BUREAU OF RECLAMATION

Critical vs Non-Critical Features for Risk-Informed Seismic Design of Reclamation Spillways

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National Dam Safety Program Technical Seminar | E8535

Overview

Outline

Introduction to Dams

Spillways

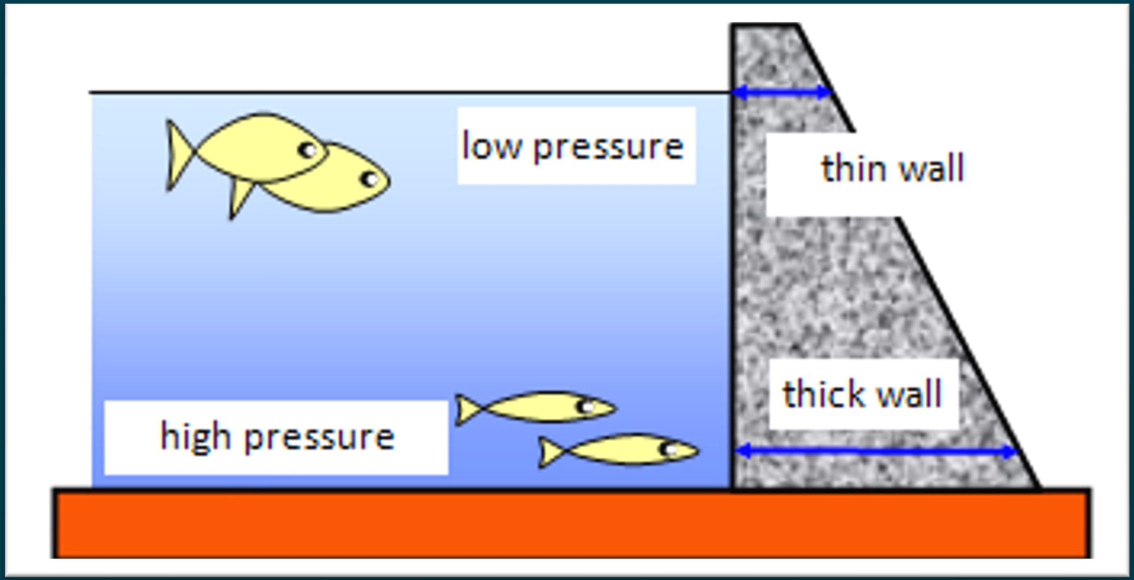
Critical vs. Non-Critical Features

Case Studies

Design

Conclusion

Dams



Structures Associated with Dams: Plant Structures

Hydropower plant

Structures Associated with Dams: Water Conveyance

Tunnels and Canals

Structures Associated with Dams: Civil Structures

Roads and bridges

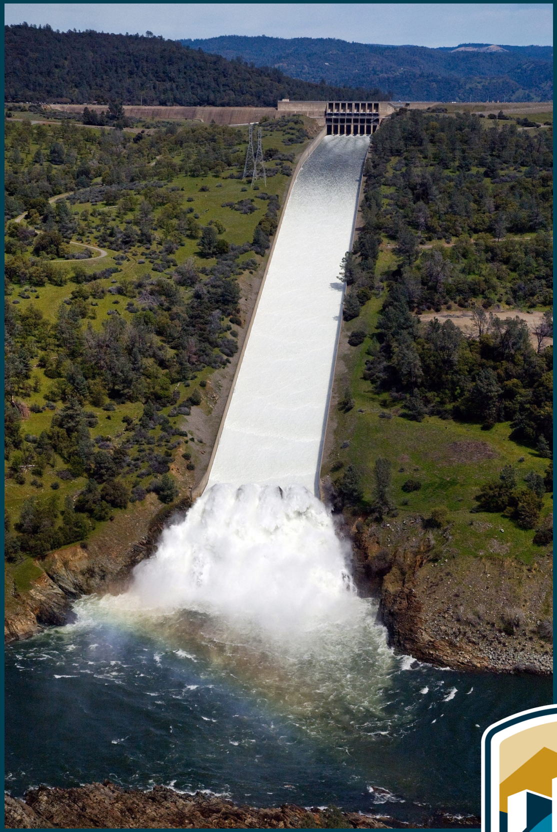
Structures Associated with Dams: Waterways

