Introduction

Best Practices in Dam and Levee Safety Risk Analysis

July 2019

US Army Corps of Engineers®

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

DEPARTMENT OF ENERGY
FEDERAL ENERGY REGULATORY COMMISSION

TVA

Definitions

- Risk – probability of adverse consequences
  - P(load) **x** P(failure) **|** load **x** Consequences **|** failure

- Risk Analysis – A quantitative calculation or qualitative evaluation of risk

- Risk Assessment – The process of deciding whether risk reduction actions are needed

Dam Safety Risk Analysis is New?

"The possibility of failure must not be lost sight of. To sum up in a concrete manner, it is my judgment that the chances of failure with the water at varying elevations will be substantially as follows:

ELEVATION	CHANCES
3795	1 in 5000
3800	1 in 2000
3805	1 in 500
3810	1 in 100
3815	1 in 10

LIKELIHOOD

In case of failure, while there might be no loss of life, yet the loss in time, in property, in money and in prestige would many times over exceed the cost of even an entirely new structure." CONSEQUENCES

Thaddeus Merriman, New York, February 21, 1912

Why Risk Analysis?

- Teton Dam failure in 1976-- Reclamation begins developing risk analysis methodology for dams
- Hurricane Katrina in 2005-- USACE recognized need to implement risk analysis following failure of levees in New Orleans
- Improve and balance risk reduction benefits with limited budget (e.g. upgrading a few dams to pass the PMF vs. using available budget to reduce risk at many dams)
- Transparency and justification for dam and levee safety decisions

Workshop (Some Highlights)

- First in Casper, Wyoming in 2009 (Pathfinder)
- 2010 at TVA Offices
- 2011 in Denver – Reclamation in co-op with USACE
- 2012 info added to address levees and related structures
- 2015 workshop in Denver for USSD
- 2018 in Denver

Typical Workshop Attendance

- Civil
- Construction Management
- Dam Instrumentation
- Dam Safety
- Economist
- Engineering and Lab Sciences
- Geologist
- Geotech
- Hydrology and Hydraulics
- Mechanical
- Structural
- Waterways and Concrete Dam

Workshop Evolution

2017

- Exercises added
- Modified presentations
- Added new presentation topics

2018

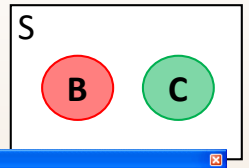
- Updated chapters
- New chapters
  - Concrete material properties, Levee closure sections

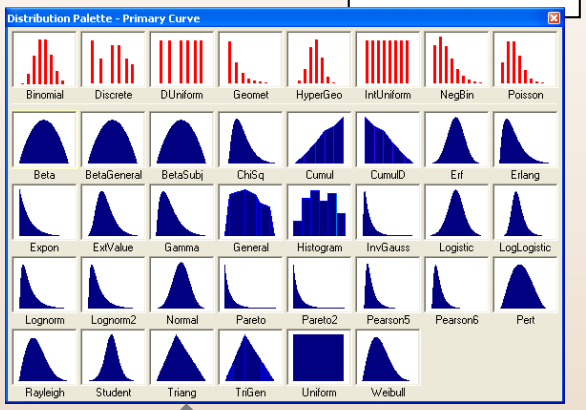
2019

- Very similar to 2018
- Considering some changes for future training so give feedback

