RAC
Engineers & Economists

2nd International Week on Risk Analysis
as Applied to Dam Safety and Dam Security
**Theoretical-Practical Course**
Universidad Politecnica de Valencia
Valencia, Spain
27 & 28 February 2008

Utah State University
IDSRM

**Risk Analysis as Applied to Dam Safety Fundamentals:**

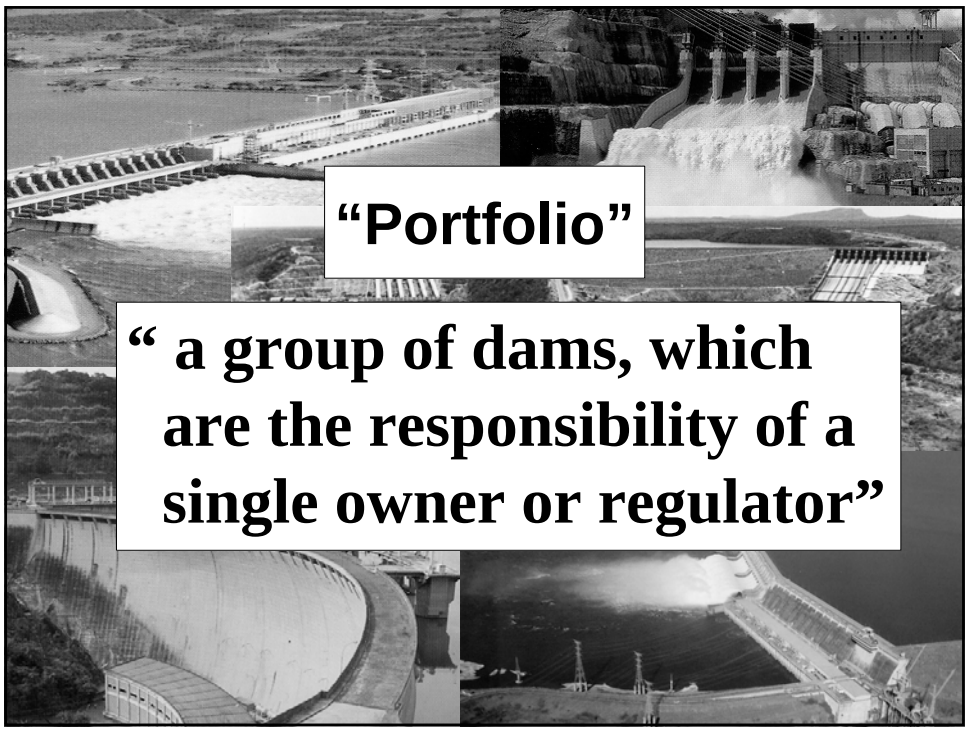
# L.2 - Portfolio Risk Management:

