

# Risk-Informed Decision-Making

Federal Energy Regulatory Commission  
Office of Energy Projects  
Division of Dam Safety and Inspections



# Welcome



# Risk is a construct – Before risk there was fate

Bernstein P.L.

*Against the Gods: The Remarkable Story of Risk,*

Wiley: New York (1996)



# Definition of Key Terms



# Risk

Measure of the probability and severity of an adverse effect to life, health, property, or the environment. In the general case, risk is estimated by the combined impact of all triplets of scenario, probability of occurrence and the associated consequence. In the special case, average risk is estimated by the mathematical expectation of the consequences of an adverse event occurring (that is, the product of the probability of occurrence and the consequence, combined over all scenarios).



# Risk

“The product of the likelihood of an adverse event and the consequences of that event.” *U.S. Bureau of Reclamation, Guidelines for Achieving Public Protection in Dam Safety Decisionmaking, 2003*

“Measure of the probability and severity of undesirable consequences.” *U.S. Army Corps of Engineers, Draft ER, 2009*

“Risk is a function of three terms:  $v_{LL}$  (frequency of life loss), LL (actual number of lives lost), and p (probability that provides a measure of the uncertainty in the analysis)” *Martin McCann, Stanford University*



# Risk

Risk requires an understanding of:

- The probability of the scenario, i.e. the failure mode
- The probability of an adverse response to the scenario, i.e. the probability of an uncontrolled release of water given the scenario occurs
- The consequences given the adverse response occurs
- There is uncertainty associated with all 3 parts and this must be understood and explicitly accounted for



# Risk Analysis

The use of available information to estimate the risk to individuals or populations, property or the environment, from hazards.

Risk analyses generally contain the following steps:

- scope definition,
- hazard identification, and
- risk estimation.





# Risk Assessment

The process of making a decision recommendation on whether existing risks are tolerable and present risk control measures are adequate, and if not, whether alternative risk control measures are justified or will be implemented.

Risk assessment incorporates the risk analysis and risk evaluation phases.



# Risk Assessment

Risk assessment is a decision-making process, often sub-optimal between competing interests, that results in a statement that the risks are, or are not, being adequately controlled.

Risk assessment involves the analysis, evaluation and decision about the management of risk and all parties must recognize that the adverse consequences might materialize and owners will be required to deal effectively with consequences of the failure event



# Risk-Informed Decision-Making

Decision-making, which has as an input the results of a risk assessment.

Risk information will play a key role in decisions related to dam safety but will not be the only information to influence the final decisions.

RIDM involves a balancing of social and other benefits and the residual risks.



# Probability

A measure of the degree of confidence in a prediction, as dictated by the evidence, concerning the nature of an uncertain quantity or the occurrence of an uncertain future event.

It is an estimate of the likelihood of the magnitude of the uncertain quantity, or the likelihood of the occurrence of the uncertain future event.

This measure has a value between zero (impossibility) and 1.0 (certainty).



# Probability

There are two main interpretations:

- Statistical - frequency or fraction. The outcome of a repetitive experiment of some kind like flipping coins. It includes also the idea of population variability. Such a number is called an “objective” probability because it exists in the real world and is in principle measurable by doing the experiment.
- Subjective probability - Quantified measure of belief, judgment, or confidence in the likelihood of an outcome, obtained by considering all available information honestly, fairly, and with a minimum of bias.



# Probability

Concepts of Probability developed in relation to gambling  
(managing an economic risk)



# Uncertainty

Uncertainty is the result of imperfect knowledge concerning the present or future state of a system, event, situation, or (sub) population under consideration. The level of uncertainty governs the confidence in predictions, inferences, or conclusions.

Aleatory – Uncertainty (randomness) of nature such as when flipping a coin or rolling dice

Epistemic – Uncertainty related to our understanding such as the probability of dam failing under a given loading



# Probability

As an aside, the term *Aleatory*, which refers to unknowns that differ each time we run the same experiment, draws its root from the Greek, *Aleatorius*, that refers to games of chance in general.