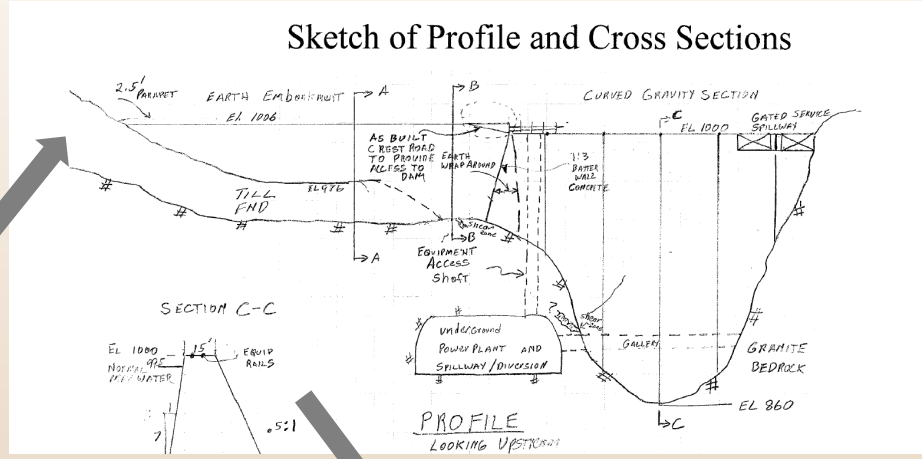
Day 1

Basics

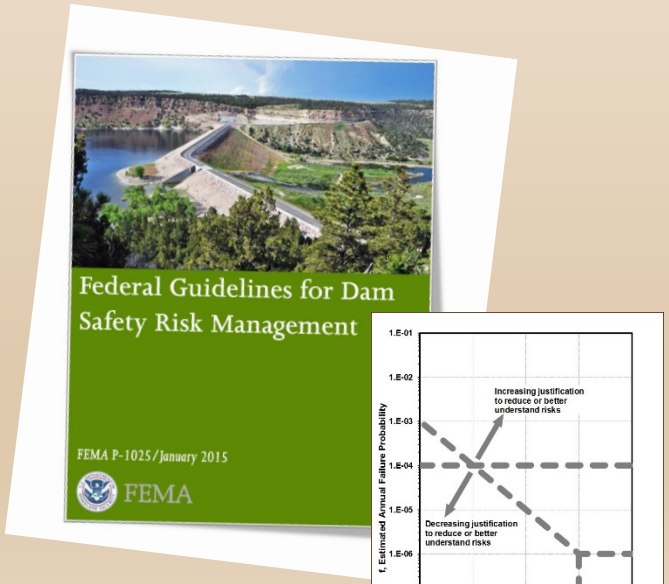




Failure Mode Analysis & SQRA



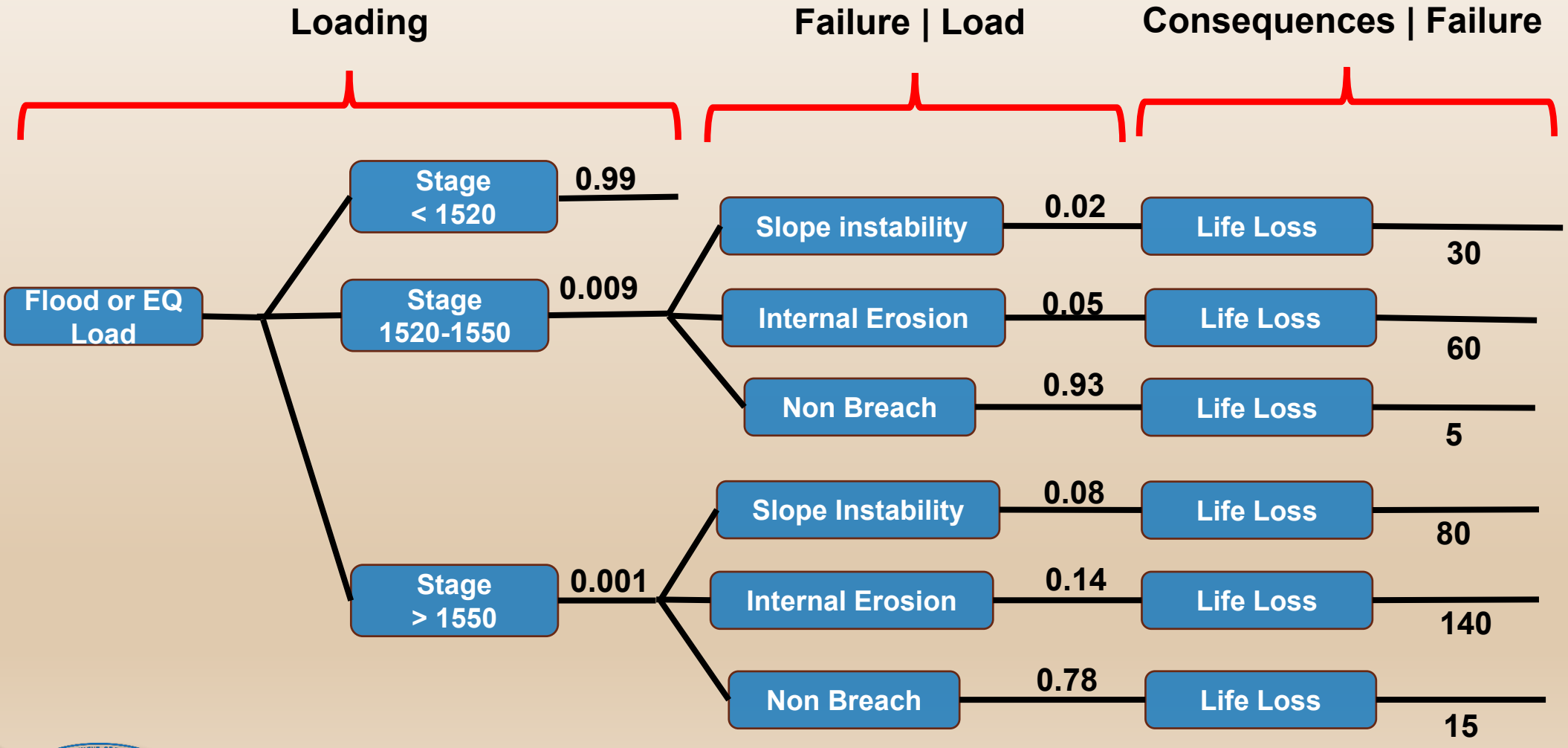
Guidelines



Geo Needs

Event Trees

Day 1 (Event tree)

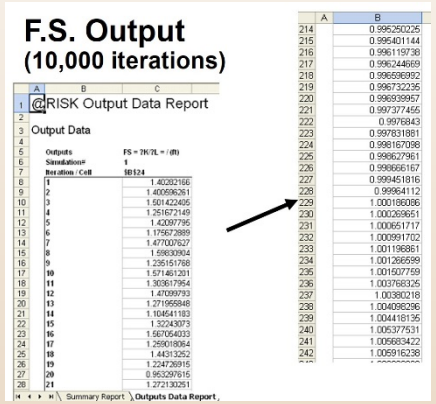


