

Introduction to Economic Risk Assessment for Flood Risk Management Studies

Hydrologic Engineering Center

Davis, CA

Course Overview

This course covers risk assessment methods and concepts, many of which are required by USACE guidance. The objective is to enable participants to readily adapt these methods and concepts to their own studies and projects after successfully completing the course. Policy issues, concepts in statistical analysis, and risk and uncertainty methods used in the evaluation of flood risk management projects are emphasized in the course. Course workshops provide participants with the opportunity to apply the course's concepts using the Hydrologic Engineering Center Flood Damage Reduction Analysis (HEC-FDA) software program.

The course is intended for persons that are or will be involved in risk assessment for flood risk management studies. It is typically expected that participants have a minimum of two years of experience in engineering, economics, planning, or project management.

HEC Instructors

Cameron Ackerman
Lea Adams
Brennan Beam
Christopher Dunn
Beth Faber
David Ho
Richard Nugent
Julia Slaughter

Guest Instructors

Chris Bouquot, *Headquarters*
Stephen Cowdin, *HDR*
Brian Hubel, *South Pacific Division*
Kurt Keilman, *South Pacific Division*
Jordan Lucas, *St. Louis District*
Brian Maestri, *Mississippi Valley Division*
Jesse Morrill-Winter, *South Pacific Division*
Jason Needham, *Risk Management Center*
Nathan Pingel, *HDR*

Day 1

Reading assignment: CECW-2020-04, Director's Policy Memorandum, Risk Informed Decision Making (RIDM) for Program and Project Delivery; Chapters 1-3 of Engineering Manual 1110-2-1619, titled "Risk-Based Analysis for Flood Damage Reduction Studies," dated March 1996, [HEC-FDA Quick Start Guide](#), Introduction.

0800 – 0845: **1.1. Introduction and Pre-test.**

0845 – 0930: **1.2. Risk Assessment and Risk Management: Transforming the USACE, Chris Bouquot.** This presentation describes USACE Headquarters' (HQUSACE) current philosophy on the practice and application of risk analysis. The future of risk analysis will be discussed, as well as methods for application in SMART planning studies.

0930 – 0945: **1.3. Break.**

0945 – 1045: **1.4. Engineering for Non-Engineers or Economics for Non-Economists, Brennan Beam, David Ho, and Richard Nugent.** Principles of water resources engineering and of economics are both important for this course. Students have the choice of an introduction to water resources engineering lecture or an introduction to water resources economics lecture.

1045 – 1130: **1.5. Flood Risk Management Planning Center of Expertise, Jesse Morrill-Winter.** This presentation provides an overview of the Flood Risk Management Planning Center of Expertise (FRM-PCX) mission and responsibilities. Planning model certification is discussed as is the flood risk Agency Technical Review (ATR) policies and processes.

1130 – 1230: **1.6. Lunch.**

1230 – 1430: **1.7. Basic Probability and Statistics, Beth Faber.** This lecture defines and describes probability, random variables, statistics and definitions of risk and uncertainty. An emphasis is placed on defining statistical parameters, probability density functions and cumulative distribution functions. Students will complete exercises exploring concepts in the lecture such as the use of relative frequency in the estimation of probability and fitting probability distributions to data.

1430 – 1445: **1.8. Break.**

1445 – 1600: **1.9. Flood Risk Assessment, Richard Nugent.** This presentation provides an overview of the application of risk analysis concepts in flood risk management studies. In particular, the presentation will provide a discussion of the application of risk analysis concepts to study configuration, engineering and economic products including probability-discharge, stage-discharge and stage-damage functions with uncertainty. Plan formulation and evaluation within the risk analysis framework will also be reviewed.

1600 – 1700: **1.10. Using the HEC-FDA Program Workshop, Julia Slaughter.** In this hands-on workshop participants use the new version HEC-FDA to define a new study, provide study information and input configuration data (e.g. streams, damage reaches, analysis years and plans) for the Muncie, Indiana example study.

Day 2

Reading Assignment: Engineering Regulation 1105-2-101, titled "Risk Assessment for Flood Risk Management Studies," dated 15 July 2019; Chapters 4-6 of Engineering Manual 1110-2-1619, titled

“Risk-Based Analysis for Flood Damage Reduction Studies,” dated March 1996; [HEC-FDA Quick Start Guide](#): Terrain through Economics.

0800 – 0900: **2.1. Background Policy and Regulations for Risk Analysis, Chris Dunn.** This presentation provides a description of the present HQUSACE policy, risk analysis requirements and ongoing USACE activities. An overview of ER 1105-2-101, “Risk Analysis for Flood Damage Reduction Studies” will be presented.

0900 – 0915: **2.2. Break.**

0915 – 1115: **2.3. Incorporating Uncertainty into the Expected Annual Damage Computation, Beth Faber.** This presentation provides an interpretation of EAD and describes the traditional EAD computation when uncertainty parameters are not applied. Monte Carlo simulation is introduced along with its approach to incorporating uncertainty in HEC-FDA inputs. Students will complete exercises exploring statistical concepts used in risk assessment are presented in a hand-on environment. Concepts explored in these exercises include median and expected values of analytical functions used for evaluation and Monte Carlo simulation.

1115 – 1215: **2.4. Lunch.**

1215 – 1325: **2.5. Uncertainty in Exceedance Probability Functions, Beth Faber.** This presentation describes the causes of uncertainty in exceedance probability functions (e.g. frequency curves). Methods for evaluating uncertainty and computing confidence intervals are reviewed and their entry into the HEC-FDA program is described.