Unacceptable Risk  
Tolerable Risk  
Broadly Acceptable Risk

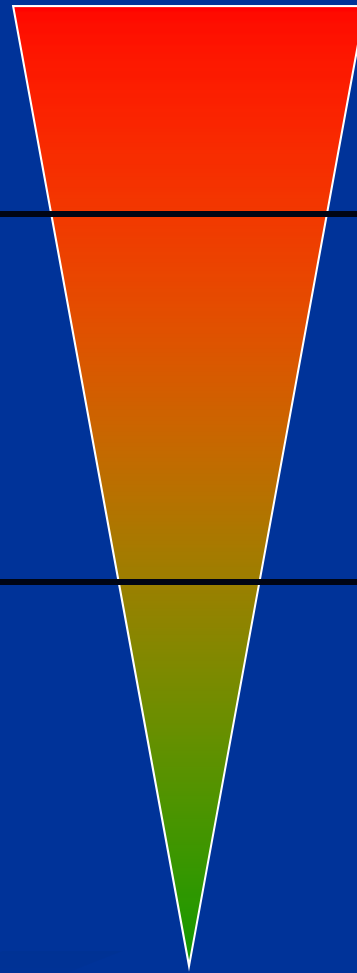


# Risk Triangle

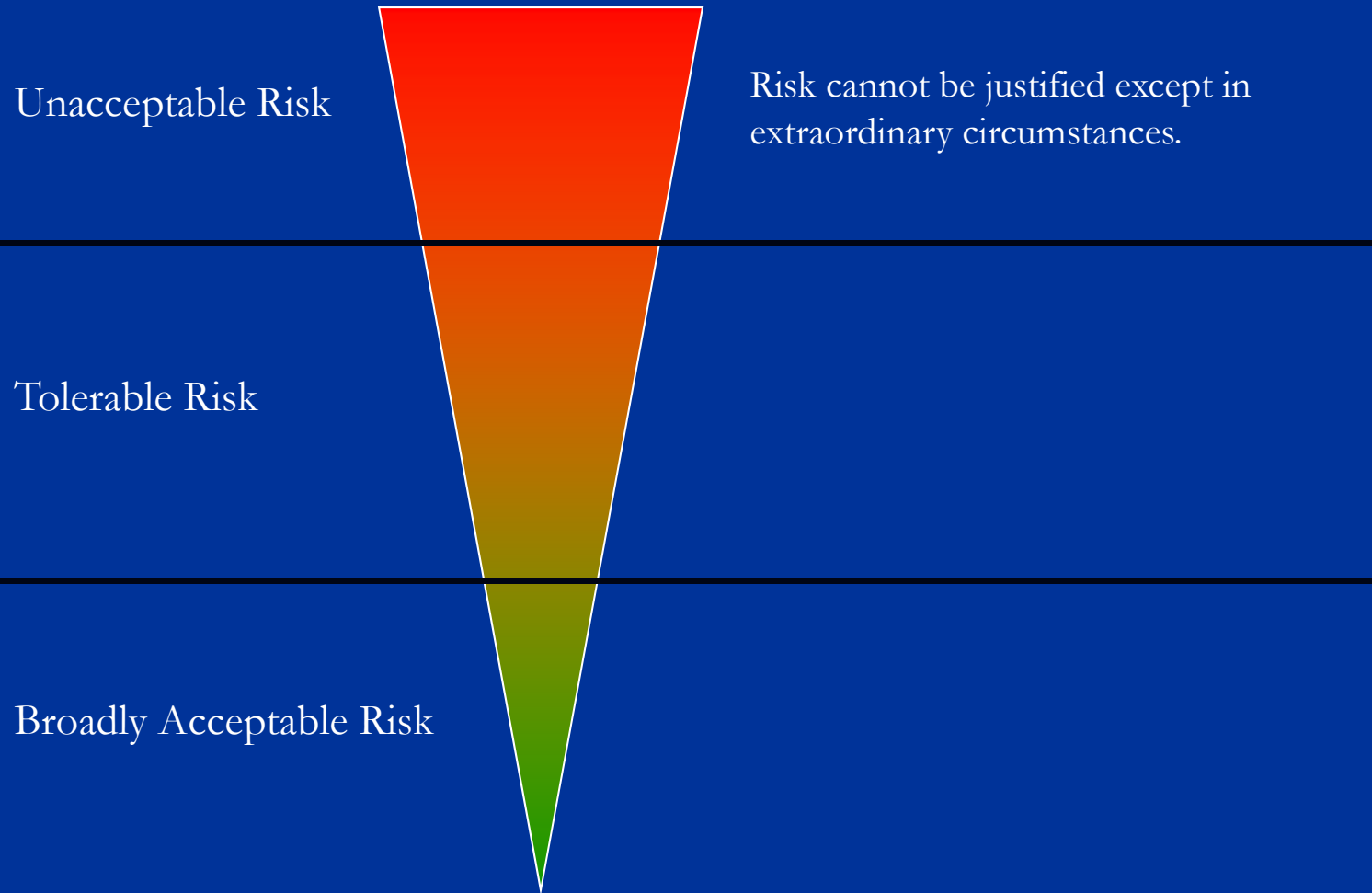
Unacceptable Risk

Tolerable Risk

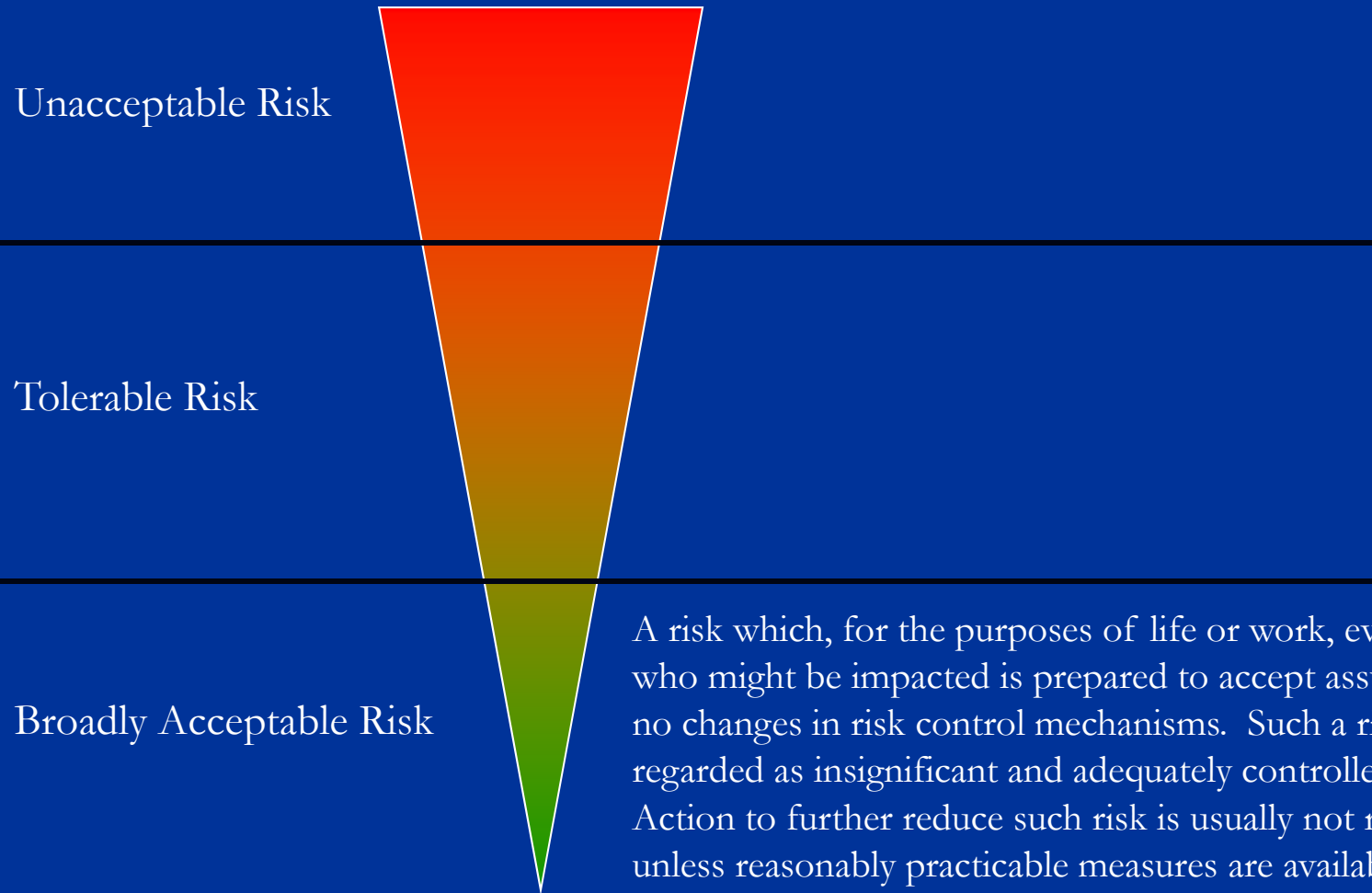