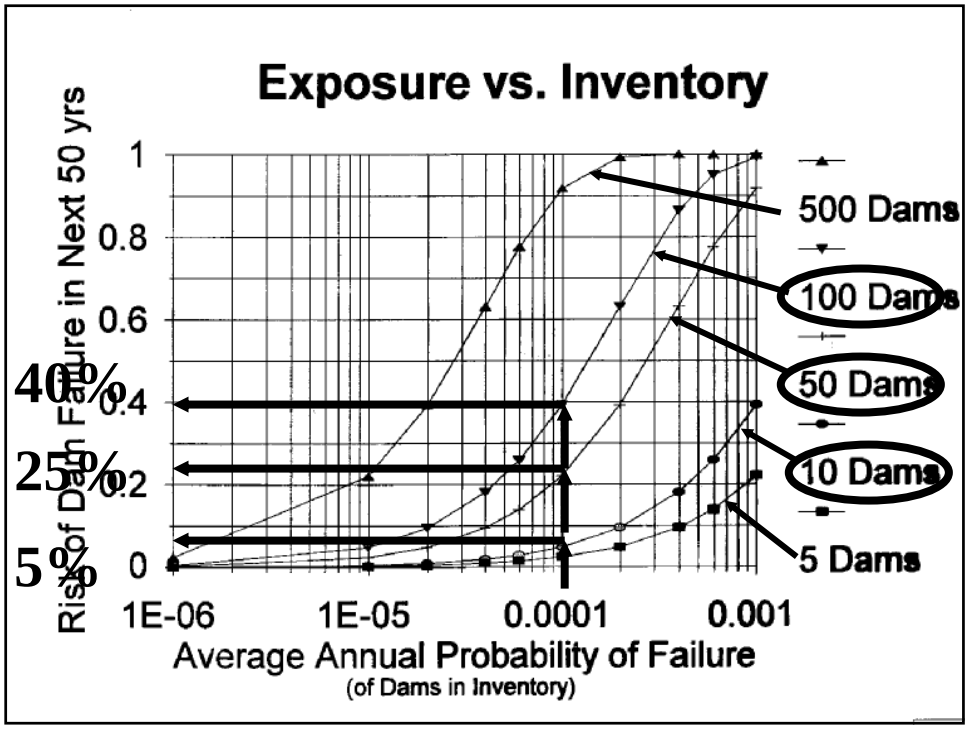
## with Examples from North America, Australia and Europe

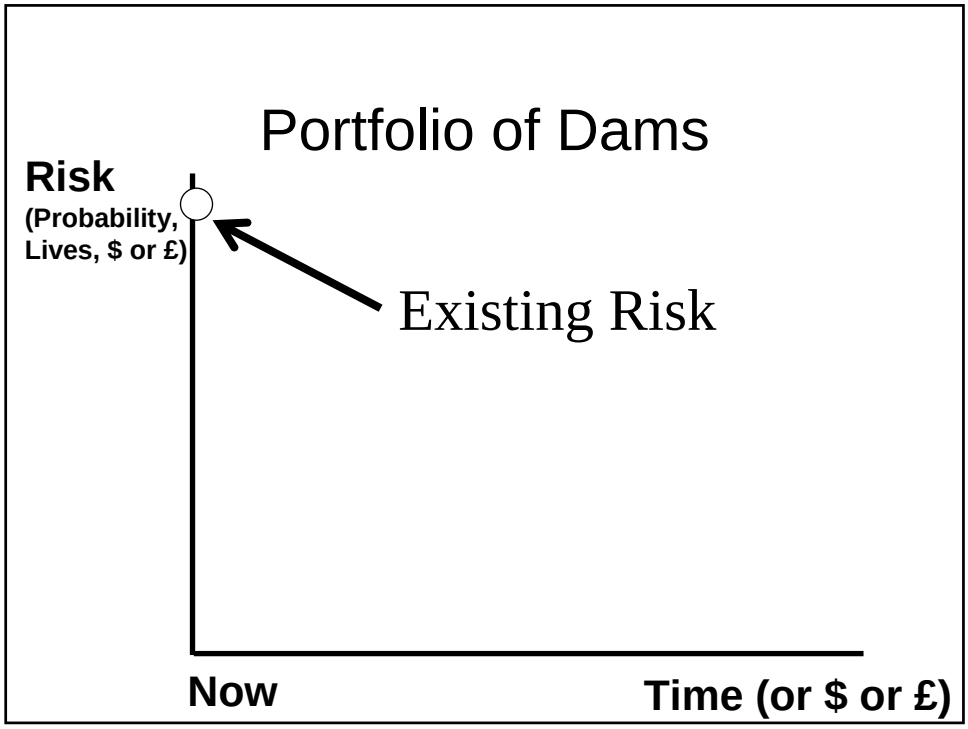
**David S. Bowles**
Institute for Dam Safety Risk Management - Utah State University
and RAC Engineers & Economists

