Risk Assessment Making the Case

RISK ASSESSMENT

- Risk assessment is a set of procedures developed to review risk analyses.
- For example the US Corps of Engineers uses a quality control review team to review risk analyses after completion
- This QC Team strives to help analysts achieve good quality analyses which are consistent throughout the country
- Once successfully passed by the QC team, the risk analysis is then shown to the Senior Oversight Group (SOG)
- The SOG reviews the RA to determine if it has made the Dam Safety Case.

RISK ASSESSMENT

- The FERC has yet to develop procedures for how Risk Assessments will be performed.
- A committee will develop these procedures in the coming years.
- Preliminarily, the following slide shows how it might look

RISK ASSESSMENT

- A Quantitative Risk Analysis (QRA) is performed by the owner's staff, consultants, and FERC staff.
- Once completed it would be shown to the FERC Regional Office (RO) and risk QC team (national).
- When it successfully passes the QC team, it would be presented to a SOG
- When it passes the SOG, it would be signed by the analyst team, the FERC RO and the FERC Director, Division of Dam Safety and Inspections

WHY MAKE THE CASE?

- The Dam Safety Case is intended to present rationale in a methodical manner to persuade decision makers to take responsible action.
- Since the numbers are not accurate nor precise, and the tolerable risk guidelines flexible, reasoning is essential to justify recommended actions.
- Risk guidelines are not intended to be used as rigid decision-making criteria to declare a facility 'safe' solely based on a risk estimate.

Post Risk Analysis Review

- If you have a bad day trying to make the case, it is probably because:
  - Your failure modes are not adequately described and understood by everyone in attendance
  - You did not portray the current condition of the dam (design, analysis, construction, structural behavior) and its ability to withstand future loadings
  - You did not adequately support the risk estimate numbers with the reasons why they make sense
  - The state of the facility, the risk numbers, and the recommendations are not consistent with each other

Six Questions Dam Safety Reviewers Are Supposed To Ask:

- Do risks agree with the understanding of current conditions and the ability to withstand future loads?
- Do recommended actions agree with portrayed risks?
- Is it reasonable to continue operating until the next Part 12 Review?
- What are the most appropriate future actions?
- Do recommendations sufficiently capture needed actions?
- Does the overall report and its conclusions make sense?

Dam Safety Case:

- A Logical Set of Arguments…
  - Recommending additional safety-related action is justified, or no additional safety-related action is justified.

- Is convincing when decision-makers sense that the following are coherent:
  - the dam's existing condition and ability to withstand future loading,
  - the risk estimates,
  - and the recommended actions.

Findings Template

- Three main components:
  - The risk is tolerable or intolerable
  - The need for action is urgent or not
  - The uncertainty is great and additional investigations has a good chance of changing perceptions of risk tolerability or urgency

Findings Template

1. The estimated risk is tolerable, and confidence is high so that no further actions or studies are necessary.
2. The estimated risk is tolerable, but the confidence is low and it is reasonable to expect additional information could increase the perceived risk such that risk reduction actions may be justified.
3. The estimated risk justifies risk reduction measures, but the confidence is low and it is reasonable to expect additional information could decrease the perceived risk such that the perceived risk may be tolerable.

Findings Template

- 4. The estimated risk justifies expedited action, but the confidence is low and it is reasonable to expect additional information could make the risks either tolerable or such that expedited action is not required.
- 5. The estimated risk is tolerable, confidence is high, but reasonable and prudent actions are recommended nonetheless.
- 6. The estimated risk justifies risk reduction measures and confidence is high so that no further studies are necessary before moving to a Corrective Action Study.
- 7. The estimated risk justifies expedited action and confidence is high so that no further studies are necessary before moving to a Corrective Action Study.

Findings Template
Monitoring

- 8. The existing monitoring program is sufficient to provide advance warning for the identified potential failure modes and contains no elements that do not relate to such warning.
- 9. The existing monitoring program should be modified because either it is not sufficient to provide advance warning for the identified failure modes or because at least some of the measurements currently recorded would reveal nothing about impending failure.

Simple Argument

- Claim:
  - Zone 2 shell material filters the Zone 1 core material.
- Evidence:
  - Gradation tests show filter criteria met (provide figure)
  - There were a large number of tests (report number)
  - Zone 2 material doesn't easily segregate (calculation)
  - Construction control procedures were excellent (describe)

"No-Action" Case for Low Seismic Risk

OK to Operate Dam Another 6 Years ?

