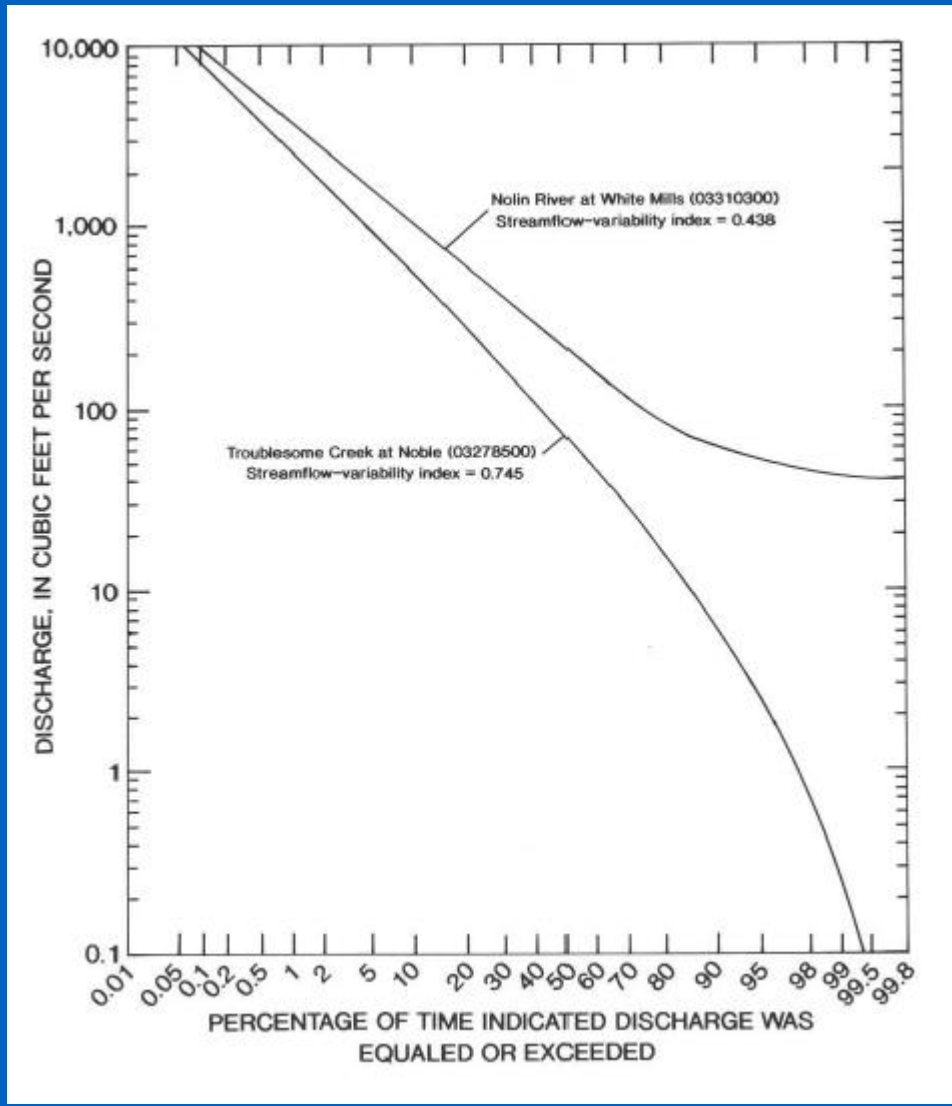


Prepared in cooperation with the
KENTUCKY NATURAL RESOURCES AND
ENVIRONMENTAL PROTECTION CABINET

HYDROGRAPH OF DAILY MEAN DISCHARGE



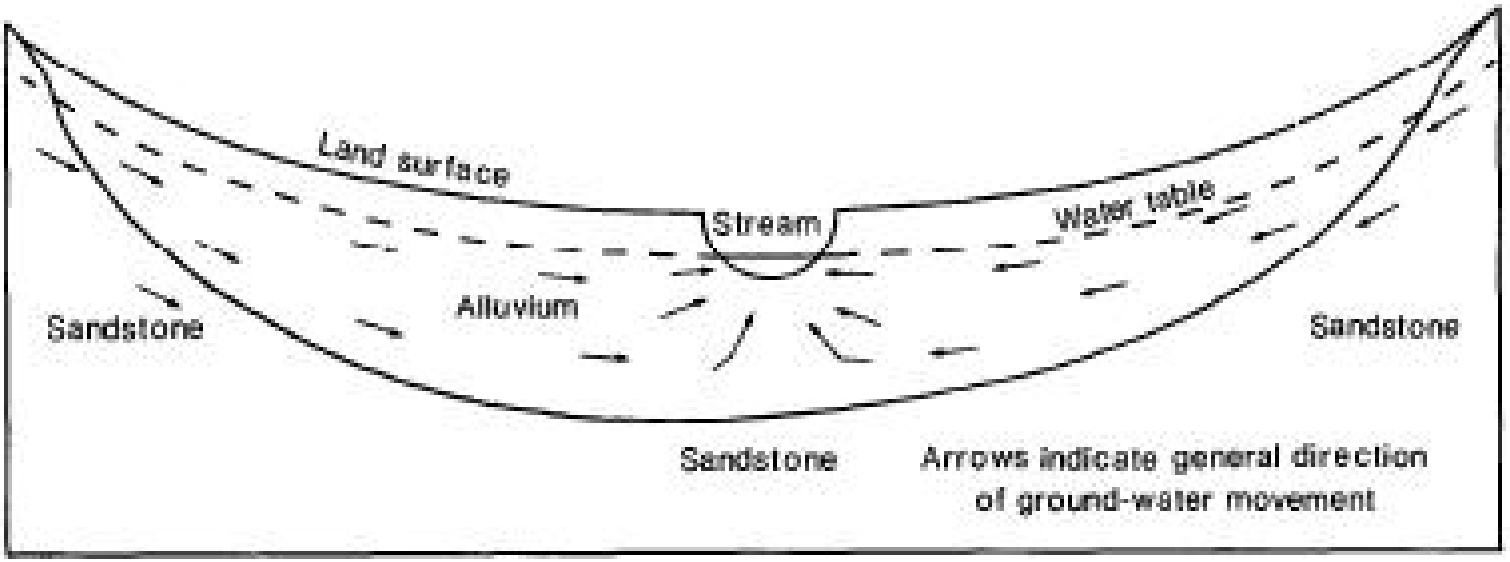
FLOW-DURATION CURVES

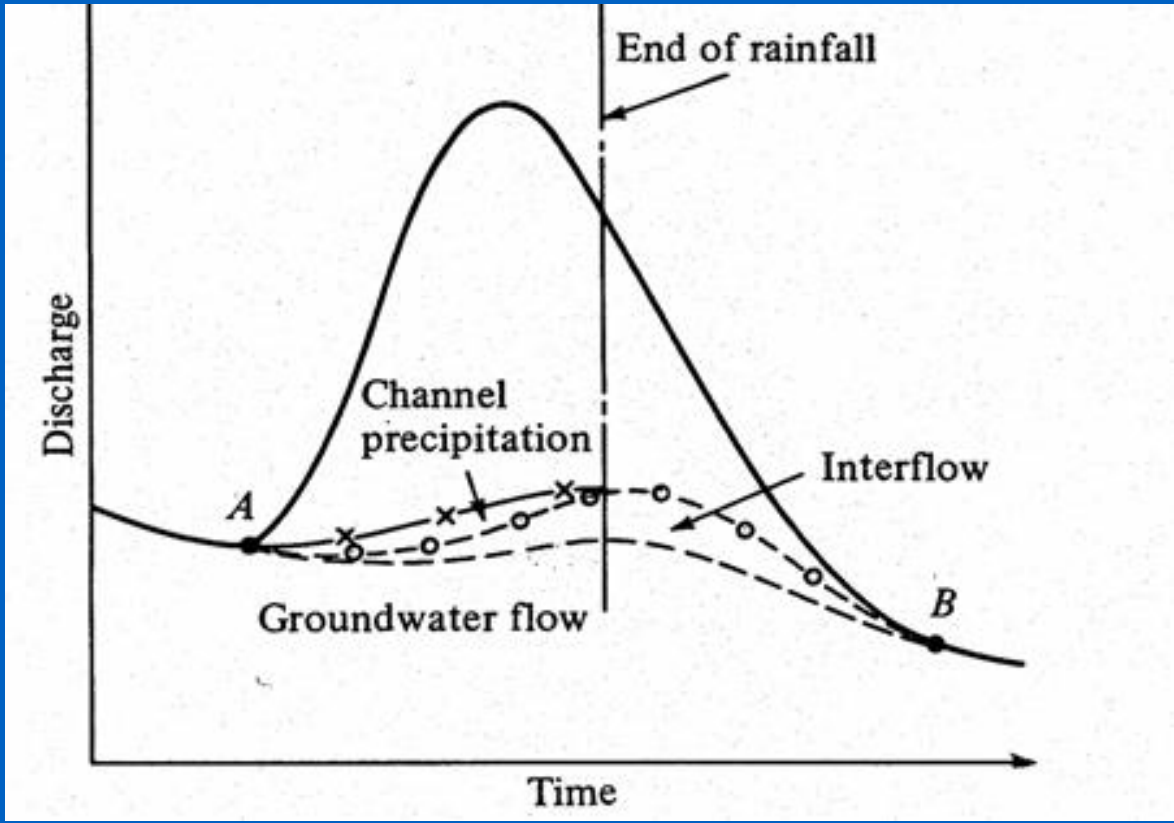


LOW-FLOW CHARACTERISTICS

- Climate: precipitation patterns in time and space, temperature regimen
- Lithology and structure of rock formations