Appurtenant Hydraulic Structures: Spillway

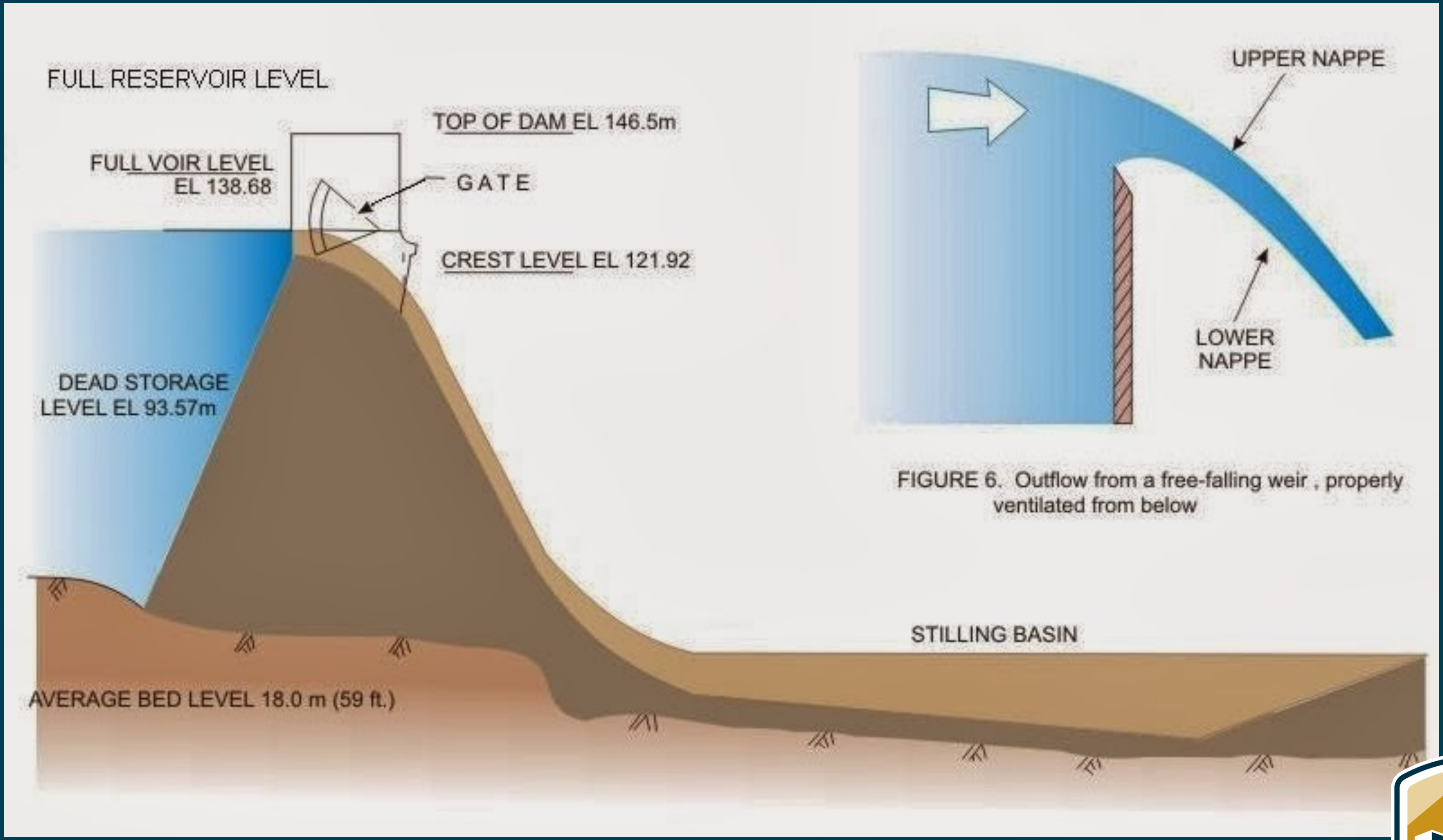
Main Types of Spillways

Overflow (ogee)

Chute (open channel)