Diminishing Justification to Take Action in the Long or Short Term

1/10,000 ---- 0.12g

1/50,000 ---- 0.27g

Powerful Earthquake Extremely Unlikely

>25 ft Freeboard, Well-Compacted Embankment, Foundation Blowcounts High, Low Blowcount Areas Not Continuous

Shaken Embankment Extremely Unlikely to Fail

PAR < 2500, Warning time >1hr, Short Distance to Safety, Breach Development Time Long

Potential Life Loss ~2 if Slow Breach, ~10 if Rapid Breach

Build the Case – Consequences

Don't just give the numbers:

From the dam to Big Lake, the destruction would be severe due to the large reservoir volume and dam height. The town of Derby and portions of Portage Falls near the river would likely be wiped clean by very rapidly rising water. Deep flooding would occur in outlying areas of Portage Falls, portions of Park Town, and rural areas down to Big Lake. At Big Lake, the flood wave would be attenuated, although the level of the lake would rise over 25 feet. Below Big Lake, severe flooding would occur in the narrow canyons downstream, although there would be significant time to warn the people at risk before the flood wave reached these areas.

Build the Case – Consequences (cont.)

Nearly 20,000 people would be at risk from failure of the dam. For some failure modes, the dam is expected to breach suddenly, creating high severity flooding and a very limited warning time at several locations within the first 10 miles from the dam (Derby and low-lying areas of Portage Falls). It is estimated that nearly ¾ of the fatalities would occur in this reach where the population at risk is about 2400. Very little loss of life would be anticipated at Big Lake and areas downstream due to the gradual rise in the lake level and significant warning time. Loss of life estimates resulting from dam failure during normal operations range from about 400 to 1900, with a best estimate of about 1200.

Build the Case
Conditional Response

The reservoir is high enough to cause significant consequences and loading on the left abutment block most of the time (about 97 percent). The presence of continuous joints was assigned a high likelihood (90 to 99 percent) based on the construction photos which show continuous bedding planes across the left abutment, gamma logs and borehole image logs which identified continuous bedding plane partings, and the mapped faults and joints which form the side plane and back release boundaries.

Build the Case
Conditional Response

Even though movements are predicted from all of the analyses, it was judged that the chance of movement actually occurring would be relatively unlikely (0.1 or less) up to and including the 50k ground motions. The primary factors leading to this conclusion are: (1) the contraction joints are keyed, providing load transfer that was not modeled, (2) no bond was included in the analysis at the base of monolith 10; the actual bond here will reduce the tendency for movement, (3) full uplift was included on the back release surface in the analyses, which is unlikely to exist under current conditions based on piezometric measurements and the tightness of the foundation, and (4) fault F-A was not considered to provide any resistance or restraint in the analysis (if the orientation of fault F-A is as currently believed, it would introduce resistance to sliding of the foundation block)

Build the Case
Conditional Response

The static factors of safety are considered to be adequately high even with inoperable foundation drains, that post-earthquake instability is unlikely in any case, ranging from virtually impossible (0.001) if the uplift doesn't increase, to unlikely (0.01) if linear uplift develops.