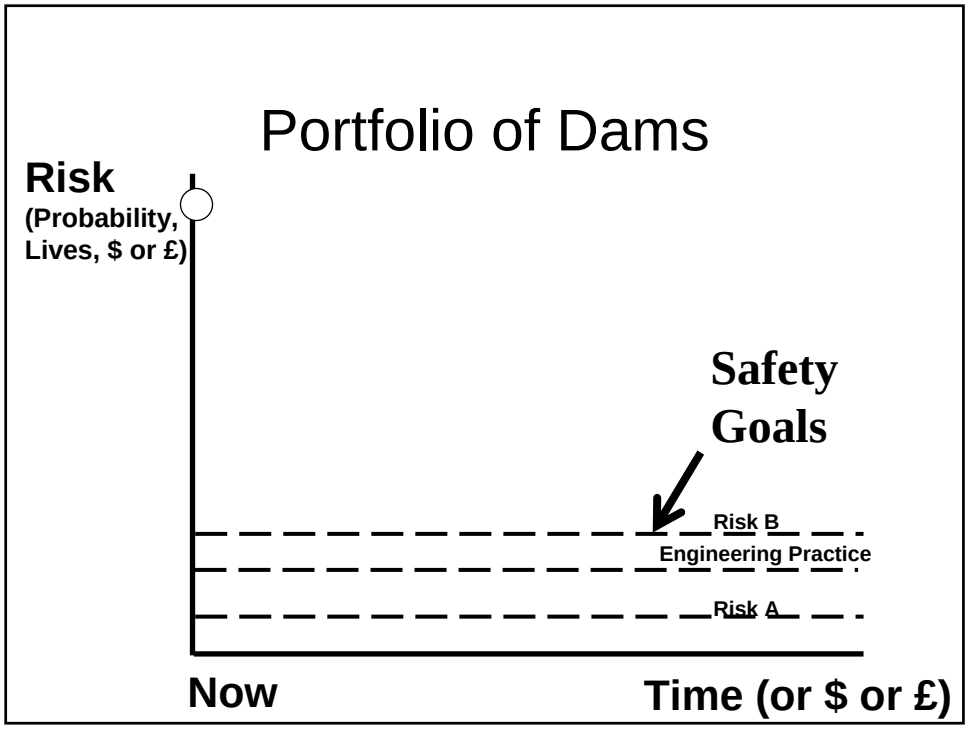
## Some Drivers that have lead to RA

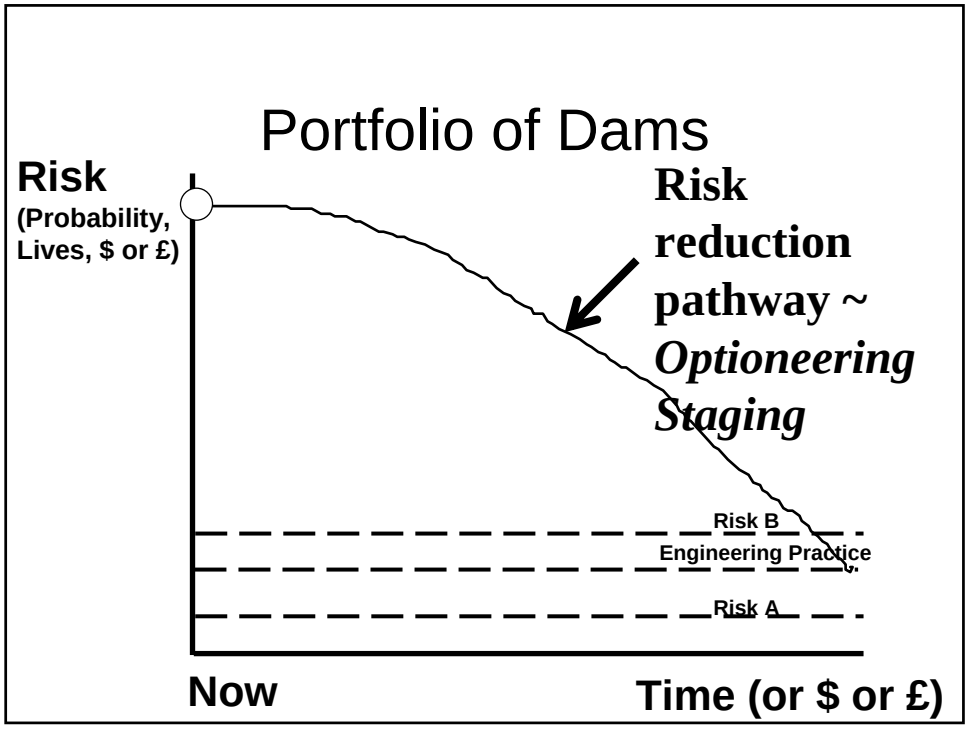
- Demand for greater JUSTIFICATION of dam safety investments than TA could provide
  - Questions about basis for some dam safety standards
  - ***"From engineers on top to engineers on tap"***
  - Comparisons with safety requirements in other fields
- BACKLOG of dam safety work
  - Need to prioritize
- SHIFT TO RISK MANAGEMENT approaches in
  - Business
  - Government
  - Regulation
  - Dam safety – USBR, ANCOLD
- Concerns about UNIDENTIFIED FAILURE MODES
  - More likely than extreme events
- Corporatization/Privatization/Deregulation
  - LIABILITY