GROUND-WATER CONTRIBUTION



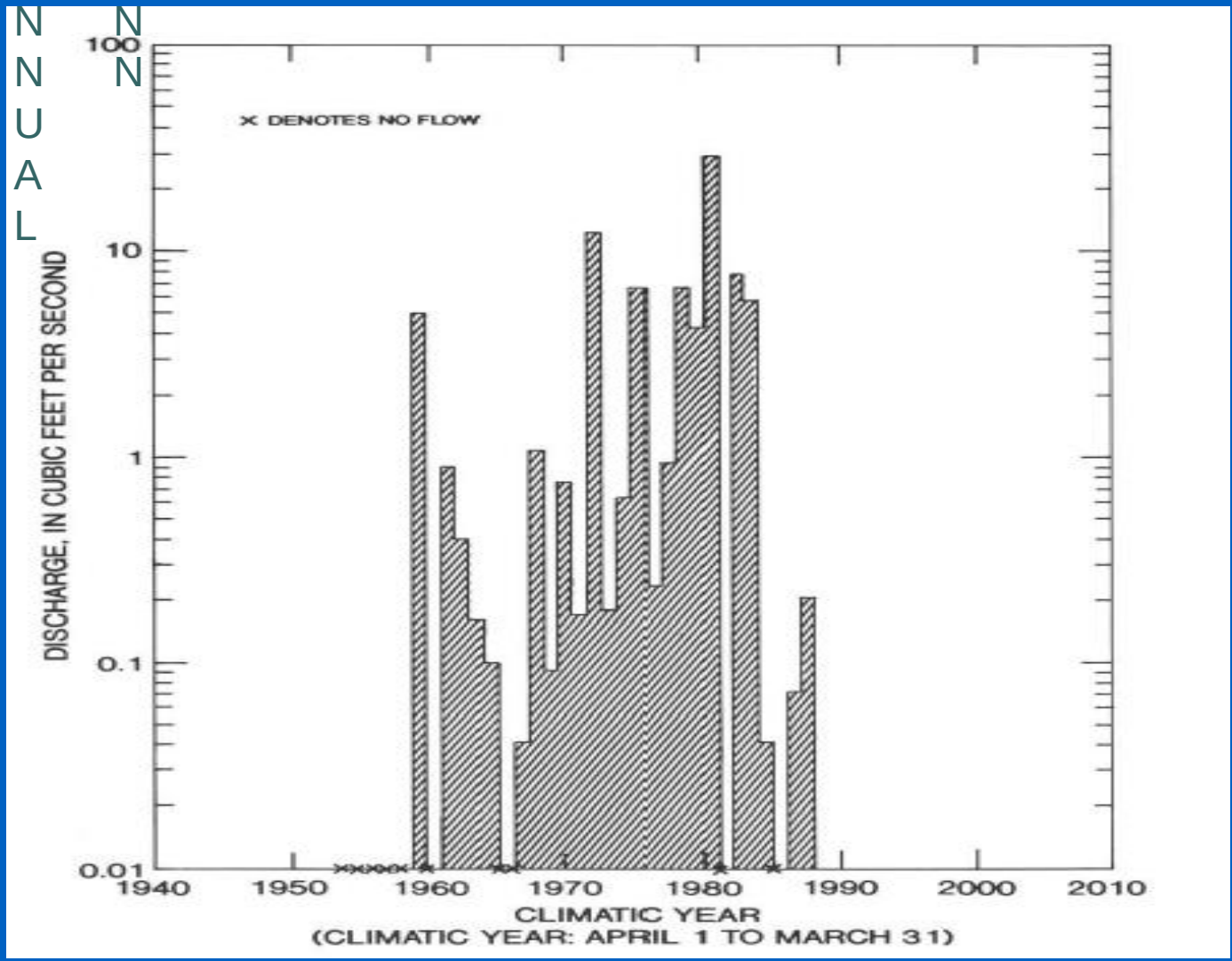

End of rainfall
Discharge
Channel
precipitation
Interflow
A
B
Groundwater flow
Time

LOW-FLOW FREQUENCY ANALYSIS

- Long-term continuous-record stations with 10 or more years of data (climate year April—March): annual N-day low flows
- Check for trends, serial correlation
- Log-Pearson Type III distribution (nonzero)
- $\text{Log } Q_T = X + KS$; f (M, SD, SKEW)
- Adjust graphically, if necessary
- Adjust for zero flows using conditional probability