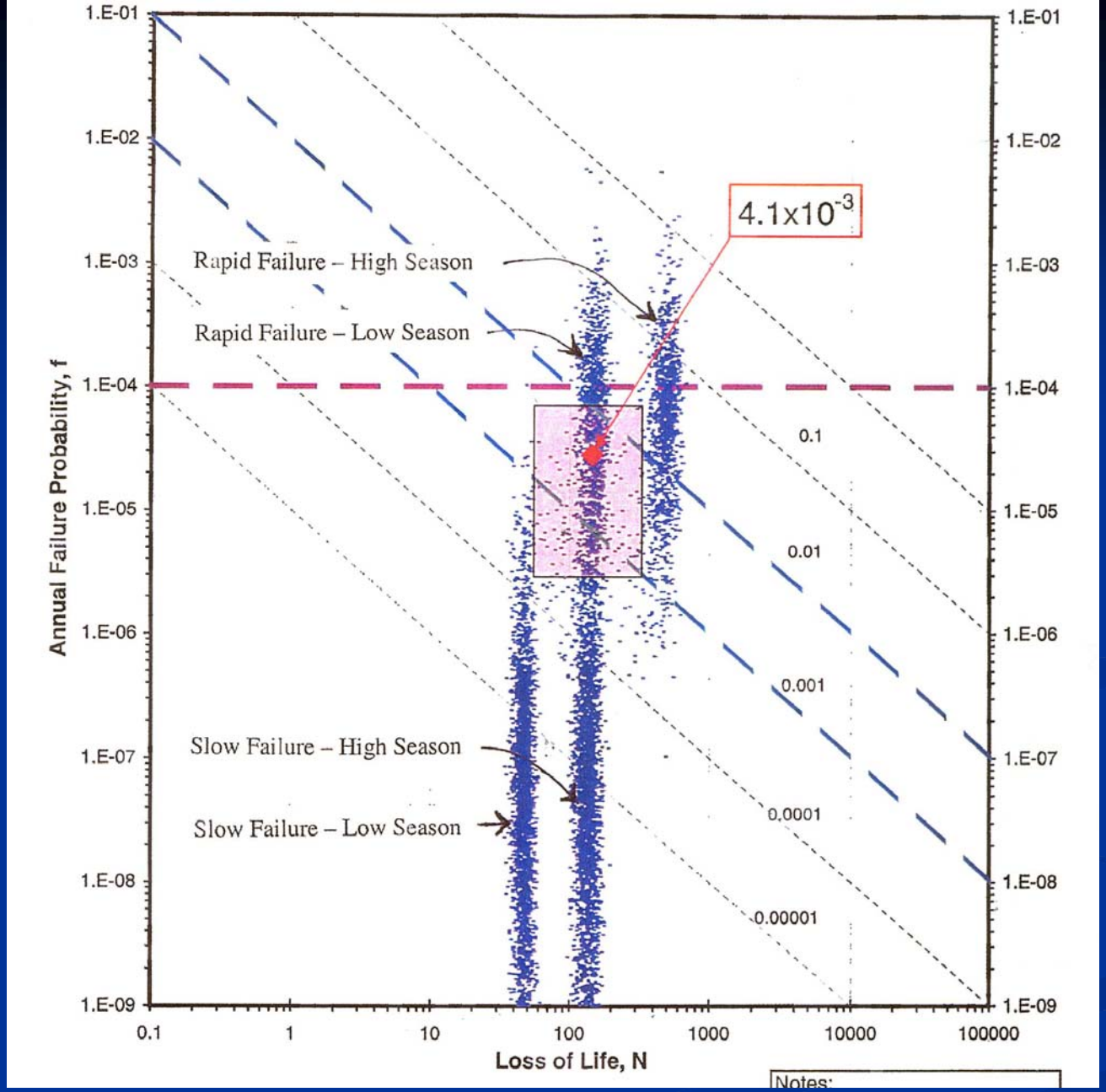
Build the Case – Recommendations

2009-SOD-A: Verify risk associated with potential foundation instability and initiate risk reduction actions, if warranted. Additional foundation stability analyses of the right abutment will likely be necessary.

Justification: A well defined foundation block can be seen within the right abutment formed by a bedding plane and continuous joint. Water squirts from rock bolt holes at the base of the block indicating high uplift pressures. Piezometers show rising levels and the drains cannot be cleaned due to the complex plumbing. Although seismic analyses have not been completed, it is anticipated that relatively frequent earthquake ground motions could lead to block movement, increased uplift, and post-earthquake instability, and that performing such analyses and estimating associated risks could indicate there is justification to take action to reduce risks along with the level of stabilization that would be needed.