Broadly Acceptable Risk



# Unacceptable Risk

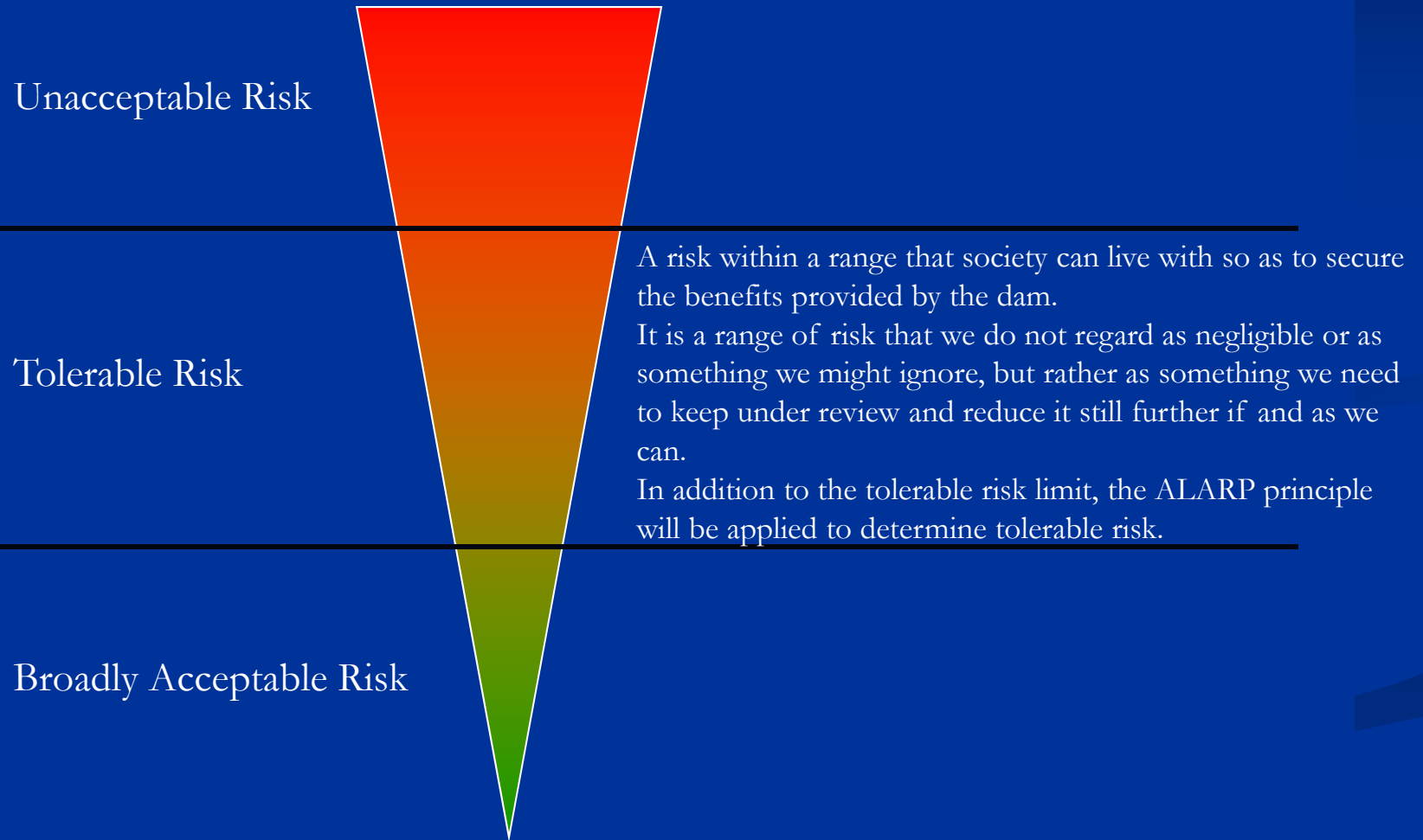


# Acceptable Risk



A risk which, for the purposes of life or work, everyone who might be impacted is prepared to accept assuming no changes in risk control mechanisms. Such a risk is regarded as insignificant and adequately controlled. Action to further reduce such risk is usually not required unless reasonably practicable measures are available at low cost in terms of money, time and effort.