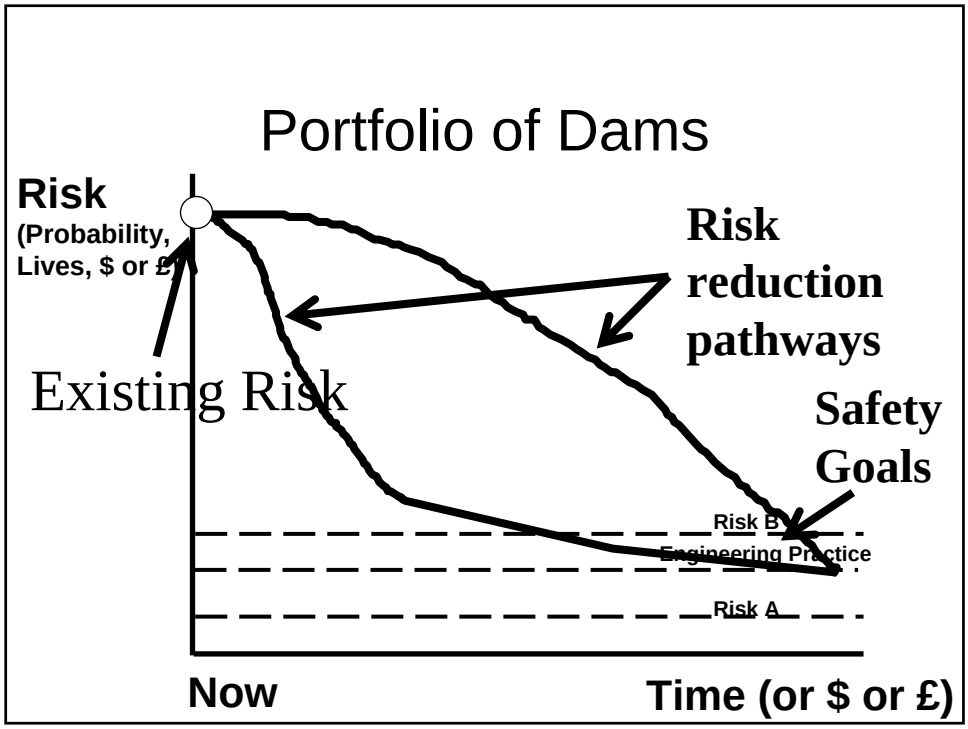

"Portfolio"
" a group of dams, which are the responsibility of a single owner or regulator"