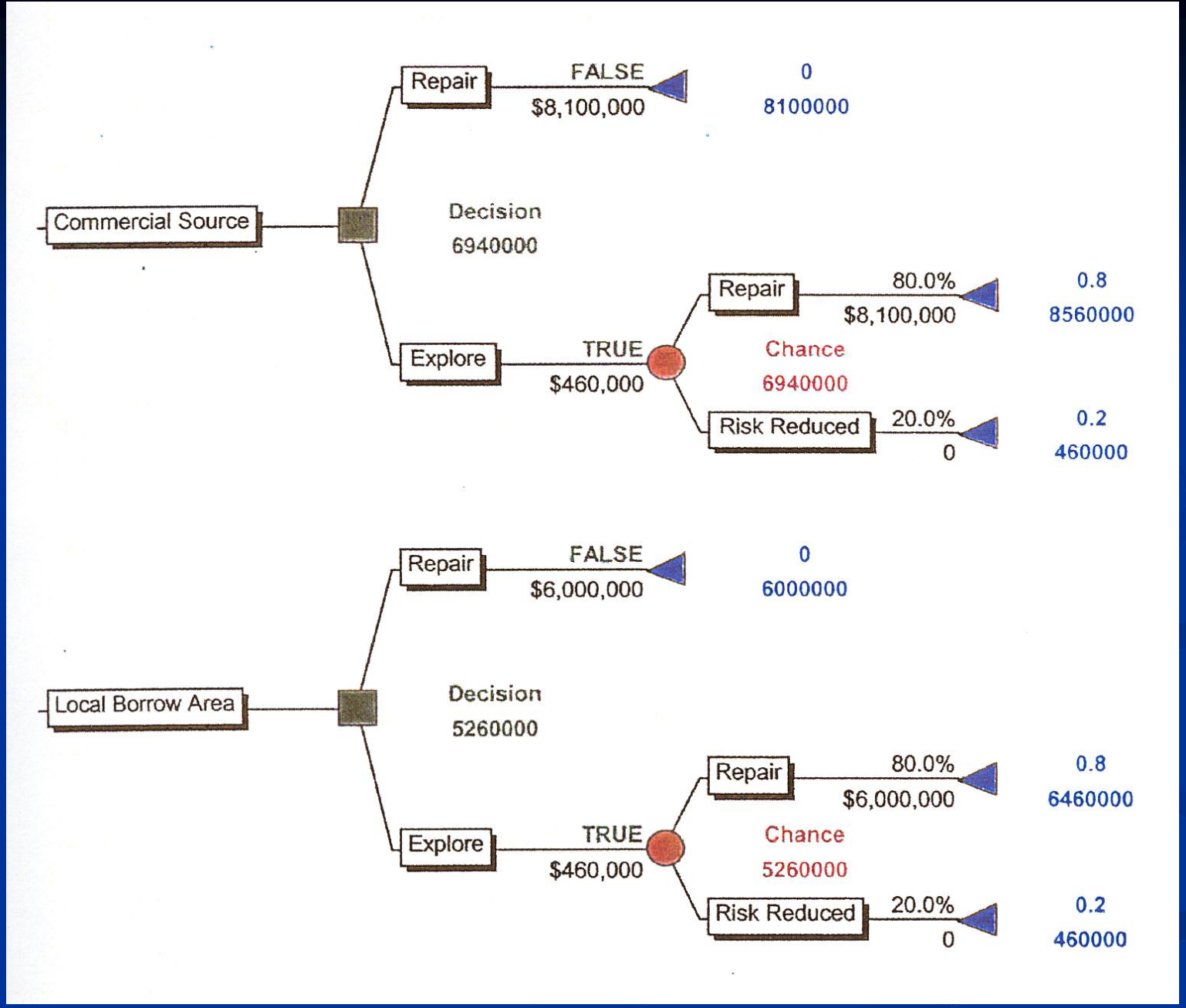
Justification to Recommend Investigations to Reduce Uncertainty

- Any actions proposed based on uncertainty must address the sensitivity of the mean risk estimate to that uncertainty.
- Moving the mean estimate changes the justification category
- There is a good likelihood the recommended investigation can reduce the uncertainty