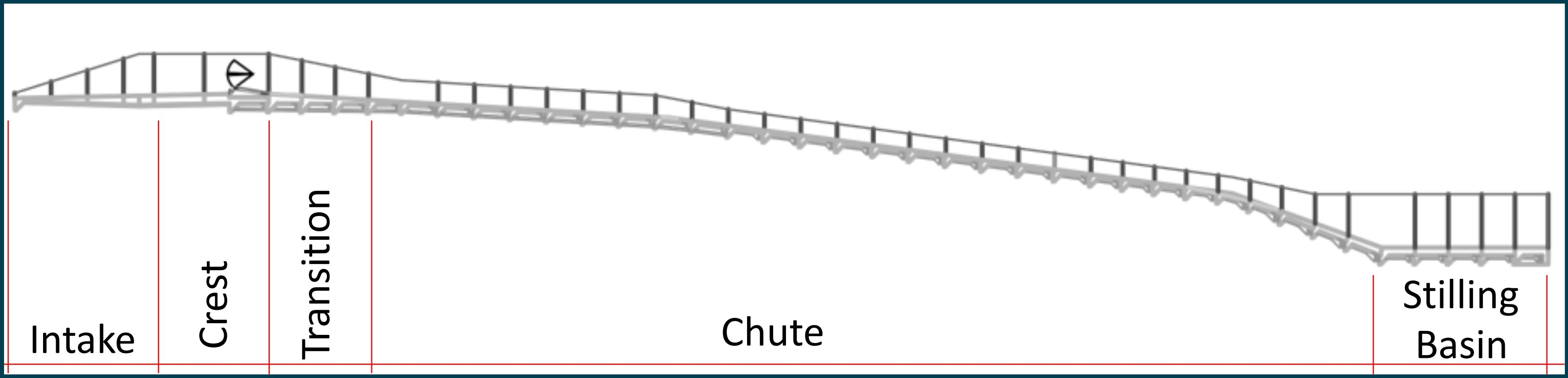
Ogee Spillway Profile



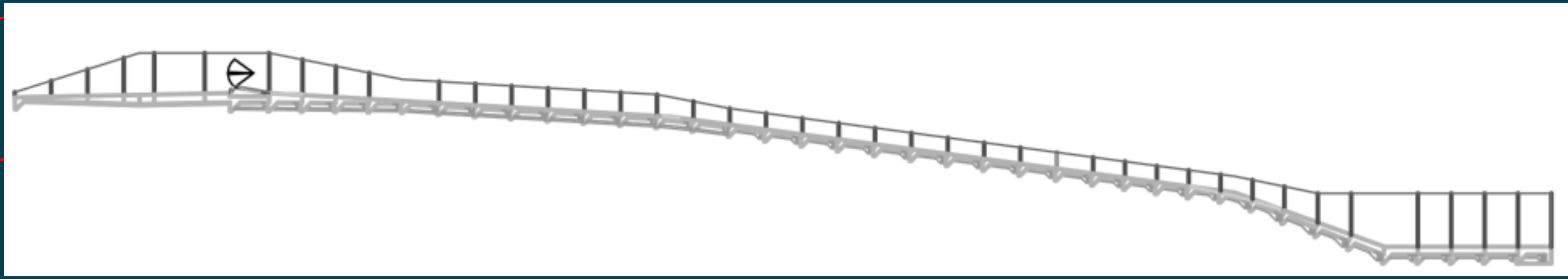
Chute Spillway Profile

Direction of flow

Downstream channel

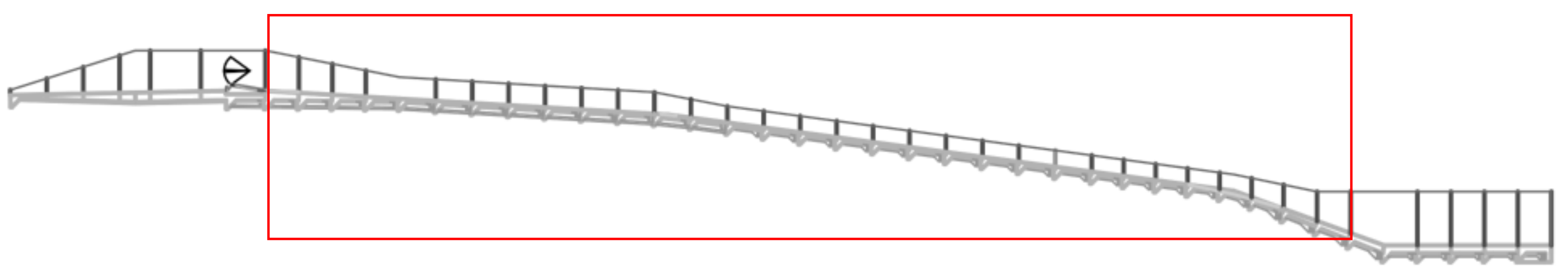


Intake

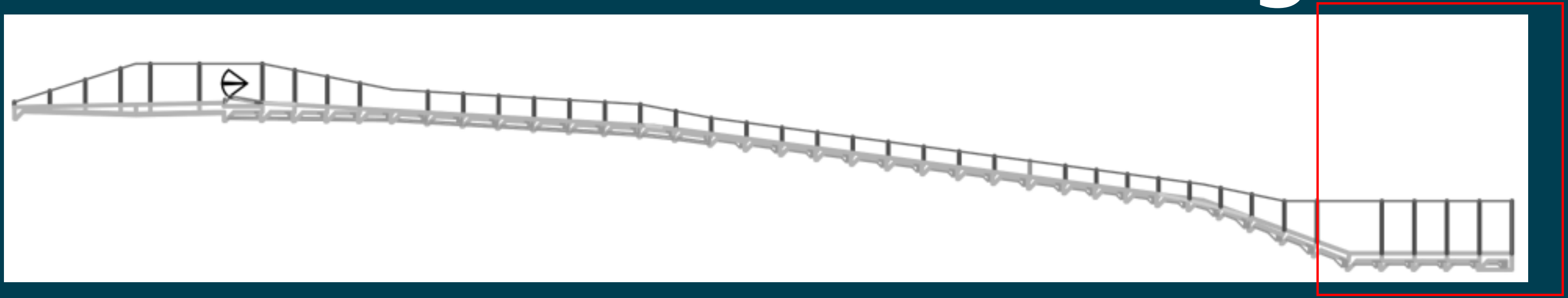


Crest

Chute

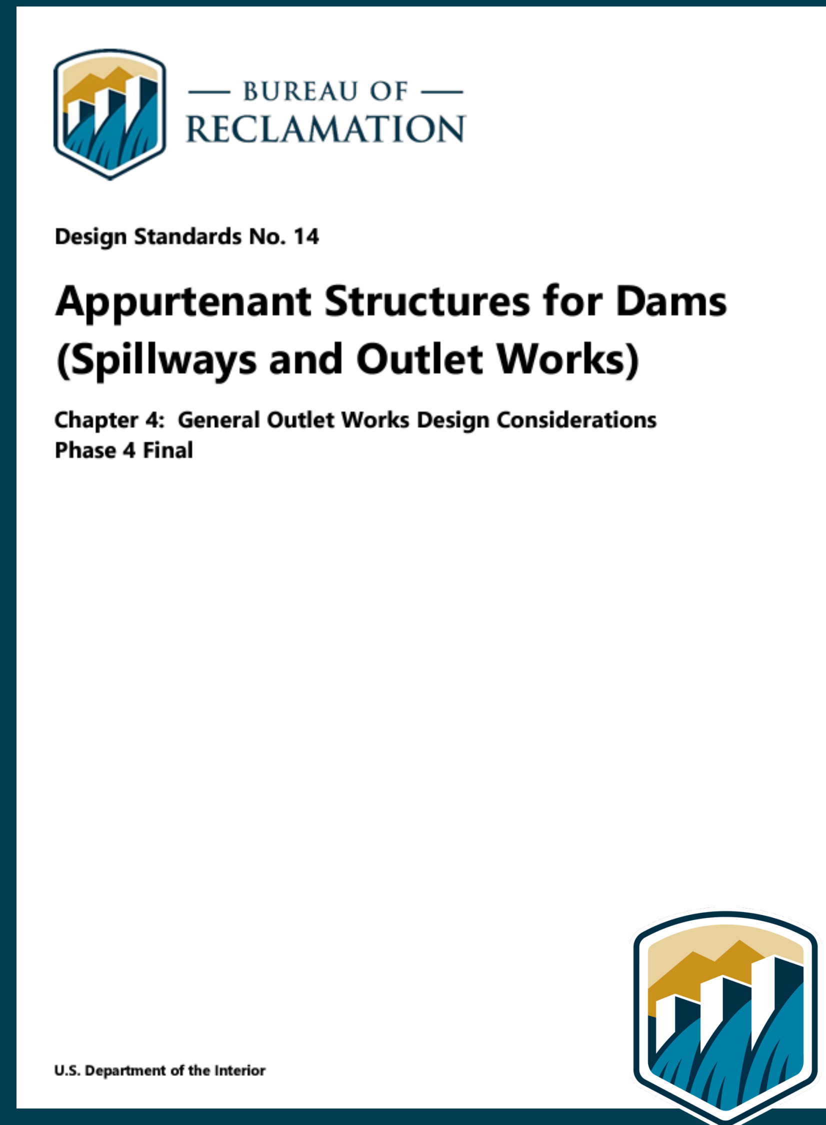


Stilling Bash



Critical vs Non-Critical Features

- DS-14 (Chapter 3)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RECLAMATION

Design Standards No. 14

Appurtenant Structures for Dams (Spillways and Outlet Works)

Chapter 4: General Outlet Works Design Considerations
Phase 4 Final

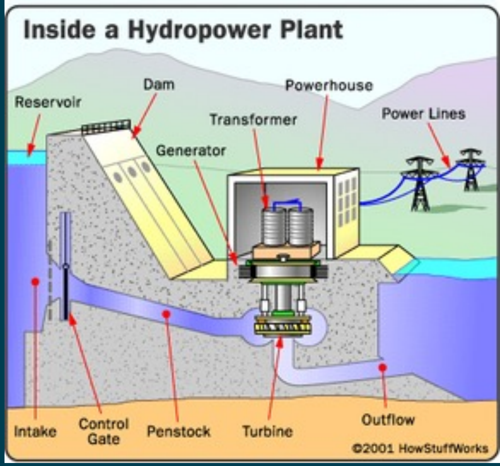
U.S. Department of the Interior

Critical vs non-critical

Critical Components:

- Definition: "Critical components are those whose damage or failure can lead to damage and/or failure of the dam and other appurtenant features."
- Impact on Dam Safety: "Failure of critical components may result in uncontrolled releases of the reservoir and generate unacceptable downstream hazards."
- Examples: Spillway gates, crest structure.

Critical vs non-critical (2)



Non-Critical Components:

- Definition: "Non-critical components are features that, if damaged or failed, do not pose an immediate risk to dam safety."
- Impact on Dam Safety: "Failure of non-critical components does not inhibit spillway releases to protect the dam and does not result in uncontrolled releases or downstream hazards."
- Examples: Access roads, lighting systems, non-essential monitoring equipment.

Differentiation Importance

- Distinguishing between critical and non-critical components allows for prioritized attention and resources to be directed towards critical components, ensuring the highest level of dam safety.
- Critical components require more rigorous design, monitoring, and maintenance to minimize the risks associated with their failure.

Design Considerations

- Critical components must be designed with robustness, redundancy, and fail-safe measures to mitigate the potential consequences of their failure.
- Non-critical components focus on functionality, ease of maintenance, and cost-effectiveness, without compromising overall safety.

Examples of Critical vs Non-Critical Features

Dam 1

Dam 1 (2)