Exposure vs. Inventory
Risk of Dam Failure in Next 50 yrs
1
0.8
0.6
0.4
0.2
0
1E-06
1E-05
0.0001
0.001
Average Annual Probability of Failure
(of Dams in Inventory)
500 Dams
100 Dams
50 Dams
10 Dams
5 Dams
40%
25%
5%


Portfolio of Dams
Risk
(Probability,
Lives, $ or £)
Existing Risk
Now
Time (or $ or £)


Portfolio of Dams
Risk
(Probability,
Lives, $ or £)
Safety
Goals
Risk B
Engineering Practice
Risk A
Now
Time (or $ or £)


Portfolio of Dams
Risk
(Probability,
Lives, $ or £)
Risk
reduction
pathway ~
Optioneering
Staging
Risk B
Engineering Practice
Risk A
Now
Time (or $ or £)


Portfolio of Dams
Risk
(Probability,
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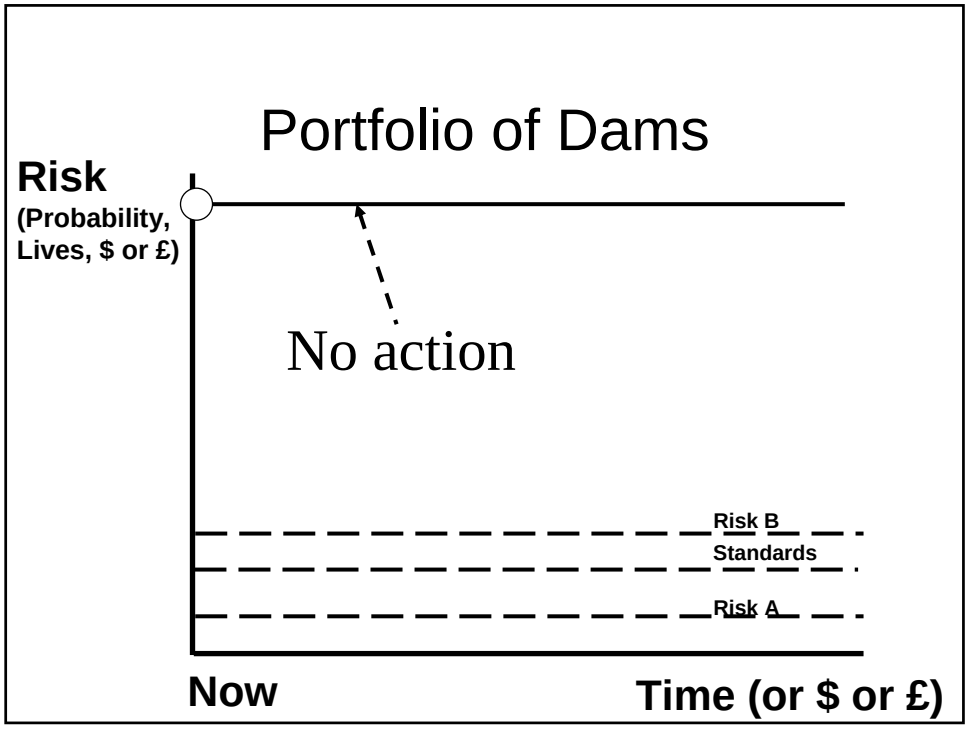
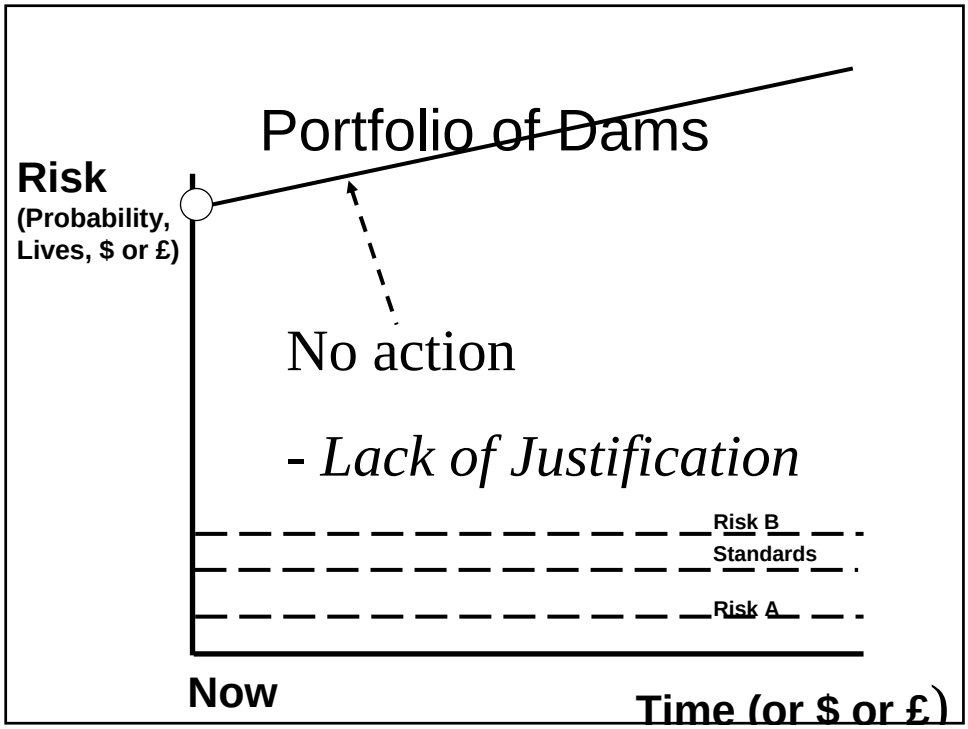
Risk
reduction
pathways
Existing Risk
Safety
Goals
Risk B
Engineering Practice
Risk A
Now
Time (or $ or £)

