Hydrologic Engineering Center

Training Course on

FLOOD FREQUENCY ANALYSIS

7 – 11 May 2018
Davis, California

Course Objectives:

The objective of this course is to provide the participant with the background required for practical application of techniques for frequency analysis. The primary references will be the "Guidelines for Determining Flood Flow Frequency" (Bulletin 17B and Bulletin 17C) and EM 1110-2-1415, "Hydrologic Frequency Analysis." An emphasis will be placed on the application of HEC Windows-based flood frequency computer program, HEC-SSP. Lectures and workshop sessions will provide the background required to understand the statistical analysis, and to apply the program and evaluate the output.

Prerequisites

The course nominees should be staff who perform professional work in the fields of hydrology and hydraulics. Nominees should have one or more years of experience in these fields. It is required that course participants be in positions, or anticipate being in positions in the next year or two, where they will be involved in developing frequency curves, performing regional analysis, or determining generalized skew coefficients.

Monday, May 7

8:00 – 8:45 a.m.	**INTRODUCTION (Director, Staff), paperwork, pre-course quiz**	
8:45 – 12:00 p.m.	Lecture 1.1:	**Introduction to Probability, Statistics, and Distributions**
	Workshop 1.2:	***Within-Lecture exercises***
12:00 – 1:00 p.m.	**Lunch**	
1:00 – 1:30 p.m.	continuation Lecture 1.1:	**Introduction continued**
1:30 – 3:30 p.m.	*Workshop 1.3:*	***Estimating Probability Distributions, Empirical / Normal***
3:30 – 3:45 p.m.	**Break**	
3:45 – 5:00 p.m.	Lecture 1.4:	**Analysis of Time Series**

Tuesday, May 8

8:00 – 9:00 a.m.	Lecture 2.1:	**Analytical Frequency Analysis**
9:00 – 9:30 a.m.	Lecture 2.2:	**General Data Representation for EMA**
9:30 – 9:45 a.m.	**Break**	
9:45 – 11:00 a.m.	Lecture 2.3:	**HEC-SSP Statistical Software**
11:00 – 11:55 a.m.	*Workshop 2.4:*	***Frequency Analysis in HEC-SSP***
12:00 – 1:00 p.m.	**class photo and Lunch**	
1:00 – 1:45 p.m.	*continuation W 2.4*	***Frequency Analysis in HEC-SSP***
1:45 – 3:00 p.m.	Lecture 2.5:	**Non-Standard Data, Low Outlier and Historical Information**
3:00 – 3:15 p.m.	**Break**	
3:15 – 5:00 p.m.	*Workshop 2.6:*	***Frequency Analysis with Outliers, Historical Info in SSP***

Wednesday, May 9

8:00 – 8:30 a.m.	Lecture 3.1:	**Update of Bulletin 17B to 17C**
8:30 – 10:00 a.m.	*Workshop 3.2:*	***Bulletin 17C and EMA in HEC-SSP***
10:00 – 10:15 am	**Break**	
10:15 – 11:30 p.m.	Lecture 3.3:	**Regional Skew**
11:30 – 12:00 p.m.	Lecture 3.4:	**Uncertainty in Frequency Estimates**
12:00 – 1:00 p.m.	**Lunch**	
1:00 – 1:30 p.m.	continuation Lecture 3.4:	**Uncertainty in Frequency Estimates (continued)**
1:30 – 2:45 p.m.	*Workshop 3.5*	***Exercises with Uncertainty in Excel***
2:45 – 3:00 pm	**Break**	
3:00 – 4:00 p.m.	Lecture 3.6:	**Graphical Frequency Analysis**
4:00 – 5:00 p.m.	Lecture 3.7:	**Estimating Frequency Curves without Gage Data**

Thursday, May 10

8:00 – 8:30 a.m.	Lecture 4.1:	**Correlation**
8:30 – 9:30 a.m.	Lecture 4.2:	**Coincident Frequency Analysis**
9:30 – 9:45 a.m.	**Break**	
9:45 – 11:00 a.m.	*Workshop 4.3:*	***Coincident Frequency in HEC-SSP and Excel***
11:00 – 12:00 p.m.	Lecture 4.4:	**Streamflow Record Extension**
12:00 – 1:00 p.m.	**Lunch**	
1:00 – 2:00 p.m.	Lecture 4.5:	**Modelling Mixed Populations**
2:00 – 3:30 p.m.	*Workshop 4.6:*	***Modelling Mixed Population in HEC-SSP***
3:30 – 3:45 p.m.	**Break**	
3:45 – 4:00 p.m.	Lecture 4.7:	**Variability and Uncertainty**
4:00 – 5:00 p.m.	Lecture 4.8:	**Frequency Analysis Applications: Hydrologic Loading, etc**