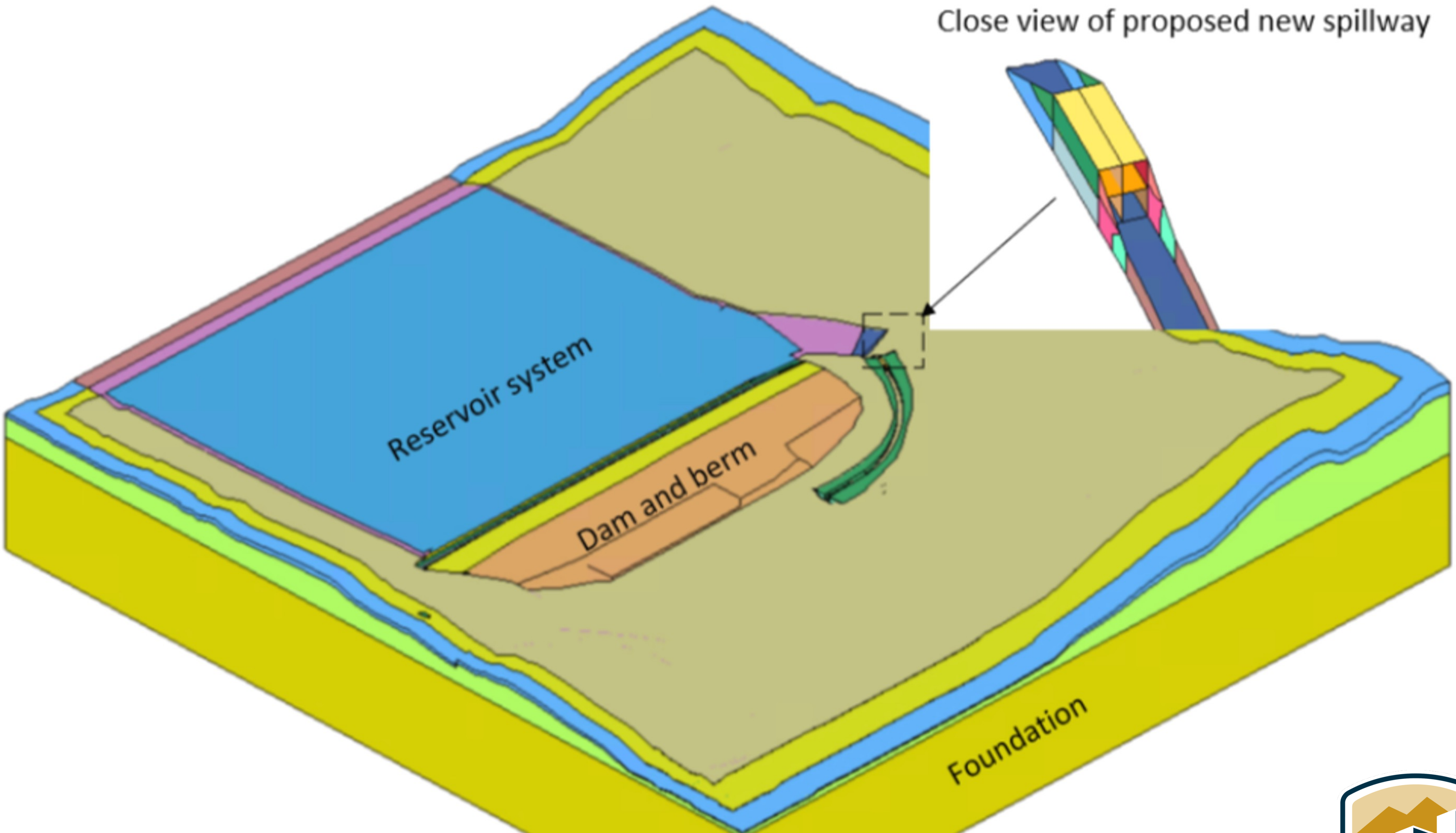
Dam 2

Dam 2 (2)