Day 1 (Cont.)

Subjective Probabilities

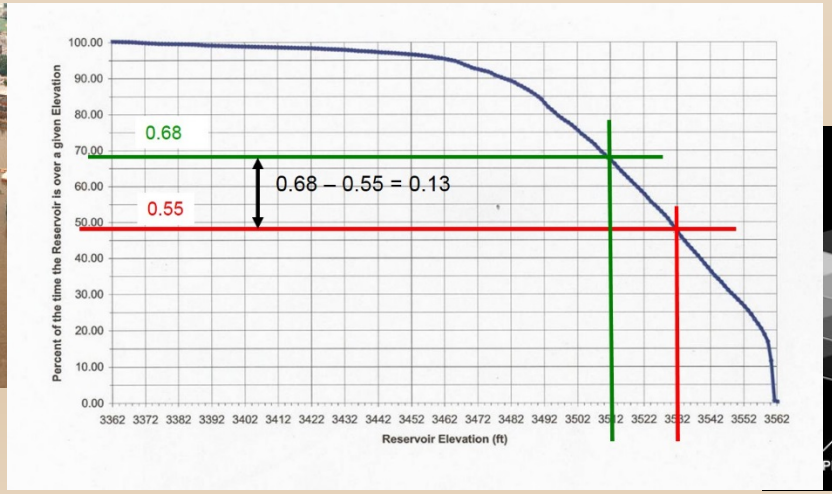
Descriptor	Associated Probability
Virtually Certain	0.999
Very Likely	0.99
Likely	0.9
Neutral	0.5
Unlikely	0.1
Very Unlikely	0.01
Virtually Impossible	0.001*