# Tolerable Risk

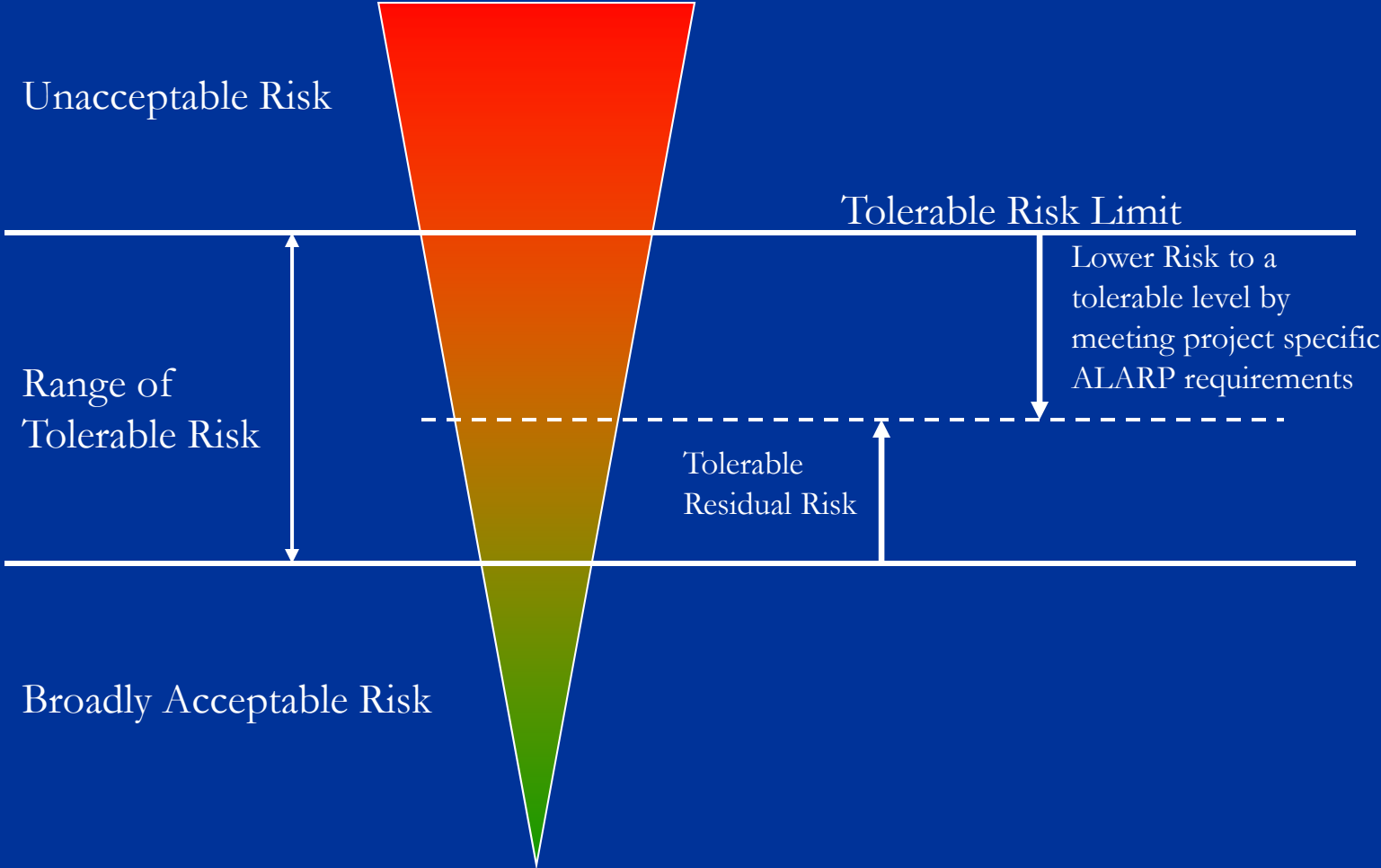


# ALARP

That principle which states that risks, lower than the limit of tolerability, are tolerable only if risk reduction is impracticable or if its cost is grossly disproportionate (depending on the level of risk) to the improvement gained.



# Tolerable Risk



# What does FERC mean by RIDM?





# Risk-Informed Decision-Making

- ▶ Decision-making, which has as an input the results of a risk assessment.
- ▶ Risk information will play a key role in decisions related to dam safety but will not be the only information to influence the final decisions.
- ▶ RIDM involves a balancing of social and other benefits and the residual risks.



From ICOLD 130 and USACE

# Risk-Informed vs. Risk-Based

- ▶ Risk-Informed implies using risk assessments as an input to decision-making.
- ▶ Risk-Based implies that risk is the basis for decision-making.



# Extension of PFMA process

- ▶ PFMA detail how a dam might fail.
- ▶ PFMA do not directly consider the scope of potential consequences.
- ▶ PFMA do not estimate the likelihood of an adverse event.
- ▶ RIDM will consider these items.



# Role of Traditional Analyses

Traditional analyses will be required as inputs to the risk analysis process and to help assess the reasonableness of risk-informed decisions





# What RIDM is Not

- 1) A way for owners to get out of doing work that needs to be done.
- 2) A way for FERC to make owners do work that doesn't need to be done



# What RIDM Is

A way to make sure we do the right things



Why is the FERC moving  
towards a RIDM approach?