Power Plant

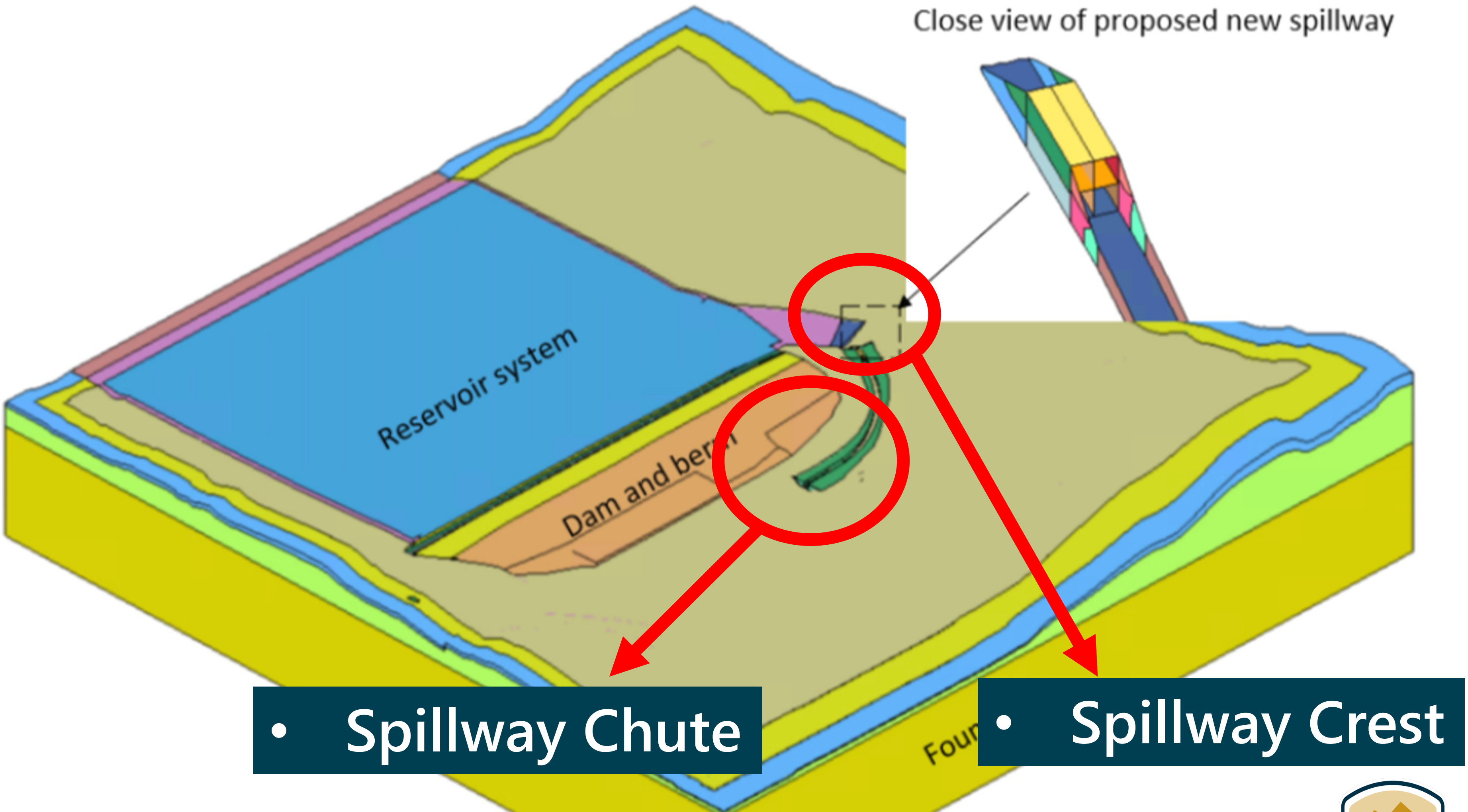
- Spillway
- Gates
- Walls
- Gate hoist

Dam 3



Close view of proposed new spillway
Reservoir system
Dam and berm
Foundation

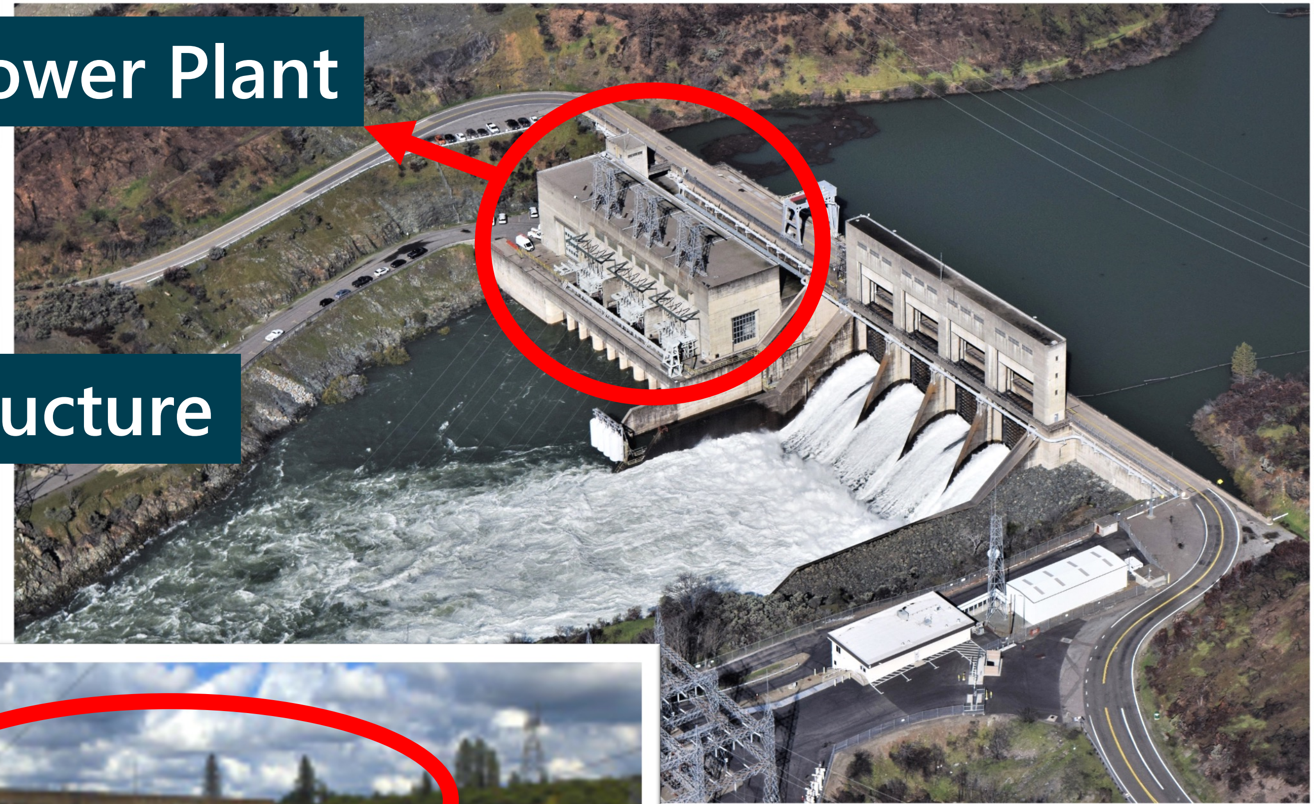
Dam 3 (2)


Close view of proposed new spillway
Reservoir system
• Spillway Chute
• Spillway Crest

Dam 4

Dam 4 (2)

- Power Plant



- Hoist superstructure

- Spillway
- Outlet works

Dam 5

Dam 5 (2)

- Spillway
- Gates
- Bridge

- Powerhouse

Dam 6

- Powerhouse

Seismic Load Determination for Critical and Non-Critical Features

(1) Feature classification	(2) Initial **Loading** Conditions	**(3) Adjustments of loading conditions based on risk analysis**	**(4) Final Seismic Loading**
Non-critical	Design Basis Earthquake (DBE) for a return period of 500 years	-	-
Critical	Design Basis Earthquake (DBE) for a return period of 10,000 years This return period is based on public protection guidelines, aiming for an annualized failure probability of less than 1E-4 (These initial assumed seismic loading conditions may or may not be adequate in terms of reducing or maintaining total risks at acceptable levels.)	A quantitative **risk analysis** methodology, as outlined in Table 3.3.2-1, is used to assess the need for more remote seismic return periods Is risk low enough? If risk is not low enough, use higher return period (back to step 2)	Determined based on the outcome of risk analysis (step 3)

Seismic Load Determination for Critical and Non-Critical Features (2)

Feature classification	Design standard followed:
Non-critical	Latest design standard code
Critical	Risk-Informed Design Approach