Friday, May 11

8:00 – 9:00 p.m.	Lecture 5.1:	**Development of Frequency in Urbanizing Areas**
9:15 – 10:45 a.m.	Lecture 5.2:	**Risk and Uncertainty Analysis**
10:45 – 11:30 a.m.		Quiz, Critique and Completion

Monday, May 7

8:00 – 8:30 a.m. **INTRODUCTION (Director, Staff)**

Welcome to HEC, class and staff introductions, and course overview.

8:30 – 8:45 a.m. **Paperwork and pre-course quiz**

8:45 – 12:00 p.m. Lecture 1.1: **INTRODUCTION TO PROBABILITY, STATISTICS AND DISTRIBUTIONS**

Objectives of statistical analyses; definitions; types of variables; histograms; cumulative distributions; concepts of parent population and sample; parameters used to define distributions, and their estimates: mean, median, mode, standard deviation, skew coefficient. Probability relationships, use of binomial equation to determine risk.

Workshop 1.2: ***Within-Lecture exercises***

Exercises are interspersed within Lecture 1.1
Exploration of using relative frequency to estimate probability, and fitting probability distributions to data.

12:00 – 1:00 p.m. **Lunch**

1:00 – 1:30 p.m. continuation Lecture 1.1: **INTRODUCTION continued**

1:30 – 3:30 p.m. *Workshop 1.3:* ***ESTIMATING PROBABILITY DISTRIBUTIONS – EMPIRICAL AND NORMAL/LOGNORMAL***

Example application of simple frequency analysis

3:30 – 3:45 p.m. **Break**

3:45 – 5:00 p.m. Lecture 1.4: **ANALYSIS OF TIME-SERIES**

Exposition of common analyses of time-series flow data, including analysis of high and low extremes, analysis of events exceeding a threshold and long-run daily exceedances. Examination of assumptions and tools involved in such analyses.

Tuesday, May 8

8:00 – 9:00 a.m. Lecture 2.1: **ANALYTICAL FREQUENCY ANALYSIS**

Fitting probability distributions; determination of statistical parameters; application of the log-Pearson type III distribution; Bulletin 17B and its methods, Bulletin 17C, Flow-Duration Frequency Analysis and synthetic events

9:00 – 9:30 a.m. Lecture 2.2: **GENERAL DATA REPRESENTATION FOR EMA**

Definitions of flow ranges and perception threshold ranges needed for EMA

9:30 – 9:45 a.m. **Break**

9:45 – 11:00 a.m. Lecture 2.3: **HEC-SSP STATISTICAL SOFTWARE**

Introduction to HEC's windows-based computer program; program capabilities; input windows; review of output.

11:00 – 11:55 a.m. *Workshop 2.4:* ***FREQUENCY ANALYSIS IN HEC-SSP***

Compute statistics of log-Pearson III distribution from sample data using both Bulletin 17B and 17C in HEC-SSP. Compute Volume-Frequency curves

11:55 – 12:00 p.m. **CLASS PHOTOGRAPH**

12:00 – 1:00 p.m. **Lunch**

1:00 – 1:45 p.m. *continuation W 2.4* ***B17B FREQUENCY ANALYSIS IN HEC-SSP***

1:45 – 3:00 p.m. Lecture 2.5: **NON-STANDARD DATA, OUTLIERS, HISTORICAL**

The effect of low outliers on frequency analysis, treatment of outliers (and PILFs), use of historical information in Bulletin 17B and 17C

3:00 – 3:15 p.m. **Break**

3:15 – 5:00 p.m. *Workshop 2.6:* ***FREQUENCY CURVES WITH LOW OUTLIER, HISTORICAL INFORMATION in HEC-SSP***

Compute log-Pearson III frequency curve when low outliers present in data and historical information is available, using both Bulletin 17B and 17C methods.

Wednesday, May 9

8:00 – 8:30 a.m. Lecture 3.1: **UPDATE OF BULLETIN 17B to 17C**

The Bulletin 17B committee finalized the new LP3 estimation methods for 17C. Topics include parameter estimation methods, treatment of outliers and historical information, and confidence intervals.

8:30 – 10:00 a.m. *Workshop 3.2:* ***BULLETIN 17C AND EMA IN HEC-SSP***

Frequency analysis examples using Bulletin 17C methods.