USGS

ANNUAL 7-DAY LOW-FLOW TIME SERIES



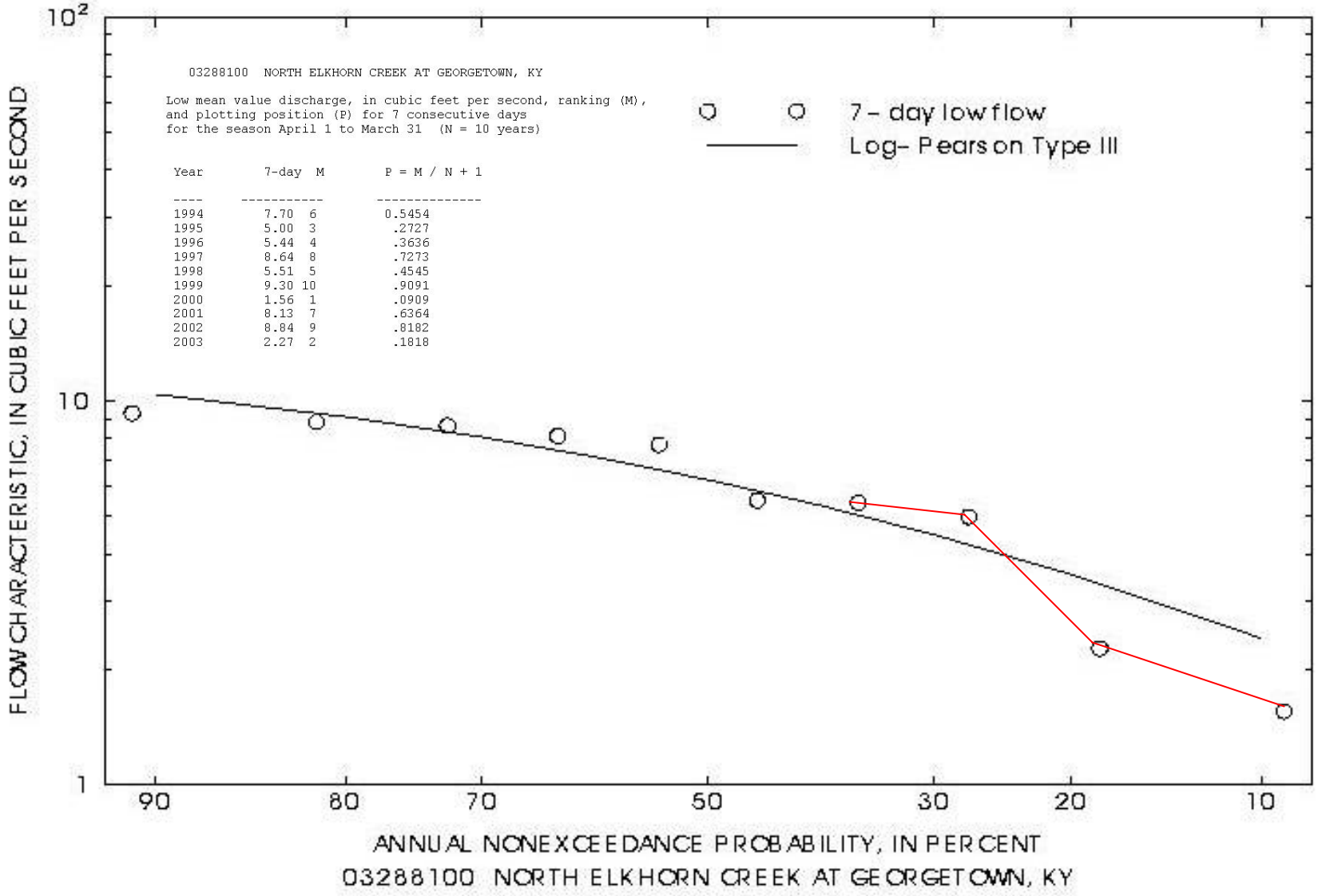
EXAMPLE: GRAPHICAL FREQUENCY CURVE

03288100 NORTH ELKHORN CREEK AT GEORGETOWN, KY

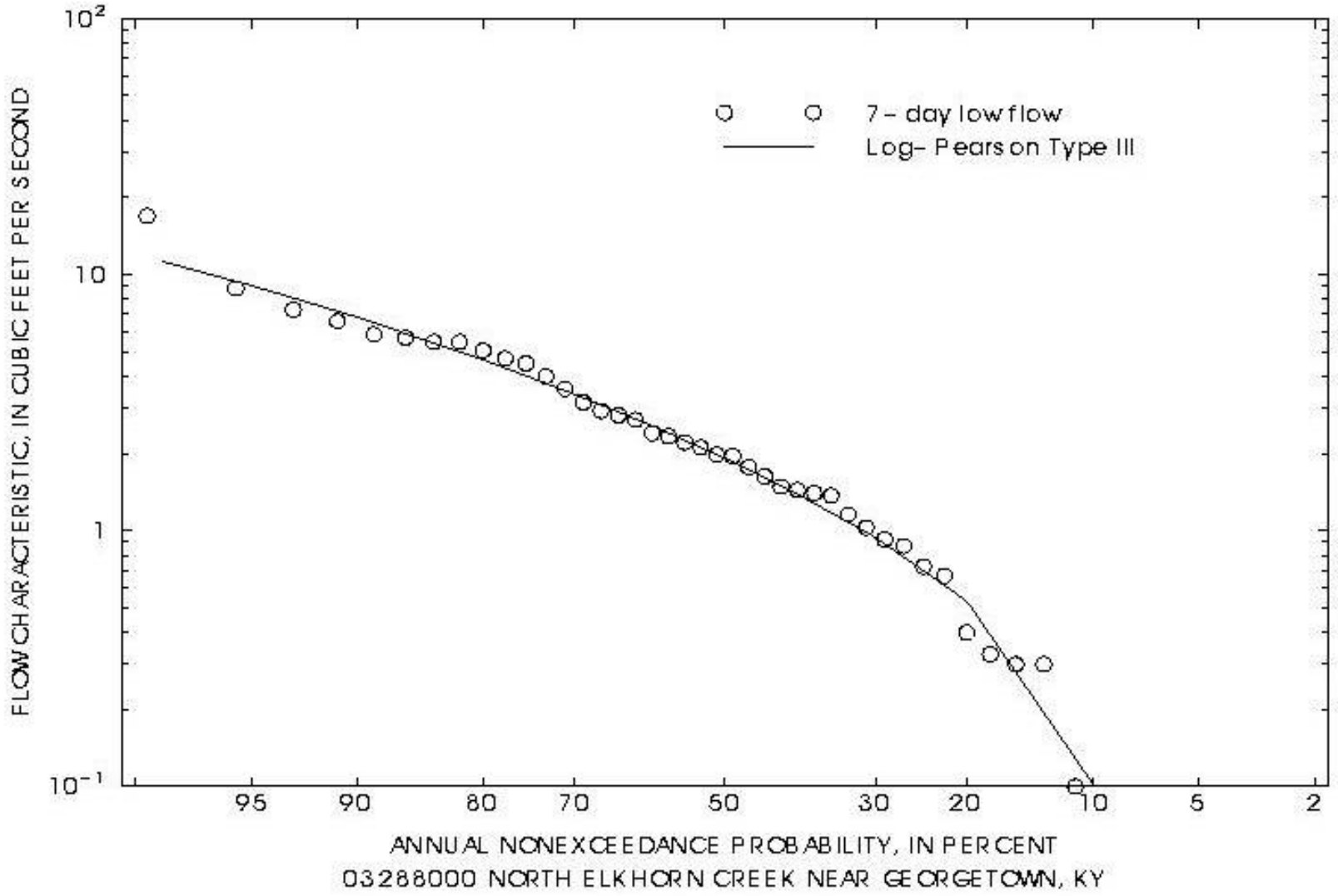
Low mean value discharge, in cubic feet per second, ranking (M), and plotting position (P) for 7 consecutive days for the season April 1 to March 31 (N = 10 years)

Year	7-day	M	P = M / N + 1
1994	7.70	6	0.5454
1995	5.00	3	.2727
1996	5.44	4	.3636
1997	8.64	8	.7273
1998	5.51	5	.4545
1999	9.30	10	.9091
2000	1.56	1	.0909
2001	8.13	7	.6364
2002	8.84	9	.8182
2003	2.27	2	.1818