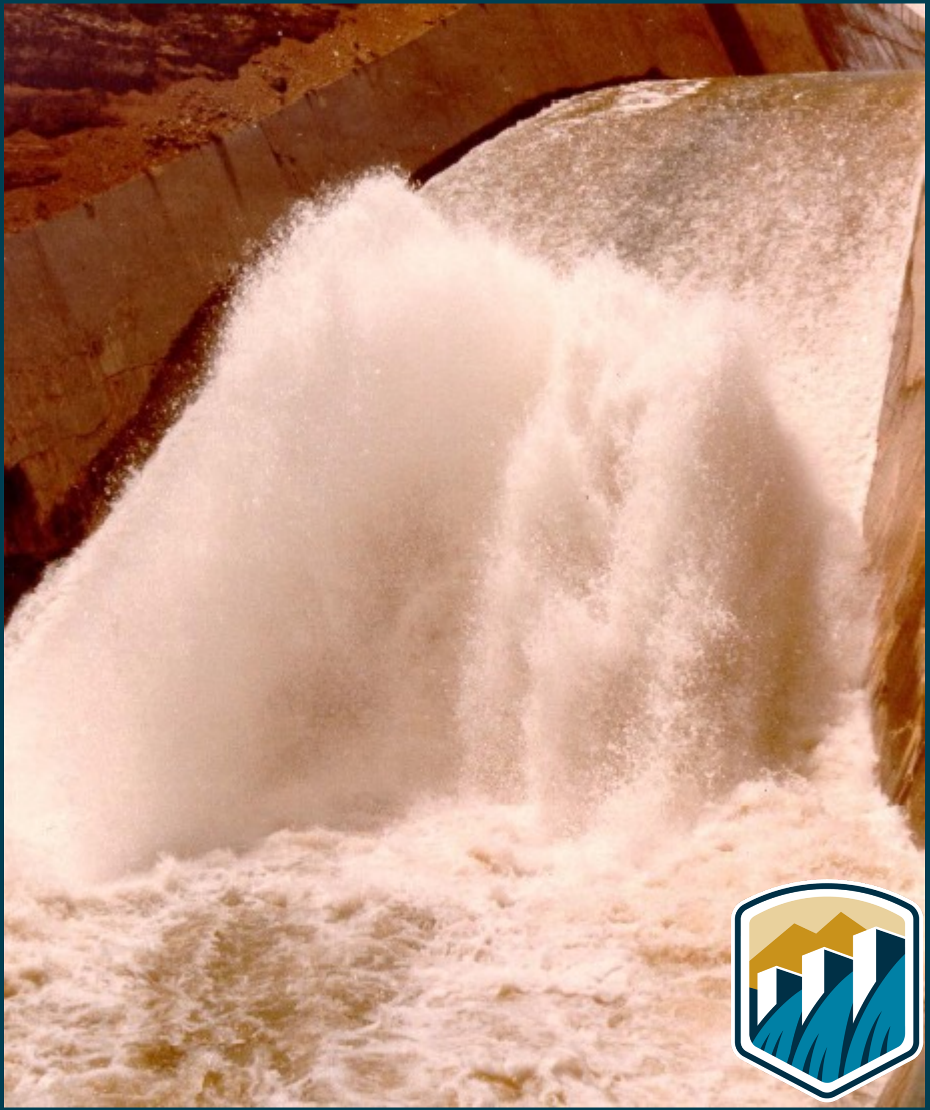
Design of Critical vs Non-Critical

- 500-year seismic event vs RIDM

Risk-Informed Decision Making

How does Reclamation define "Risk"?

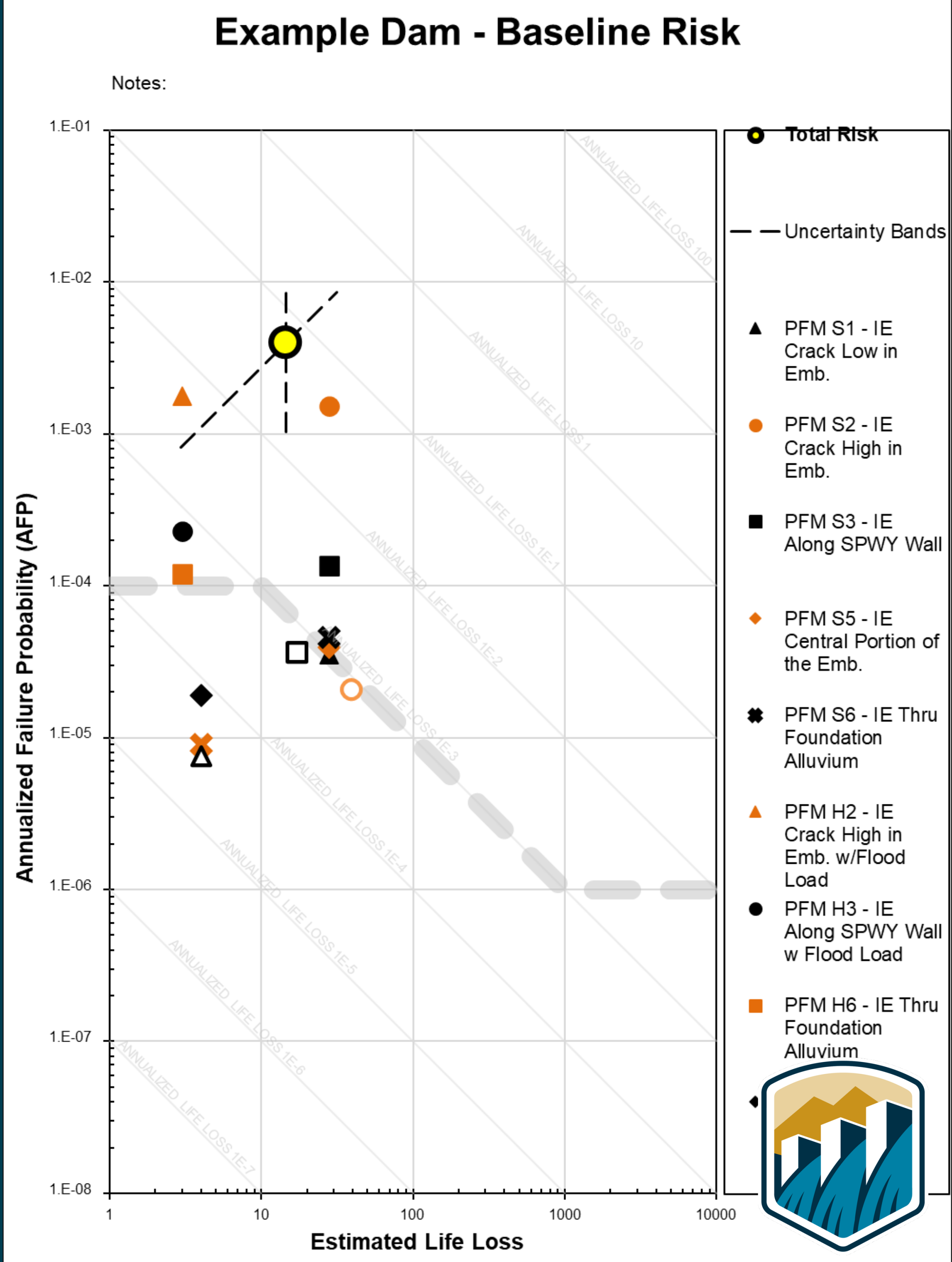
- Annualized Failure Probability (AFP)
- Annualized Life Loss (ALL)