# Better Dam Safety

- ▶ Builds on PFMA process
- ▶ We (owners, consultants, FERC) will know more about our dams
- ▶ Considers the full range of consequences
- ▶ Better utilization of resources
- ▶ Standards based approaches only look at a few things – not necessarily the things that cause dams to fail.



# RIDM, Who's Using It?

- ▶ USBR, USACE, NSW, UK-HSE, BC Hydro, EDF, ANCOLD
- ▶ NRC, EPA, FDA, DOT, FAA, Many more



Why is the  
FERC  
moving  
towards a  
RIDM  
approach?



FEDERAL ENERGY REGULATORY COMMISSION

## The Strategic Plan



FY 2009-2014

[www.FERC.gov](http://www.FERC.gov)



# FERC Strategic Plan

In FY 2009, the Commission explored how risk assessment methodologies could benefit its dam safety program. The Commission determined that risk assessment could have the following positive impacts on its program:



# FERC Strategic Plan

- Better understand and quantify potential failure modes;
- Identify previously unidentified failure modes with high risk;
- Understand the consequences of potential failure modes on life, health and property;
- Understand the uncertainty and variability in traditional analyses;



# FERC Strategic Plan

- Compare the safety of different dams using a common basis, risk;
- Compare the relative contribution to risk of all failure modes at a given dam; and
- Understand the risk associated with a single dam or the Commission's entire inventory of dams;
- Evaluate risk reduction alternatives and effectively reduce the risk that Commission-jurisdictional dams pose to the public in quantifiable and defensible terms.