FREQUENCY CURVES

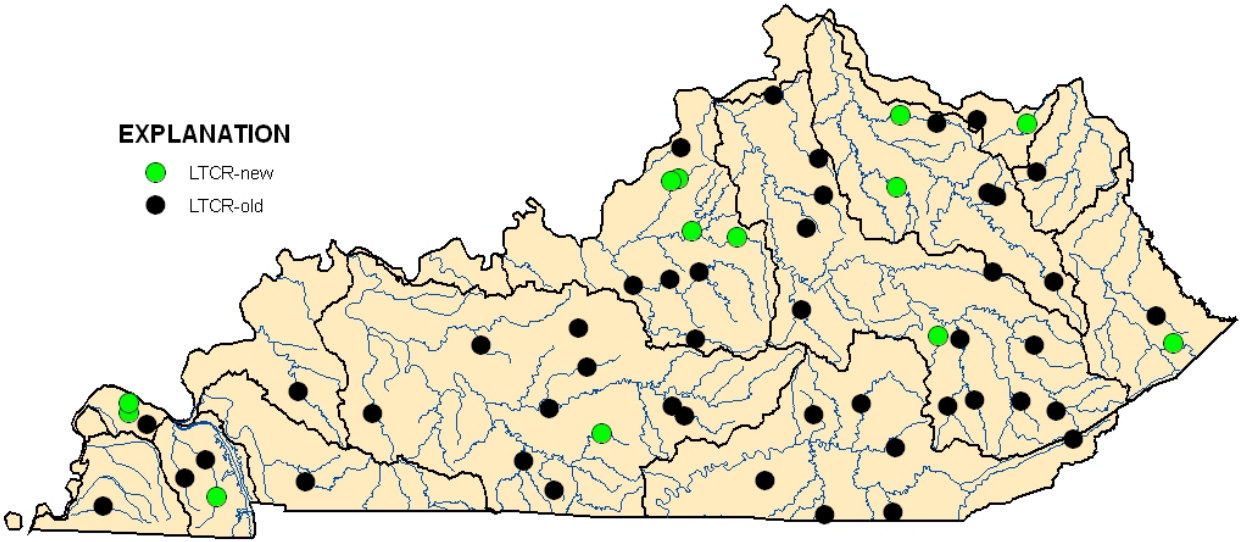


FREQUENCY CURVES



DATA COLLECTION NETWORK

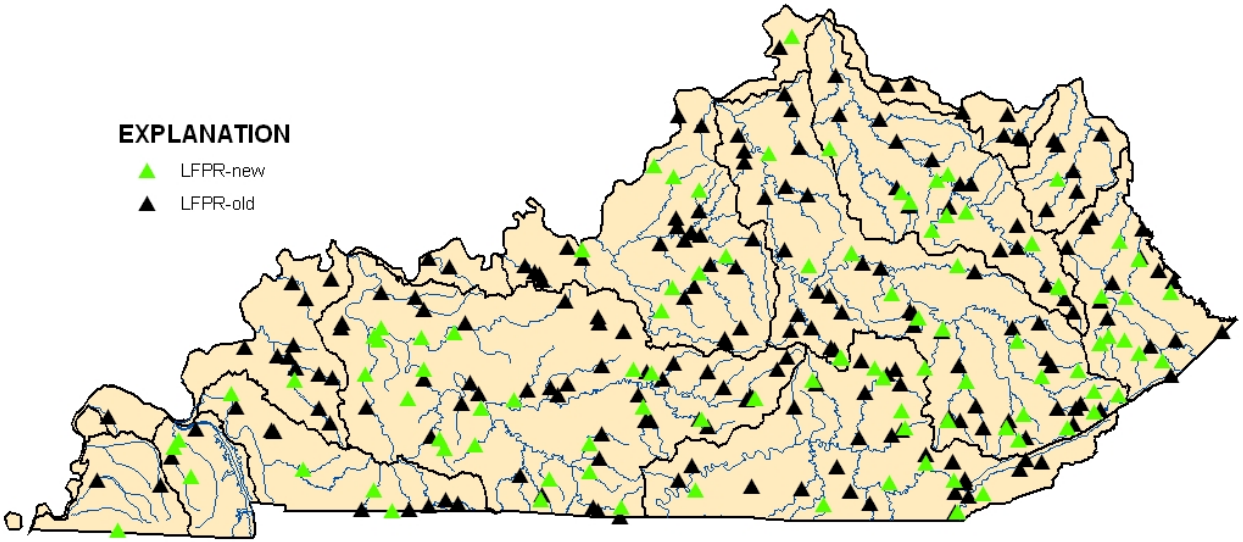
Low-Flow Index Stations



59 Index Stations: 13 new, 46 previous

DATA COLLECTION NETWORK

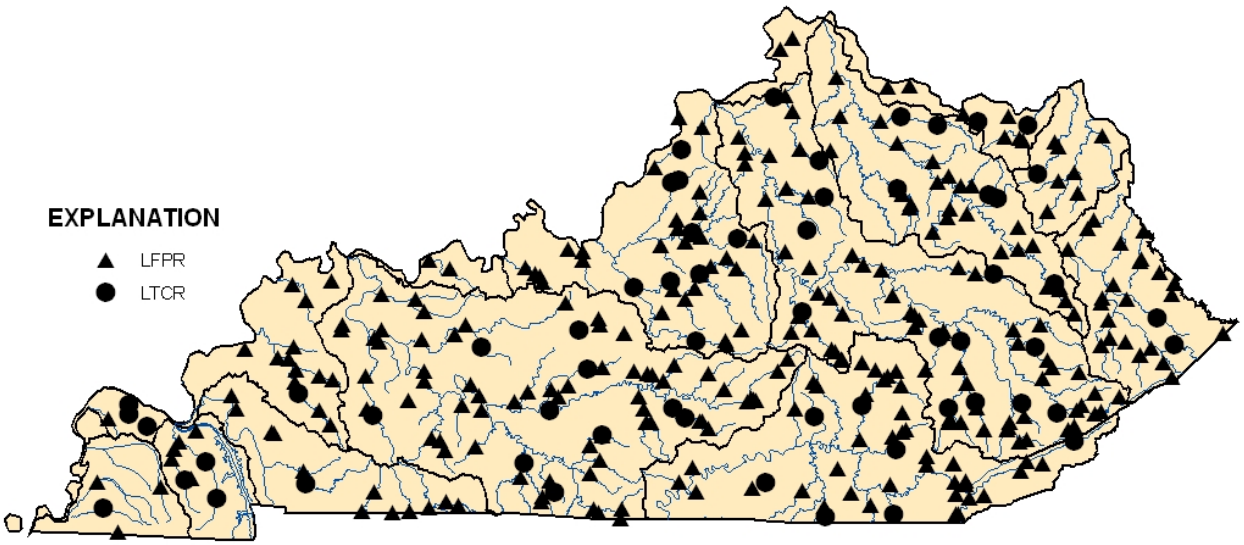
Low-Flow, Partial-Record Stations



310 LFPR Stations: 98 new, 212 previous

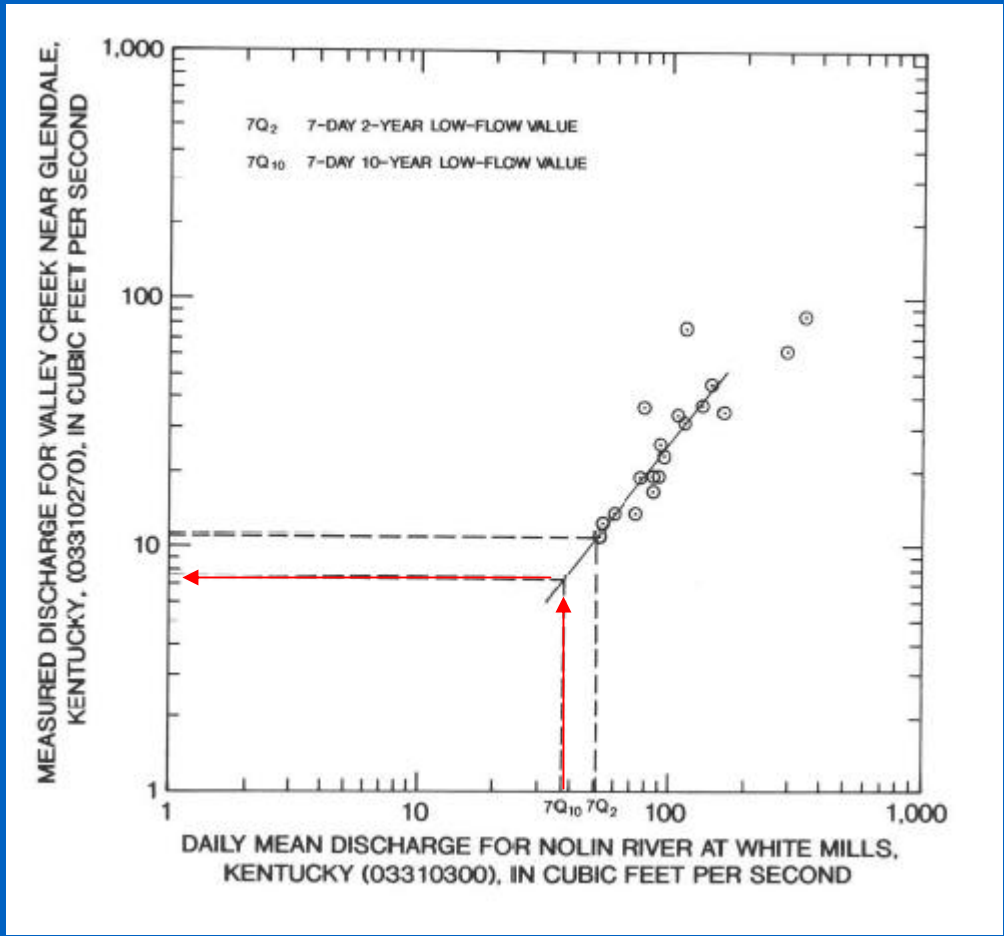