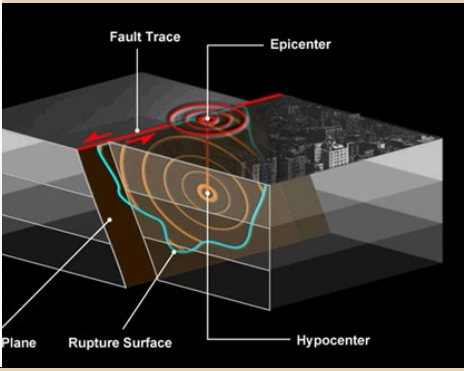
Probabilistic Approaches



Estimating Consequences

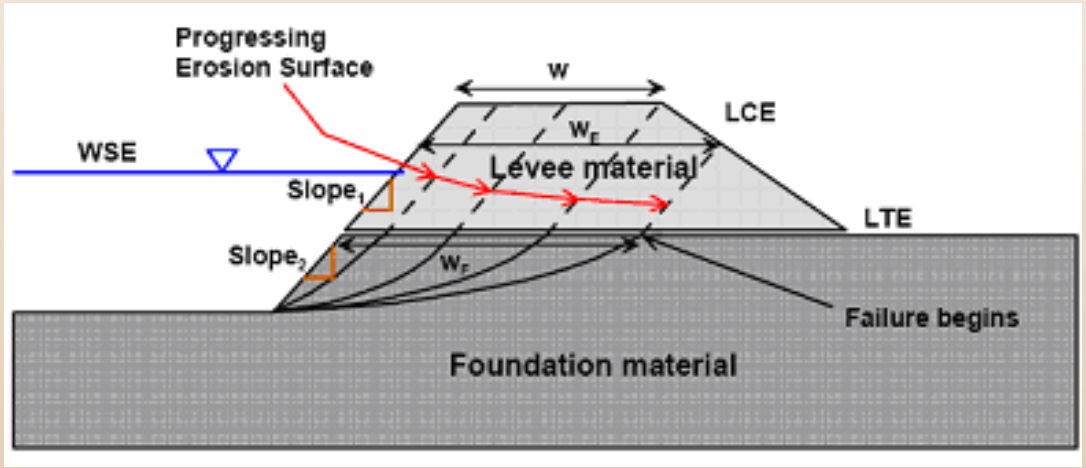
Loadings

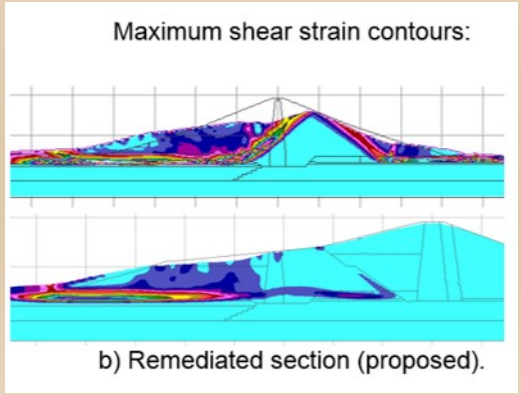




Day 2

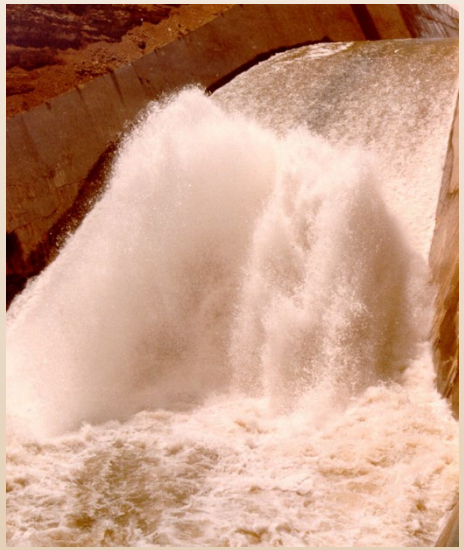
PFM's related to Soil & Rock



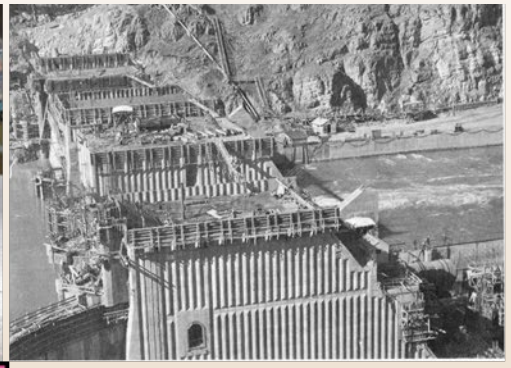


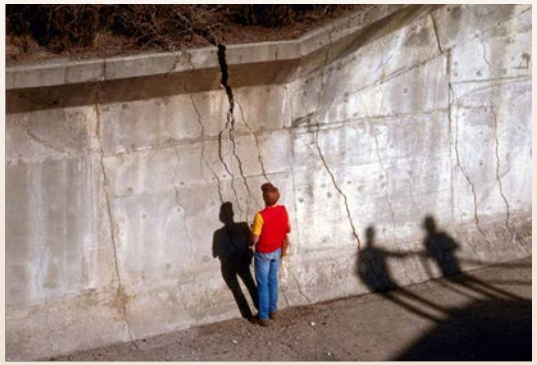
Day 3

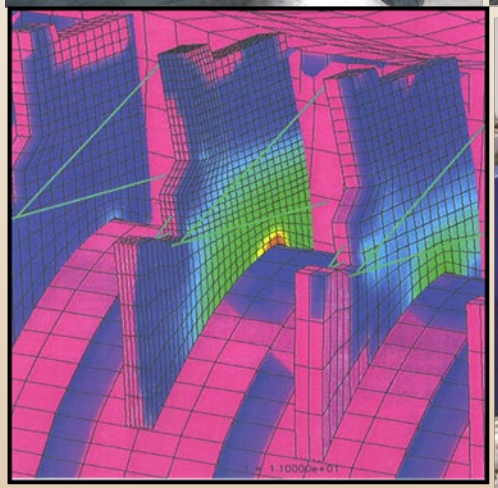
PFM's related to Hydraulics



PFM's related to Concrete



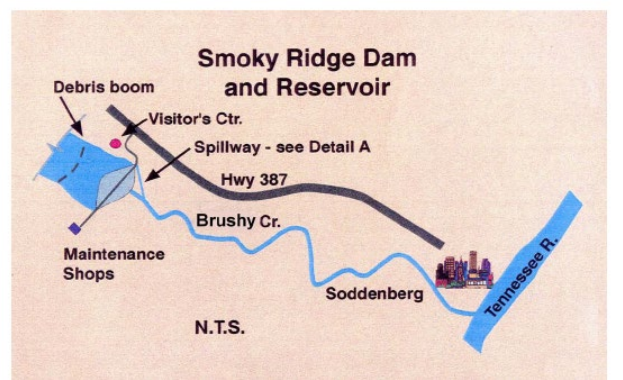




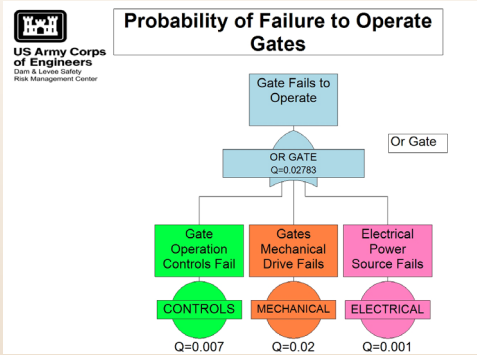
PFM's related to Steel

Day 4

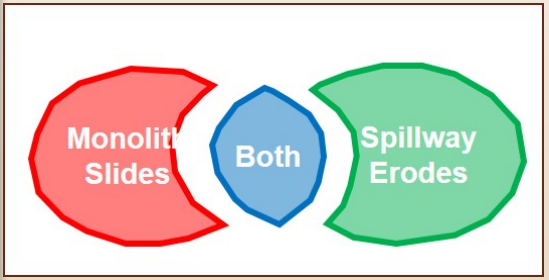
Smokey Ridge Exercise

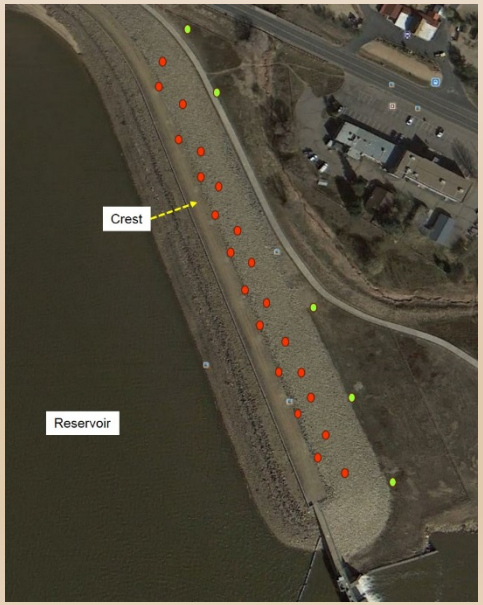


Mechanical & Electrical



Other Risks and Big Picture stuff





PFM'S of levee related structures

Example of Building the Case

- Claim:
  - The lift joints near the spillway crest are well bonded and have significant strength. This leads to a low likelihood (0.1 or less) of cracking through the section at 1/10,000 AEP or smaller ground motions.
- Evidence:
  - All lift joints near the spillway elevation were recovered intact in core drilling
  - There were a large number of tests indicating high tensile strength across joints (cite reports)
  - Construction control procedures were excellent (describe from docs)
  - Stresses are less than estimated strength (quantify from reports)

Objectives

- Risk analyses performed by:
  - people with experience on dams, levees and related specialties.
  - cross disciplined teams to perform risk analyses of dams and levees.
- We encourage individuals to develop cross discipline expertise.

Some basic rules

- Please sign in daily
- Handouts
- Feedback forms—fill out often, and be detailed
- Honor bar (pay as you go!)
- Restrooms and door code
- Laptop free zone
- Breaks and 2 min. warnings
- PDH certificates
- Jargon and acronyms: if you don’t know, ask!