# FERC Strategic Plan

- ▶ In the event of a dam failure, there are both economic (property damage, environmental impacts and costs associated with loss of use of the resource) and loss of life consequences.
- ▶ Risk-informed decision making will enable the Commission to make better dam safety decisions that will, in turn, better protect life, health and property.
- ▶ Risk-informed decision making will be an added tool with which to assess dam safety.



## OBJECTIVE 2.2

### SAFETY

Minimize risk to the public.

1. STRATEGY | Incorporate risk-informed decision making (RIDM) into the dam safety program

#### Long Term Performance Goal

- By FY 2014, risk-informed decision making will be incorporated into the FERC dam safety program.

#### ANNUAL PERFORMANCE TARGETS

FY 2010: Develop action plan

FY 2011: Portfolio Risk Assessment of FERC dam inventory

FY 2012: Determine RIDM is consistent with regulatory process

FY 2013: Finalize policy and technical guidelines

FY 2014: Fully incorporate RIDM into the dam safety program





# Benefits to Owners and FERC

- ▶ Builds on the work completed in Potential Failure Mode Analyses (PFMAs) by considering the likelihood of failure and the consequences, including life, health and property, if a failure were to occur;
- ▶ Provides a means to compare the safety of different dams using a common basis - risk;
- ▶ Provides a means to understand the uncertainty and variability in traditional analyses;



# Benefits to Owners and FERC

- ▶ Provides a process to better understand and quantify potential failure modes;
- ▶ Identifies previously unidentified failure modes with high risk, in particular, non-traditional failure modes;
- ▶ Provides a means to identify critical systems and components



# Benefits to Owners and FERC

- ▶ Provides a means to focus surveillance and monitoring programs;
- ▶ Provides a means to improve Emergency Action Plans
- ▶ Focuses resources on those structures that pose the greatest risk.
- ▶ Risk provides a way to justify expenditures on dam safety. Risk is the common language in board rooms.



# Benefits to Owners and FERC

- ▶ Provides a means to compare the relative contribution of all failure modes to the overall risk at a given dam;
- ▶ Provides a means to understand the risk associated with a single dam or an entire inventory of dams;
- ▶ Provides a means to evaluate risk reduction alternatives and effectively reduce the risk regulated dams pose to the public in quantifiable and defensible terms;



# Benefits to Owners



**Report of the Independent Review Panel  
San Bruno Explosion**



**Prepared For  
California Public Utilities Commission**

**Revised Copy  
June 24, 2011**









“There is no evidence top management has taken the steps necessary to be well-informed about the key aspects of decisions selected to manage major risks that concern PG&E.”



“Quality (risk) analysis could both facilitate two-way communication between top management and individuals with substantial knowledge about each of the relevant aspects of utility operations and provide a clear understanding of all the information available to make a key risk management decision.”



“Management could then ensure a full range of alternatives were considered in the decision and examine how each measured up in terms of each of PG&E's relevant objectives. They could examine what assumptions and judgments were used in integrating the available information to indicate the pros and cons of the alternatives. A quality analysis would highlight any significant missing information and provide a basis to examine whether it would be worth gathering if possible.”



Similarly the New York Stock Exchange rules require companies listed on the exchange to:

"discuss policies with respect to risk assessment and risk management."



"While it is the job of the CEO and senior management to assess and manage the company's exposure to risk, the audit committee must discuss guidelines and policies to govern the process by which this is handled. The audit committee should discuss the company's major financial risk exposures and the steps management has taken to monitor and control such exposures."