DATA COLLECTION NETWORK

INDEX AND LFPR STATIONS



379 Total Low-Flow Stations

RELATING CONCURRENT BASE FLOWS AT INDEX AND LFPR STATIONS



DEVELOPMENT OF REGIONAL ESTIMATING EQUATIONS

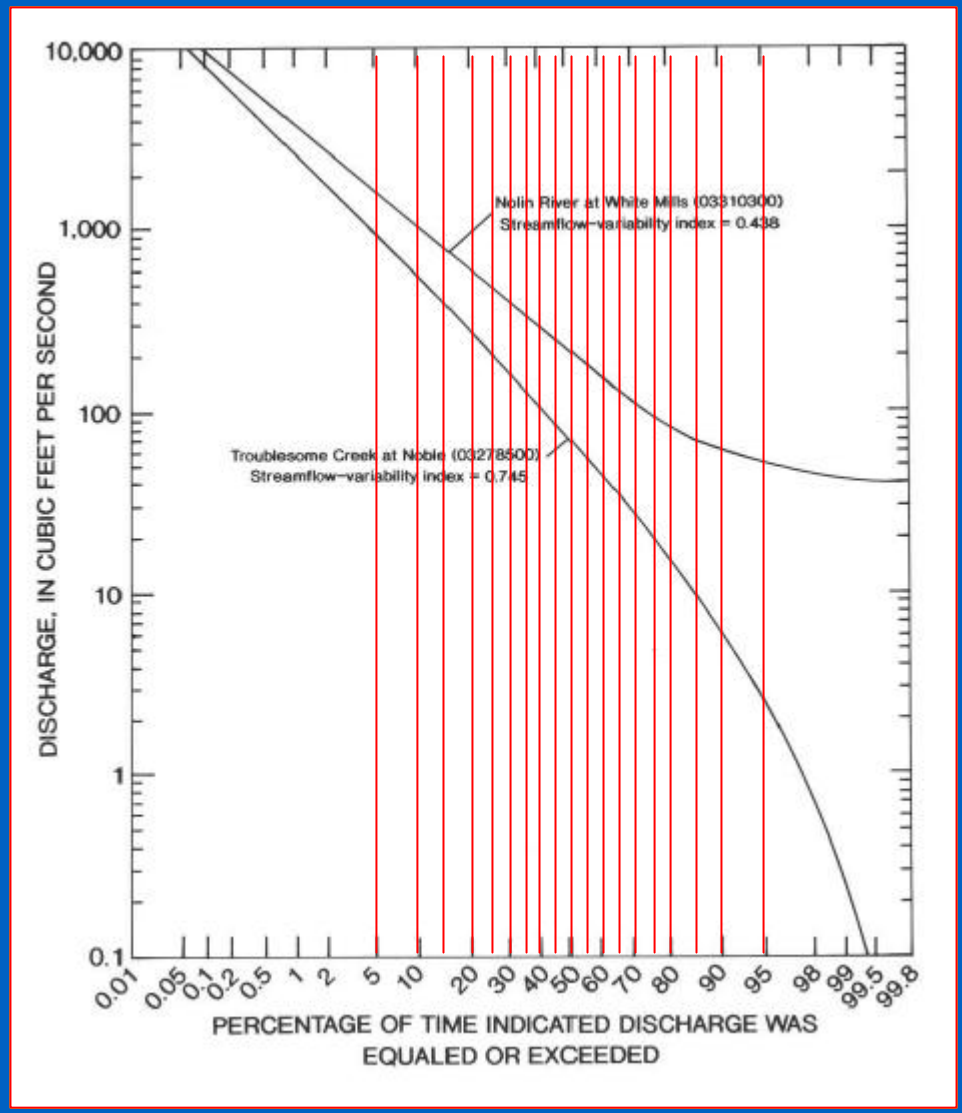
Regressions

$$Q_t = aA^dB^eC^f \ldots$$

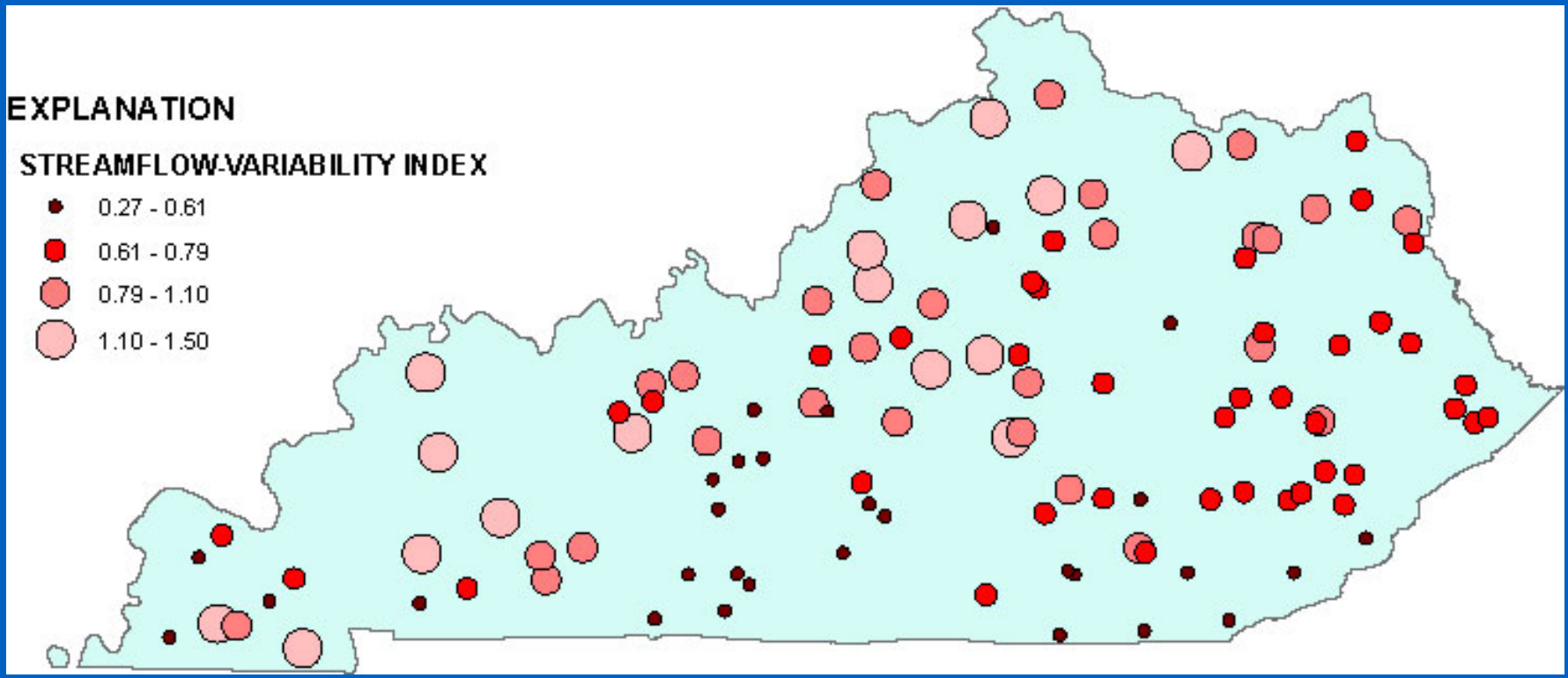
10 basin physical and climatic characteristics tried in regression analyses

