Hydrologic Engineering Center

Training Course on

FLOOD FREQUENCY ANALYSIS

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 the upcoming 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

8:00 – 8:30 a.m.	**INTRODUCTION**	
8:30 – 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 – 3:00 p.m.	Workshop 1.3:	**Estimating Probability Distributions, Empirical / Normal**
3:00 – 3:15 p.m.	break	
3:15 – 4:30 p.m.	Lecture 1.4:	**Analysis of Time Series**
4:30 – 5:00 p.m.	Paperwork and pre-course quiz	

Tuesday

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***
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*	***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

8:00 – 8:30 a.m.	Lecture 3.1:	**Update of Bulletin 17B to 17C**
8:30 – 10:00 p.m.	*Workshop 3.2:*	***Bulletin 17C and EMA in HEC-SSP***
10:00 – 10:15 am	Break	
10:15 – 11:30 a.m.	Lecture 3.3:	**Frequency Analysis Applications: Dam Safety, etc**
11:30 – 12:30 a.m.	Lecture 3.4:	**Regional Skew**
12:30 – 1:30 p.m.	Lunch	
1:30 – 2:00 p.m.	Lecture 3.5:	**Estimating Frequency Curves without Gage Data**
2:00 – 3:00 p.m.	Lecture 3.6:	**Precipitation Frequency Analysis**
3:00 – 3:15 pm	Break	
3:15 – 4:00 p.m.	Lecture 3.7:	**Graphical Frequency Analysis**
4:00 – 5:00 p.m.	*Workshop 3.8*	***Graphical Frequency Analysis in HEC-SSP***

Thursday

8:00 – 8:30 a.m.	Lecture 4.1:	**Correlation**
8:30 – 9:30 a.m.	Lecture 4.2:	**Streamflow Record Extension**
9:30 – 9:45 a.m.	Break	
9:45 – 10:45 a.m.	Lecture 4.3:	**Coincident Frequency Analysis**
10:45 – 12:00 p.m.	Lecture 4.4:	**Coincident Frequency Case Studies**
12:00 – 1:00 p.m.	Lunch	
1:00 – 2:00 p.m.	Lecture 5.5:	**Mixed Distribution Analysis**
2:00 – 3:15 p.m.	Lecture 4.6:	**Uncertainty in Frequency Estimates**
3:15 – 3:30 p.m.	Break	
3:30 – 4:30 p.m.	Workshop 4.7	**Exercises with Uncertainty in Excel**
4:30 – 5:00 p.m.	Lecture 4.8:	**Distinguishing Variability and Uncertainty**

Friday

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

Monday

8:00 – 8:30 a.m. **INTRODUCTION**

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

8:30 – 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 – 3:00 p.m. Workshop 1.3: **ESTIMATING PROBABILITY DISTRIBUTIONS – EMPIRICAL AND NORMAL/LOGNORMAL**

Example application of simple frequency analysis

3:00 – 3:15 p.m. break

3:15 – 4:30 p.m. Lecture 1.4: **ANALYSIS OF TIME-SERIES**

A review of some of the many times of analysis that can be performed on time-series data, including the inherent assumptions and uses of the products

4:30 – 5:00 p.m. **Paperwork and pre-course quiz**

Tuesday

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 (Faber)**
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

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 p.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: **FREQUENCY ANALYSIS APPLICATIONS: DAM SAFETY etc**

Applications of flood frequency analysis including dam safety and the flood insurance program.

11:30 – 12:30 a.m. Lecture 3.4: **REGIONAL SKEW**

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

12:30 – 1:30 p.m. Lunch

1:30 – 2:00 p.m. Lecture 3.5: **ESTIMATING FREQUENCY CURVES WITHOUT GAGE DATA**

Methods for estimating flow frequency curves in watersheds without a stream gage. Comparison of the uncertainty in those methods, versus uncertainty from Bulletin 17 analysis.

2:00 – 3:00 p.m. Lecture 3.6: **PRECIPITATION FREQUENCY ANALYSIS**

Estimation of precipitation frequency using regional analysis and L-moments.

3:00 – 3:15 pm Break

3:15 – 4:00 p.m. Lecture 3.7: **GRAPHICAL FREQUENCY ANALYSIS**

Estimating Frequency Curves that don't assume an analytical distribution.

4:00 – 5:00 p.m. *Workshop 3.8* ***GRAPHICAL FREQUENCY ANALYSIS IN SSP***

General Frequency Analysis in HEC-SSP, using the graphical frequency tab.

Thursday

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:	**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)	
9:30 – 9:45 a.m.	Break	
9:45 – 10:45 a.m.	Lecture 4.3:	**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.	
10:45 – 12:00 p.m.	Lecture 4.4:	**COINCIDENT FREQUENY CASE STUDIES**
	Two case studies examining new simulation methods for examining and evaluating coincident frequencies.	
12:00 – 1:00 p.m.	Lunch	
1:00 – 2:00 p.m.	Lecture 5.5:	**MIXED DISTRIBUTION ANALYSIS**
	Computation of mixed distributions	
2:00 – 3:15 p.m.	Lecture 4.6:	**UNCERTAINTY IN FREQUENCY ESTIMATES**
	Techniques for determining reliability; sampling errors of mean, standard deviation, and skew; statistical significance, confidence limits.	
3:15 – 3:30 p.m.	Break	
3:30 – 4:30 p.m.	Workshop 4.7	**Exercises with Uncertainty in Excel**
4:30 – 5:00 p.m.	Lecture 4.8:	**DISTINGUISHING VARIABIILTY 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	

Friday

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 – 10:30 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.

10:30 – 10:45 a.m. Quiz

10:45 – 11:15 a.m. **CRITIQUE AND COMPLETION**