“A penalty of \$1 billion would be a ‘challenge’ to the utility . . . The company would have to sell additional stock to pay for a fine of that sum”

Anthony Earley, PG&E Chairman and Chief Executive Officer



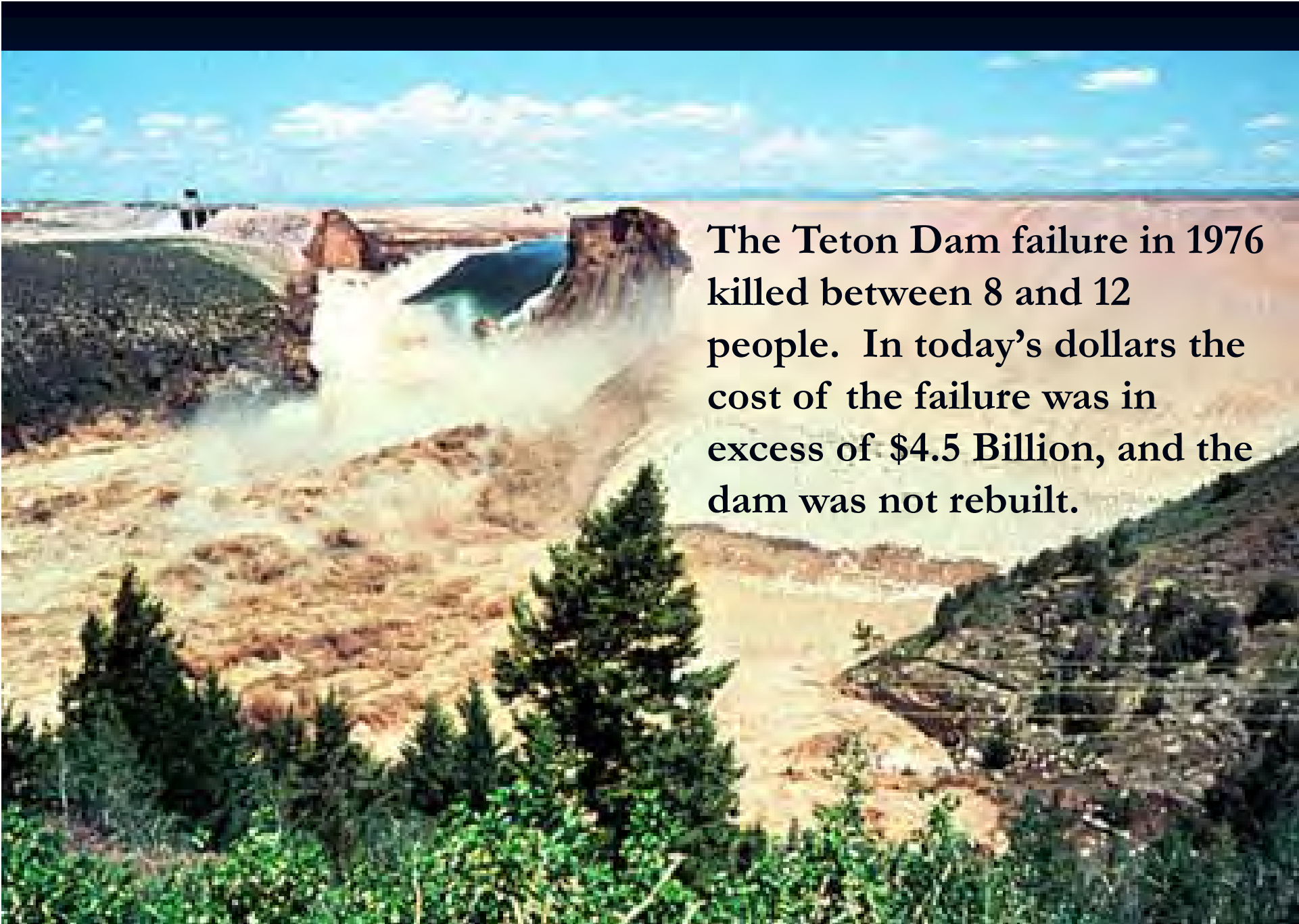
The California Public Utilities Commission has recommended a \$2.25 Billion fine.





The Taum Sauk Failure  
cost Ameren over \$1.5B.





**The Teton Dam failure in 1976 killed between 8 and 12 people. In today's dollars the cost of the failure was in excess of \$4.5 Billion, and the dam was not rebuilt.**

# What Can Owners Do Now?

- Clean up failure modes
  - Full description (Initiation, Progression, Failure)
  - Event Trees – Not event reeds
- Improve dam break studies
- Estimate consequences