A and V in final estimating equations

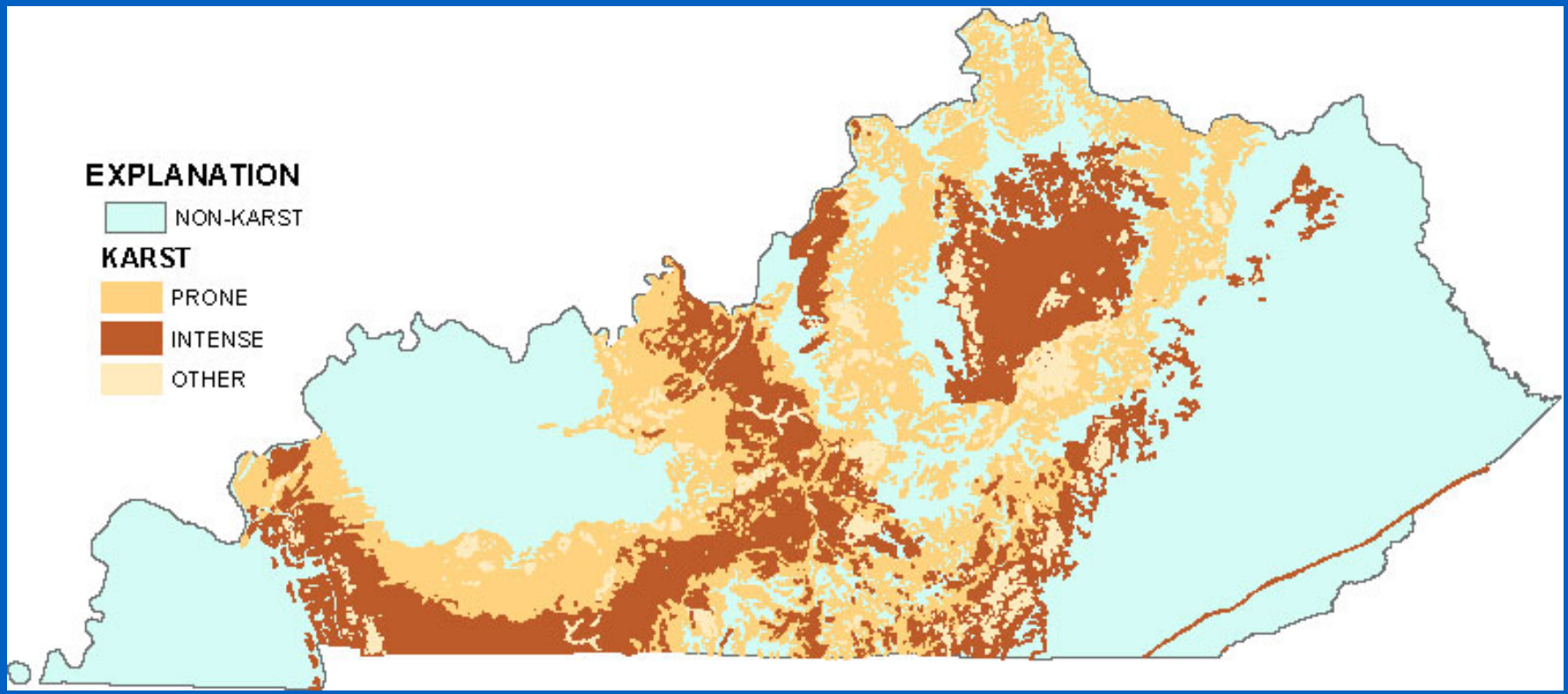
STREAMFLOW-VARIABILITY INDEX

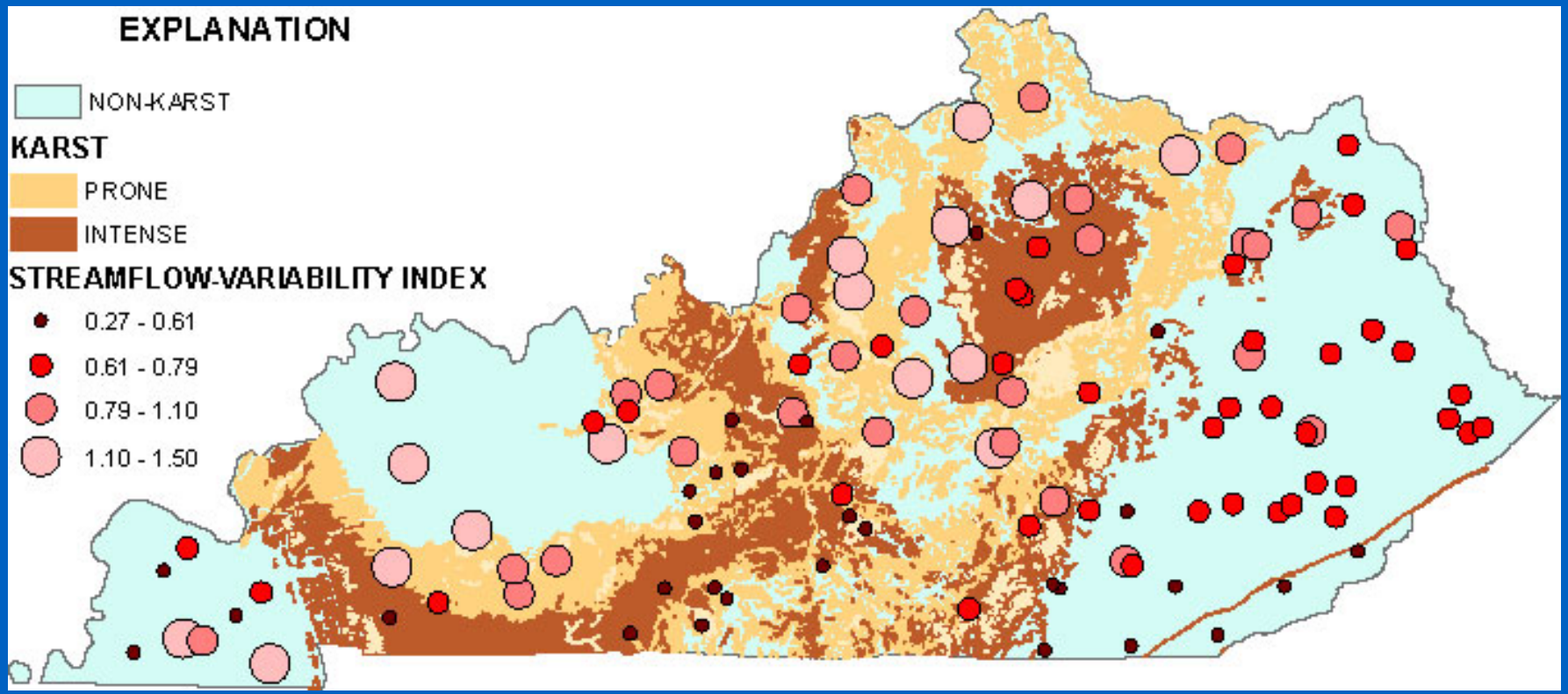


STATION VALUES OF STREAMFLOW-VARIABILITY INDEX

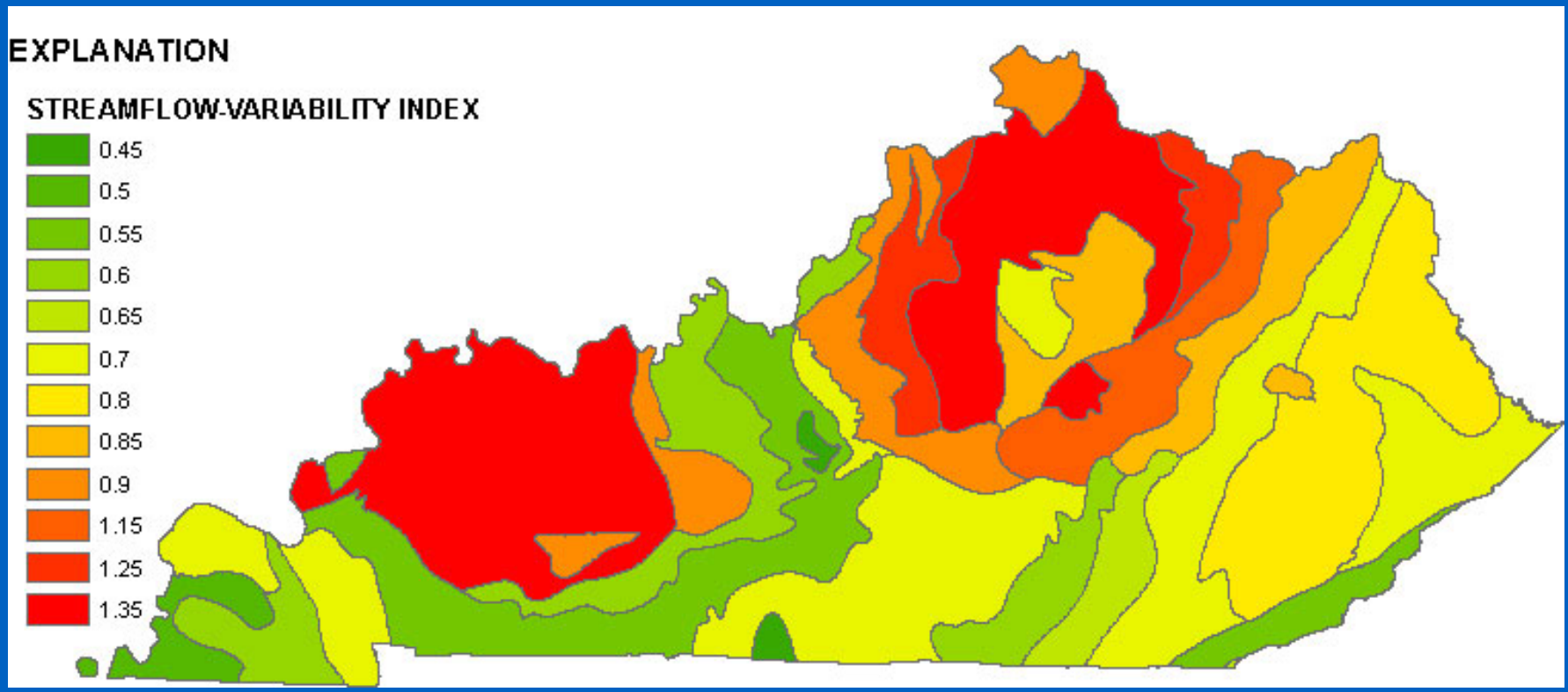


KARST DISTRIBUTION

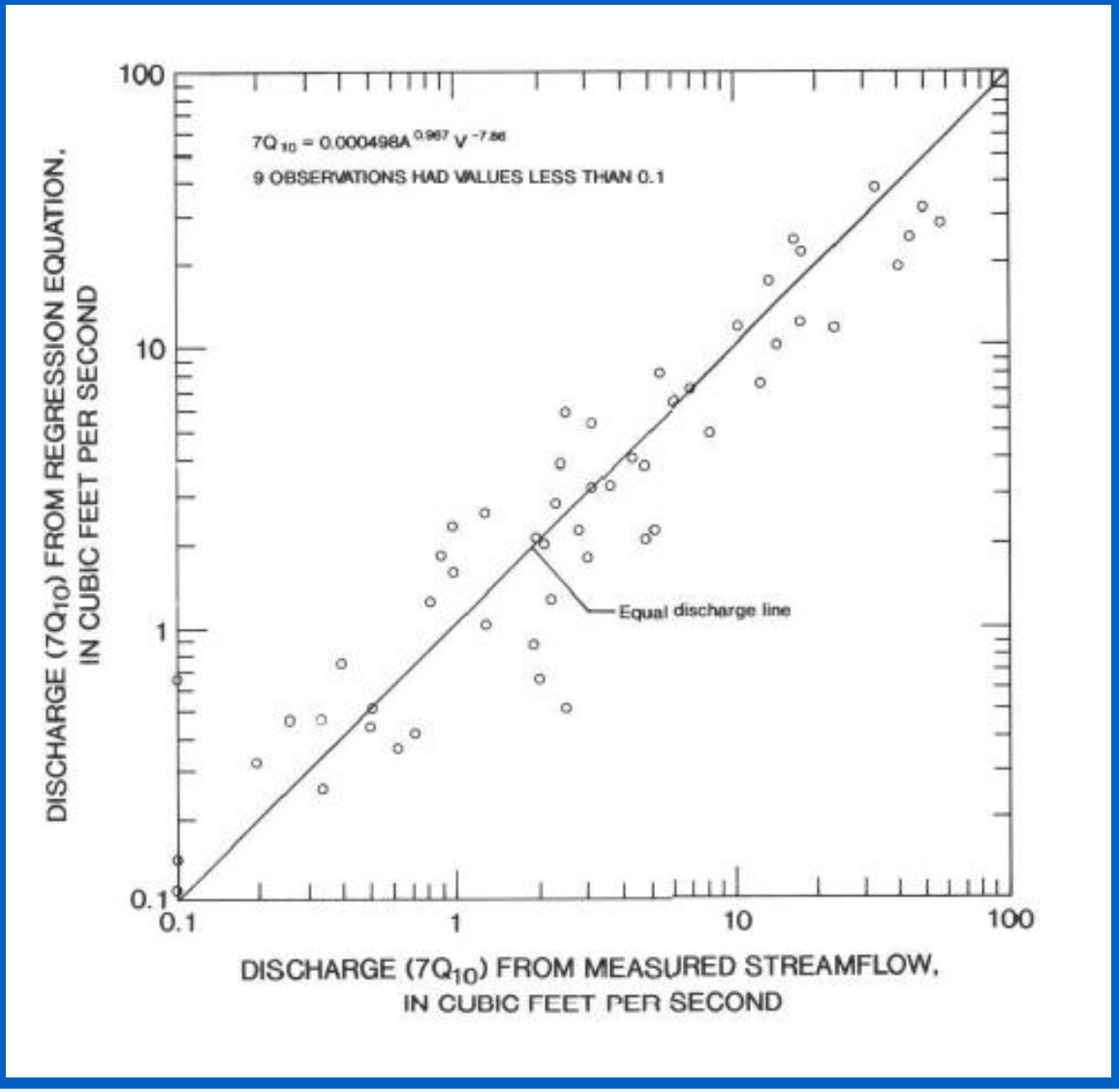



EXPLANATION
NON-KARST
KARST
PRONE
INTENSE
STREAMFLOW-VARIABILITY INDEX
0.27 - 0.61
0.61 - 0.79
0.79 - 1.10
1.10 - 1.50

MAPPED STREAMFLOW-VARIABILITY INDEX REGIONS



OBSERVED AND PREDICTED 7Q10