Dam Safety Public Protection Guidelines (Interim, December 2022)

Risk-Informed Decision Making (2)

Risk Portrayal Chart



Risk-Informed Design

Step 1

Identification of potential failure modes and their existing risks which helps identify deficiencies that can be addressed with structural modifications

Step 2

Design of modification follows current design standards

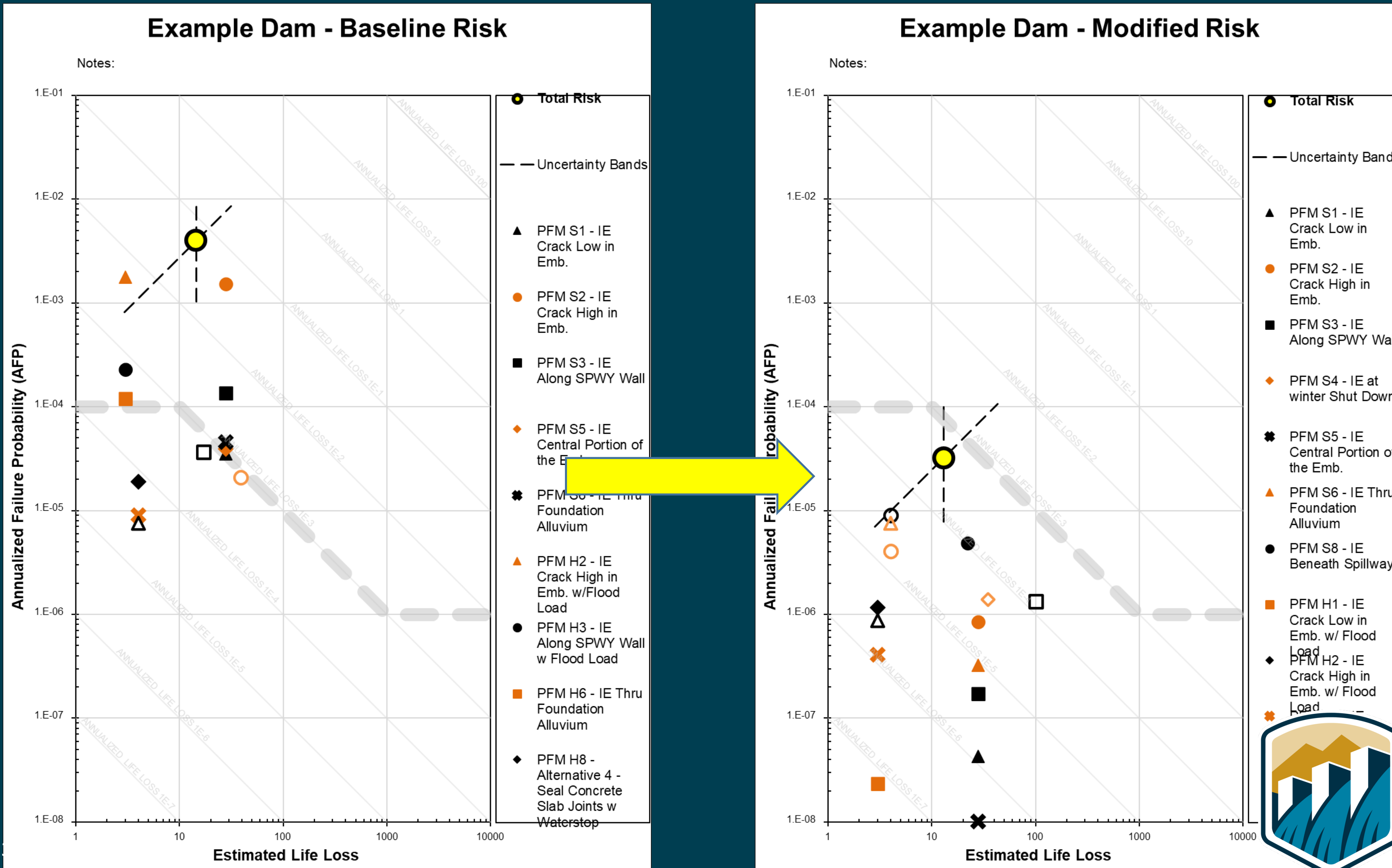
Step 3

Risk verification = evaluating if the modifications reduce the perceived risk and to what relative degree, consideration of the modification being(as low as reasonably practicable) ALARP or if further improvements are possible, technically and economically

Step 4

Decision Process (Risk informed decision making process to confirm the most technically sound, and ALARP modification is pursued)

Risk-Informed Design (2)



Conclusion

- Failure of critical features can lead to dam failure
- Failure of non-critical features leads to an incident (not dam failure)
- Prioritized attention and resources are directed towards critical components, ensuring the highest level of dam safety.
- Critical components require more rigorous design, monitoring, and maintenance to minimize the risks associated with their failure

Thank You!

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