Blow Count

Mean: 16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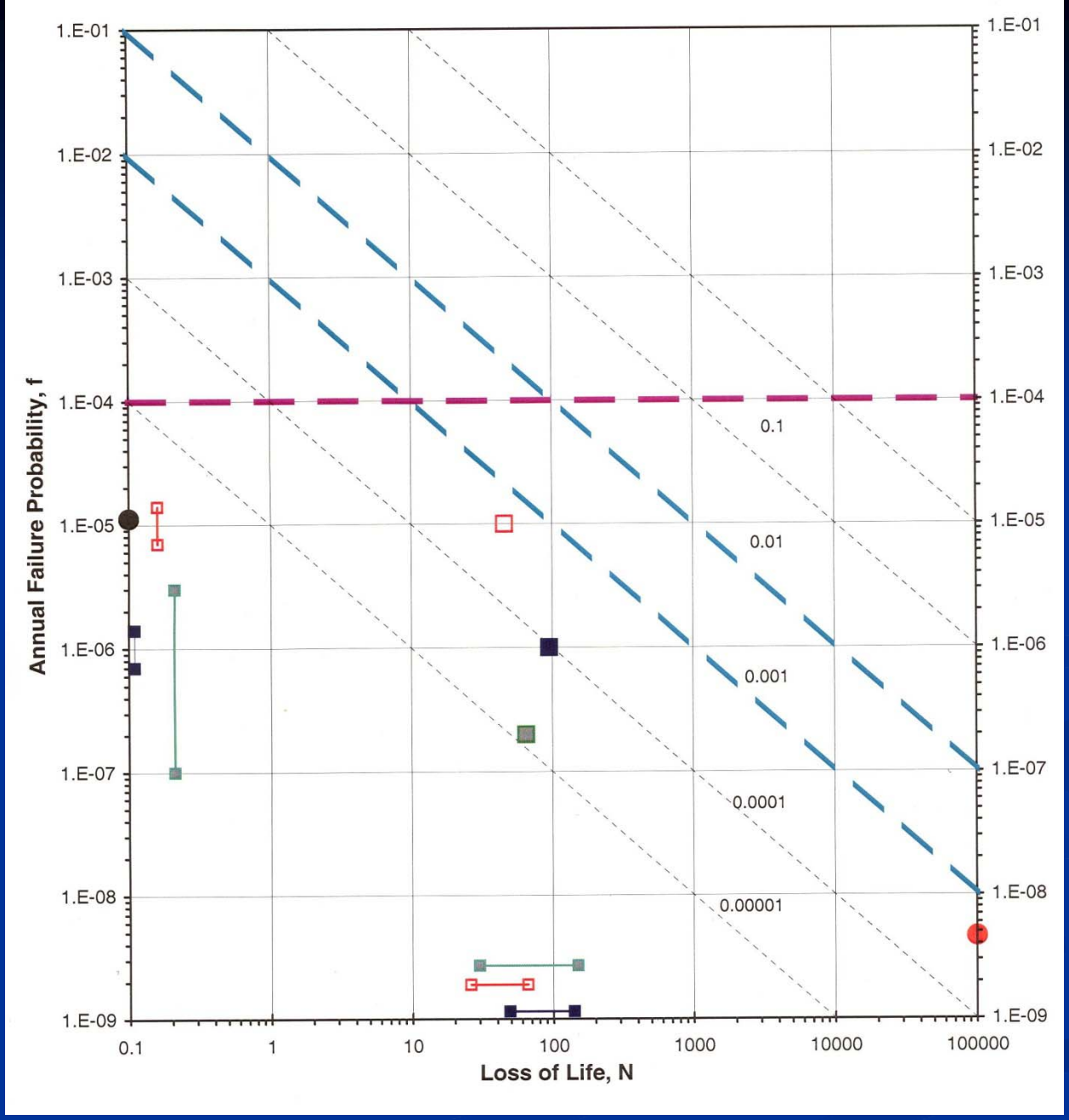
Annual Failure Probability, f
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
0.1
0.01
0.001
0.0001
0.00001
0.1
1
10
100
1000
10000
100000
Loss of Life, N

Justification to Recommend Investigations to Reduce Uncertainty

- The mean estimate of risk was shown to be sensitive to the blowcount uncertainty.
- The likely change in the mean estimate changed the justification category.
- There was strong evidence the recommended investigation could reduce the uncertainty.

Diagnosis

- Formulating Hypotheses
  - What conditions might lead to adverse performance?
- Applying Intuition
  - A before-thinking awareness
- Identifying Relationships
  - Comparing information and observations get a feel for their proper order
- Visualizing Processes
  - A mental image of conditions and the failure process

Diagnosis

- Identify failure modes and essential events
- Visualize detailed event descriptions.
- Recognize weak spots in geology, design, or construction.
- Hypothesize how factors related to the event likely and unlikely.

Analysis

- Synthesis of evidence, information, underlying knowledge from different sources
- Assessing probable truth of hypotheses
- Generalizing from specific cases

Analysis

- Weigh the evidence with relative descriptors or by empirical means
- The more you rely on tables to assign probabilities, the less likely you are to generate evidence to support the case
- Review the 'likely' and 'unlikely' bullet items and choose key evidence and inferences supporting numerical evaluation.
- Digest Monte Carlo Simulation Results
  - Verify assumptions
  - Hold a key variable constant at upper and lower end and see where the mean goes
  - Count things in various ways

Interpretation

- Critical Review
- Evaluation – ‘make sense’
- Establish meaning and content

Interpretation:

- Bring forward the most significant contributors to failure probability or risk.
- Identify the key elements for believing there is or is not justification to take action.
- Identify key uncertainties and what additional information could reduce the uncertainties
- Identify potential risk-reduction 'low hanging fruit'
- Relate adverse or favorable conditions to other, familiar cases
- Project how recommended actions will improve the situation