1325 – 1335: **2.6. Break.**

1335 – 1445: **2.7. Stage Discharge Relationship Uncertainty, Cameron Ackerman.** This presentation describes approaches for estimating uncertainty in stage-discharge relationships that are defined in ER 1105-2-101 and EM 1110-2-1619. An emphasis is placed on estimating the uncertainty associated with gauged and ungauged locations.

1445 – 1455: **2.8. Break.**

1455 – 1550: **2.9. Hydrologic and Hydraulic Uncertainties Workshop, Julia Slaughter.** In this hands-on workshop participants use their previously generated HEC-FDA study files to input and evaluate probability-discharge and stage-discharge relationships with uncertainty.

1550 – 1700: **2.10. Stage-Damage Relationship Uncertainty Derivation, Kurt Keilman.** This presentation describes approaches for estimating uncertainty in stage-damage relationship that are defined in ER 1105-2-101 and EM 1110-2-1619. The impact of altering stage-damage functions will also be discussed.

Day 3

Reading Assignment: Chapters 7-8 of Engineering Manual 1110-2-1619, titled “Risk-Based Analysis for Flood Damage Reduction Studies,” dated March 1996; [HEC-FDA Quick Start Guide](#), Scenarios

0800 – 0915: **3.1. Stage-Damage Uncertainty Workshop, Julia Slaughter.** In this hands-on workshop participants use their previously generated HEC-FDA study files to compute and evaluate stage-damage relationships.

0915 – 0945: **3.2. Uncertainty Workshops Review, Julia Slaughter.**

0945 – 1000: **3.3. Break.**

1000 – 1115: **3.4. Project Formulation and Evaluation Using Risk Assessment, Chris Dunn.** This presentation describes project formulation and evaluation procedures for multiple reaches and mixed measures (levees, channels, and reservoirs).

1115 – 1215: **3.5. Lunch.**

1215 – 1330: **3.6. Without-Project Conditions Workshop, Julia Slaughter.** In this hands-on workshop participants use their previously generated HEC-FDA study files to perform a without-project analysis for the Muncie, Indiana example study, including the computation and evaluation of expected annual damage and average annual equivalent damage.

1330 – 1400: **3.7. Without-Project Conditions Workshop Review, Julia Slaughter.**

1400 – 1415: **3.8. Break.**

1415 – 1530: **3.9. Project Performance and Geotechnical Analysis, Brian Hubel.** This presentation describes modeling the flood control project feature performance for the risk assessment, what do the geotechnical folks so, ETL 1110-2-588, PFMA's, Event Trees, and Conditional Nodal Probabilities. An example of fragility analysis of a levee and interpretation of geotechnical data including brief discussion of aleatoric variability and epistemic uncertainty.

1530 – 1545: **3.10. Break.**

1545 – 1700: **3.11. Case Study, Southwest Coastal Louisiana Feasibility Study, Brian Maestri.** This presentation will present a risk assessment study using HEC-FDA in a coastal area for the Southwest Coastal Louisiana Feasibility Study.

Day 4

Reading Assignment: Chapter 9 of Engineering Manual 1110-2-1619, titled "Risk-Based Analysis for Flood Damage Reduction Studies," dated March 1996; ETL 1110-2-588 (pg 1-8), EGM 23-01, [HEC-FDA Quick Start Guide](#), Alternatives and Alternative Comparison Reports

0800 – 0915: **4.1. Levee Assessment Workshop, Julia Slaughter.** In this hands-on workshop, participants use their previously generated HEC-FDA study files to evaluate the economic feasibility and project performance of various levee alternatives. Participants recommend the "best" alternative.

0915 – 0945: **4.2. Levee Assignment Workshop Review, Julia Slaughter.**

1000 – 1015: **4.3. Break.**

1015 – 1100: **4.4. The RMC and Life Safety, Jason Needham.** This presentation provides an overview of the USACE Risk Management Center's (RMC's) approach to risk analysis. Topics include risk analysis in support of dam and levee safety program objectives with a special focus on life safety. HEC-FIA and LifeSim are introduced.

1100 – 1145: **4.5. HEC-FDA Limitations and Practical Considerations, Jordan Lucas.** HEC-FDA is not the best tool for every risk assessment study. In this presentation, the limitations of the HEC-FDA program are discussed.

1145 – 1245: **4.6. Lunch.**

1245 – 1315: **4.7. HEC-WAT and the FRA Compute, Lea Adams.** This presentation covers one of the newest tools in the risk and uncertainty assessment toolbox and compares the tool with HEC-FDA.

1315 – 1345: **4.8. Break.**

1345 - 1445: **4.9. Case Study: Coastal Texas Evaluation, Brian Maestri.** This presentation will present a risk assessment study using HEC-FDA in a coastal area in Texas.

1445 – 1500: **4.10. Break.**

1500– 1600: **4.11. Modeling Flood Risk Management Measures, Jordan Lucas.** This presentation introduces how flood risk management measures are modeled using summary relationships in HEC-FDA.

1600 – 1700: **4.12. Plan Formulation Workshop, Julia Slaughter.** In this hands-on workshop participants use their previously generated HEC-FDA study files to formulate and evaluate flood risk management for the Muncie, Indiana study area. The workshop emphasizes formulation and evaluation of several flood risk management plans including a levee only plan, detention only plan and joint detention and levee plan.

Day 5

0800 - 0900: **5.1. Plan Formulation Workshop Continued, Julia Slaughter.**

0900 – 0930: **5.2. Plan Formulation Workshop Review, Julia Slaughter.**

0930 – 0945: **5.3. Break.**

0945 – 1100: **5.4. Case Study: Lower Sacramento River, Stephen Cowdin and Nathan Pingel.** This presentation will present a risk assessment study of the Lower Sacramento River.

1100 – 1200: **5.5. Post-Test, Critique, and Closing, Richard Nugent.**