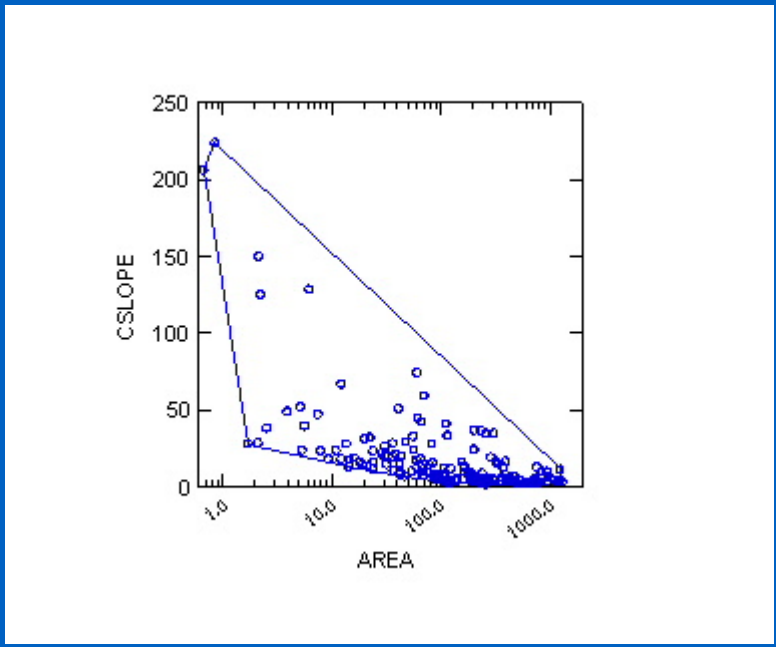


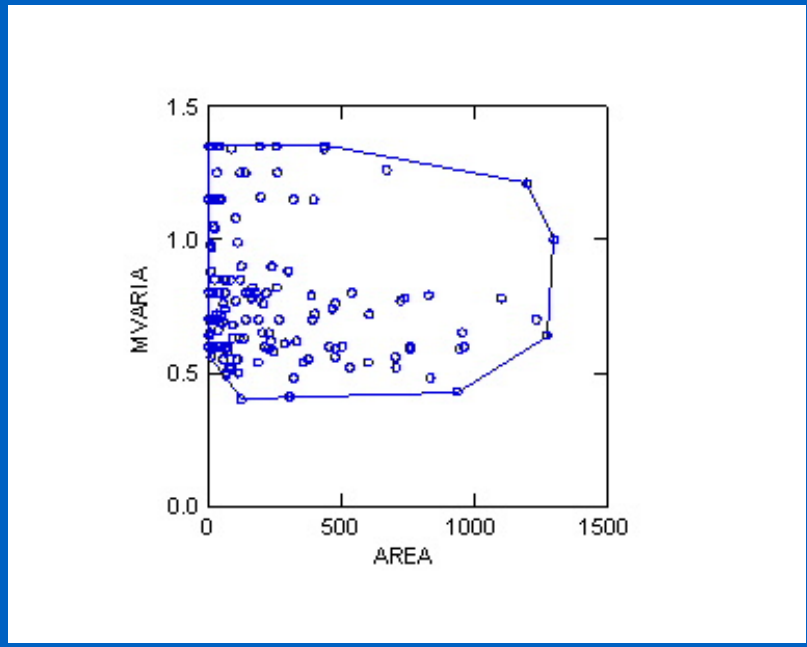
EQUATION ACCURACY

- Time-sampling errors--record length
- Spatial-sampling errors--gage density

- Model error

SAMPLE SPACE CHARACTERISTICS





ESTIMATING EQUATION ACCURACY

MEAN ANNUAL FLOW	14 %
PEAK FLOW – Q100	20-62 %
LOW FLOW – 7Q10	91 %

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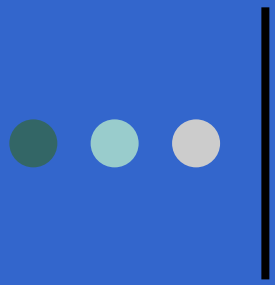
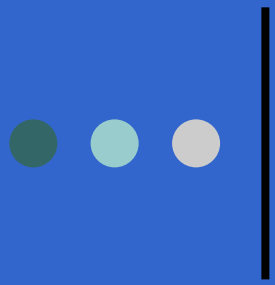
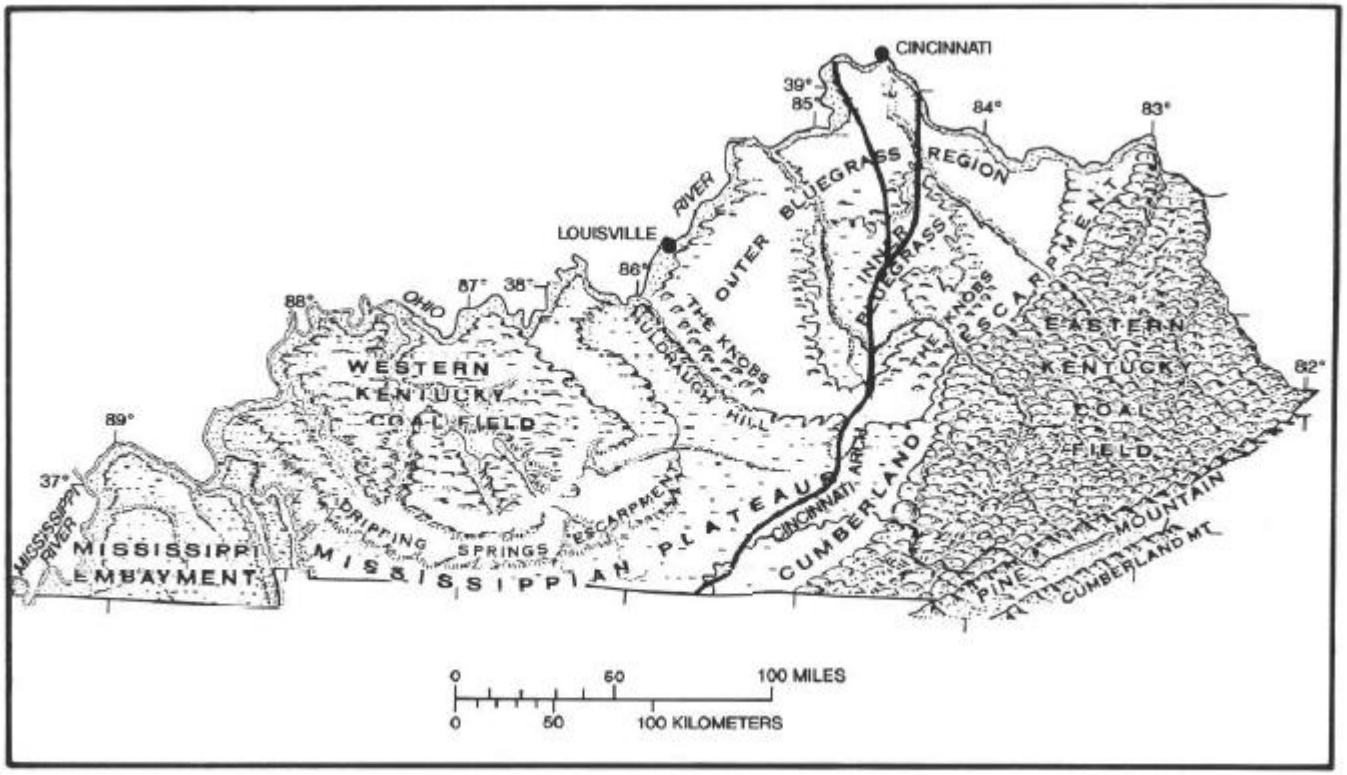