Take Away

- Dam Safety Case – structured arguments developed to have the facility's condition, risk estimates, and recommended actions make sense

- Do not use the risk value as sole basis
- Show why it is reasonable to believe the Risk and APF numbers.
- Fully develop the justification to take action
- Address the sensitivity of the mean to key parameters, the likelihood a a change justification class, and likelihood of success when recommending additional studies to reduce uncertainty

Risk-Informed Decision Making

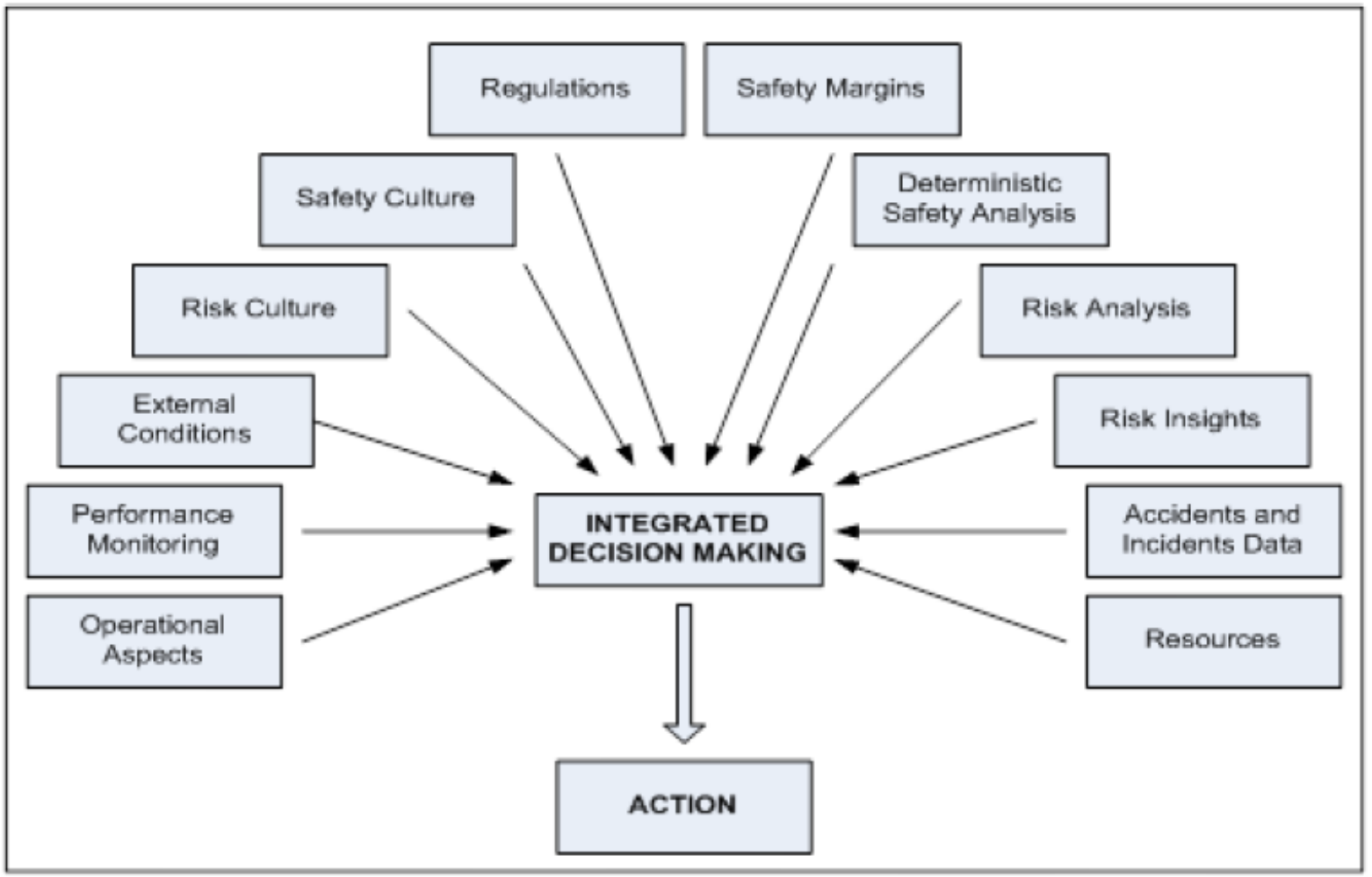

Figure 3. Integrated Risk-informed Decision Making (ICOLD 2011)