10:00 – 10:15 am **Break**

10:15 – 11:30 a.m. Lecture 3.3: **REGIONAL SKEW**

Estimating regional skew, use of skew maps, uncertainty in computed skew coefficient; mean square error; computation of weighted skew, limitations

11:30 – 12;00 p.m. Lecture 3.4: **UNCERTAINTY IN FREQUENCY ESTIMATES**

Understanding sampling error from limited data (streamflow record). Sources of uncertainty in frequency estimates; sampling errors of mean, standard deviation, and skew; confidence intervals.

12:00 – 1:00 p.m. **Lunch**

1:00 – 1:30 p.m. continuation Lecture 3.4: **UNCERTAINTY IN FREQUENCY ESTIMATES**

1:30 – 2:45 p.m. *Workshop 3.5* ***Exercises with Uncertainty in Excel***

2:45 – 3:00 pm **Break**

3:00 – 4:00 p.m. Lecture 3.6: **GRAPHICAL FREQUENCY ANALYSIS**

Estimating empirical frequency curves without an analytical distribution. Computation and interpretation of plotting positions.

4:00 – 5:00 p.m. Lecture 3.7: **ESTIMATING FREQUENCY CURVES WITHOUT GAGE DATA**

Development of flood frequency estimates at sites with limited or absent streamflow data including record extension, hydrologic routing of frequency-based rainfall and regional regression. Discussion of weighting of independent frequency estimates.

Thursday, May 10

8:00 – 8:30 a.m. Lecture 4.1: **CORRELATION**

Examining the relationship between two or more variables

8:30 – 9:30 a.m. Lecture 4.2: **COINCIDENT FREQUENY ANALYSIS**

Situations in which coincident frequency analysis is required, assumptions and technique to compute coincident frequency. Use of Monte Carlo Simulation for coincident frequency analysis.

9:30 – 9:45 a.m. **Break**

9:45 – 11:00 a.m. *Workshop 4.3:* ***COINCIDENT FREQUENY in HEC-SSP and Excel***

Use of HEC-SSP for traditional Coincident Frequency Analysis, and evaluation of the same problem in Excel using Monte Carlo simulation to account for correlation.

11:00 – 12:00 p.m. Lecture 4.4: **STREAMFLOW RECORD EXTENSION**

Using a long record station to improvement frequency curve estimate at short record station with 2-station comparison. Extending short record with regression or Maintenance of Variance Extension (MOVE.1, MOVE.2, MOVE.3)

12:00 – 1:00 p.m. **Lunch**

1:00 – 2:00 p.m. Lecture 4.5: **MODELLING MIXED POPULATIONS**

Computation of flood frequency curves for streams affected by a mixture of flood-causing mechanisms. Discussion of common mixture types and homogenization of frequency curves. Construction of an annual maximum series from two or more flood-type specific frequency curves.

2:00 – 3:30 p.m. *Workshop 4.6:* ***MIXED POPULATIONS in HEC-SSP***

Use of HEC-SSP to develop a model for the annual flood series on a stream affected by multiple flood-causing mechanisms.

3:30 – 3:45 p.m. **Break**

3:45 – 4:00 p.m. Lecture 4.7: **VARIABILTY AND UNCERTAINTY**

The difference in the impact of natural variability and knowledge uncertainty in evaluating decision metrics. Technique for separating the impact of these random variables in Monte Carlo Simulation

4:00 – 5:00 p.m. Lecture 4.8: **FREQUENCY ANALYSIS APPLICATIONS: HYDROLOGIC LOADING, etc**

Exploration of the role of flood frequency analysis in dam safety hydrology and the importance of non-standard data in extrapolation of flood frequency curves. Discussion of level of effort required for dam safety hydrology studies.

Friday, May 11

8:00 – 9:00 p.m. Lecture 5.1: **DEVELOPMENT OF FREQUENCY CURVES IN AREAS UNDERGOING URBANIZATION**

Statistical considerations and assumptions in frequency analysis of rainfall and runoff as they pertain to watershed undergoing urban development; methods of analysis.

9:00 – 9:15 a.m. **Break**

9:15 – 10:45 a.m. Lecture 5.2: **RISK AND UNCERTAINTY**

Risk-based analysis for flood damage reduction studies. Examples of uncertainty, use of risk and uncertainty in project formulation and evaluation.

10:45 – 11:00 a.m. **Quiz**

11:00 – 11:30 a.m. **CRITIQUE AND COMPLETION**