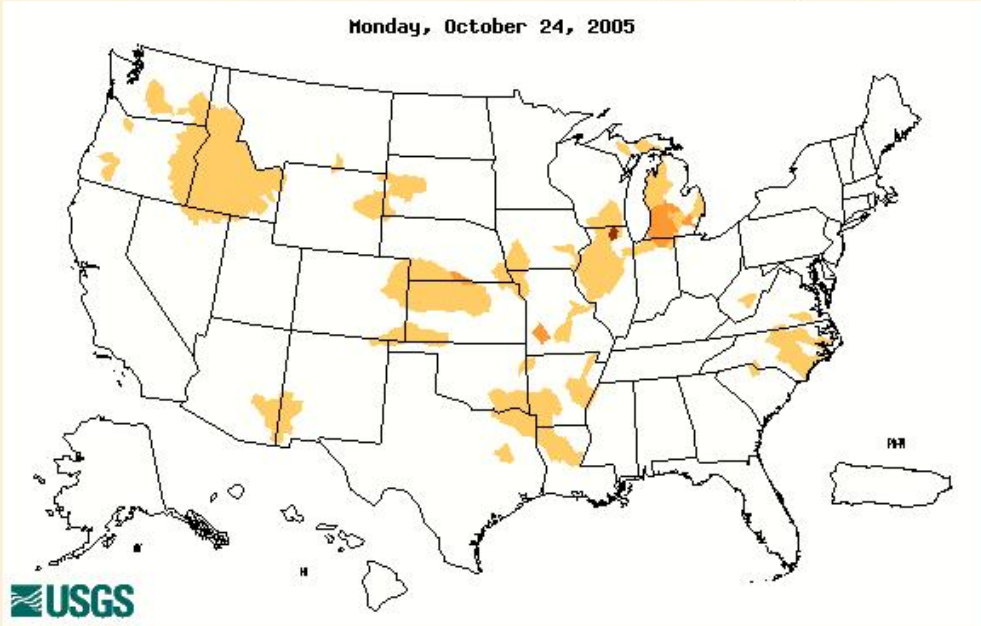




From Kentucky Geological Survey, 1980

Drought Watch -- *USGS State Information on Drought*

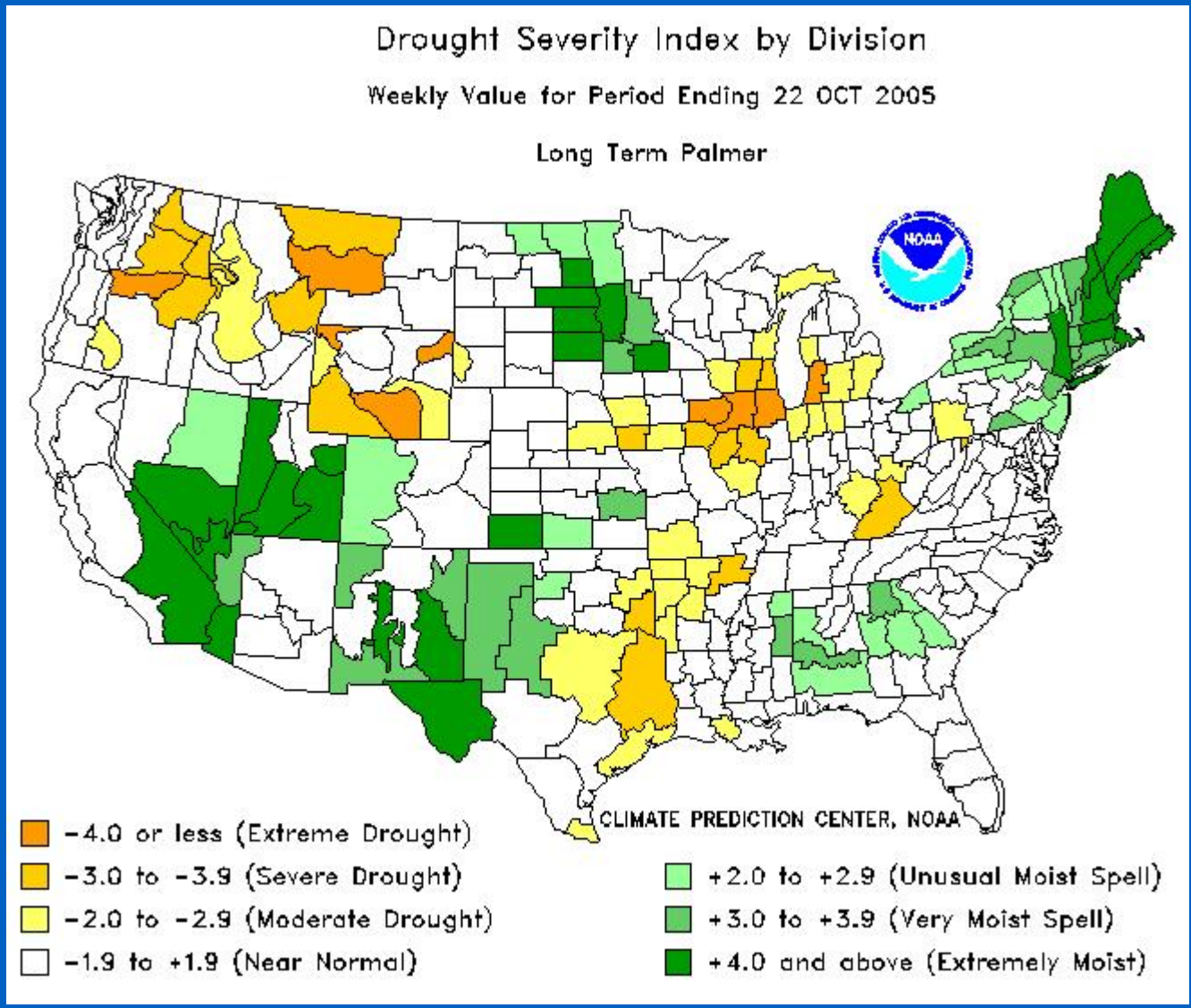
Map of below normal 7-day average streamflow compared to historical streamflow for the day of the year



Choose a data retrieval option and select a state on the map

○ **State DroughtWatch,** ◉ **State map**

Explanation - Percentile classes				
New low	≤ 5	6 - 9	10 - 24	Insufficient data for a hydrologic region
Extreme Hydrologic Drought	Severe Hydrologic Drought	Moderate Hydrologic Drought	Below Normal	


Drought Severity Index by Division
Weekly Value for Period Ending 22 OCT 2005
Long Term Palmer
NOAA
CLIMATE PREDICTION CENTER, NOAA
-4.0 or less (Extreme Drought)
-3.0 to -3.9 (Severe Drought)
-2.0 to -2.9 (Moderate Drought)
-1.9 to +1.9 (Near Normal)
+2.0 to +2.9 (Unusual Moist Spell)
+3.0 to +3.9 (Very Moist Spell)
+4.0 and above (Extremely Moist)

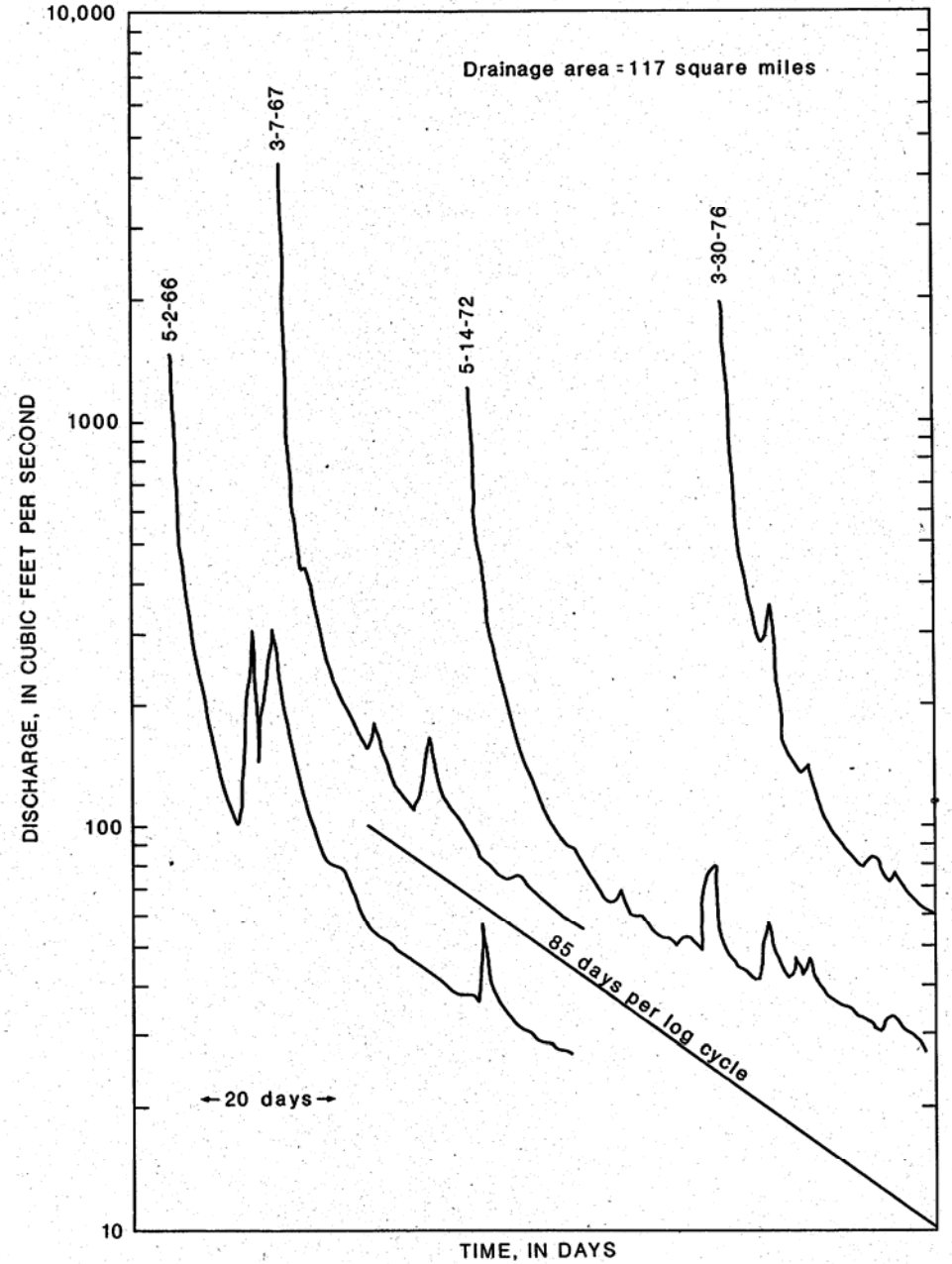


Figure 29.--Base flow recessions for Sewee Creek which drains mostly limestone and dolomite (station 115 on plate 1).

test

- test