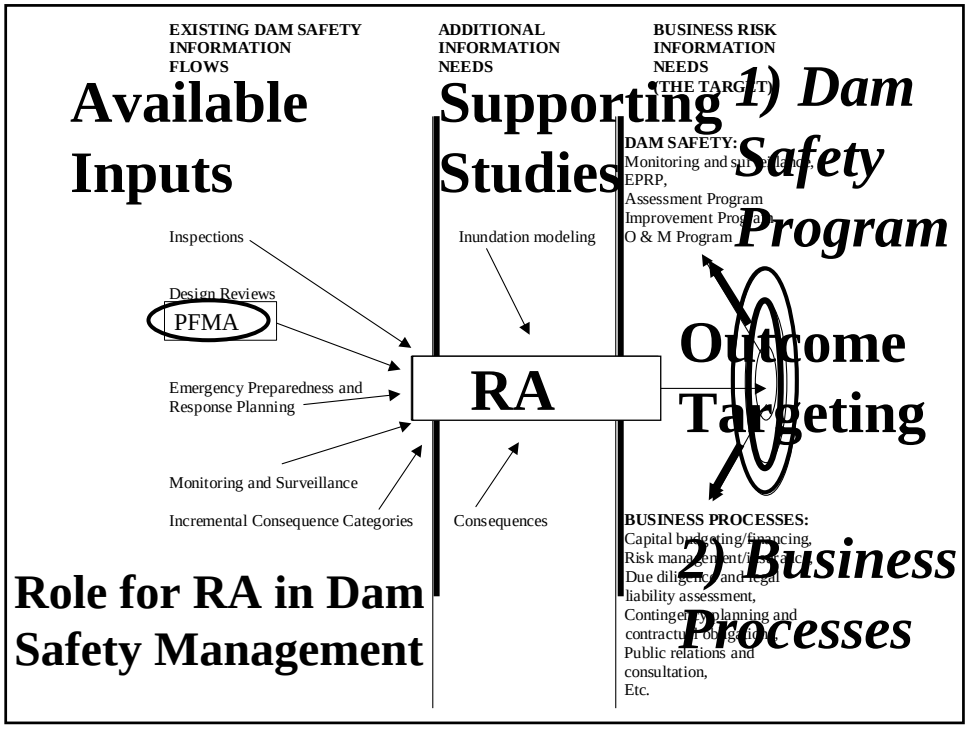

Portfolio of Dams
Risk
(Probability,
Lives, $ or £)
No action
Risk B
Standards
Risk A
Now
Time (or $ or £)


Portfolio of Dams
Risk
(Probability,
Lives, $ or £)
No action
- Lack of Justification
Risk B
Standards
Risk A
Now
Time (or $ or £)

PfRA should be more than just a prioritization of potential risk reduction measures

## Owners Considerations for Dam Safety

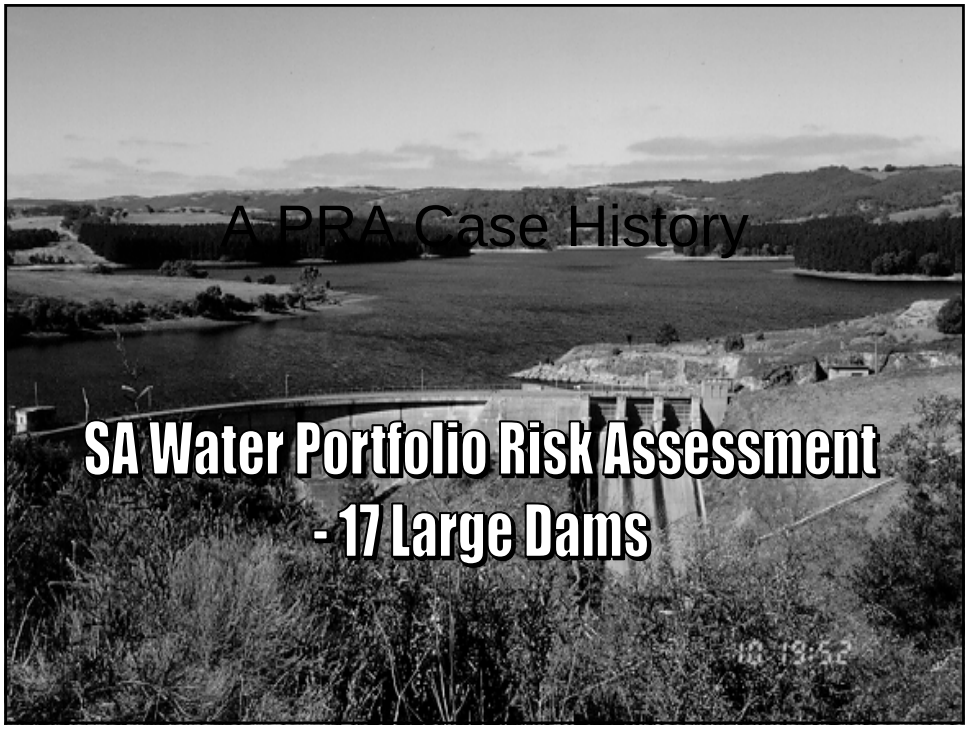
- **More than a technical matter**
- **Additional considerations** that influence overall effectiveness in managing dam safety, especially for portfolios of dams.
  - Vary between owners:
    - Safety management systems
    - need for an auditable, logical and defensible approach for relating low probability - high consequence dam safety risks to corporate governance
    - prioritizing and justifying dam safety capital and operating expenditures
    - meeting duty of care obligations
    - meeting contractual obligations
    - maintaining a license to operate
    - protecting the business from the liability associated with a dam failure, or even a widely-publicized dam safety incident.
- Requires **more than regulatory compliance**.
  - A major driver for the development of PfRA and PRM



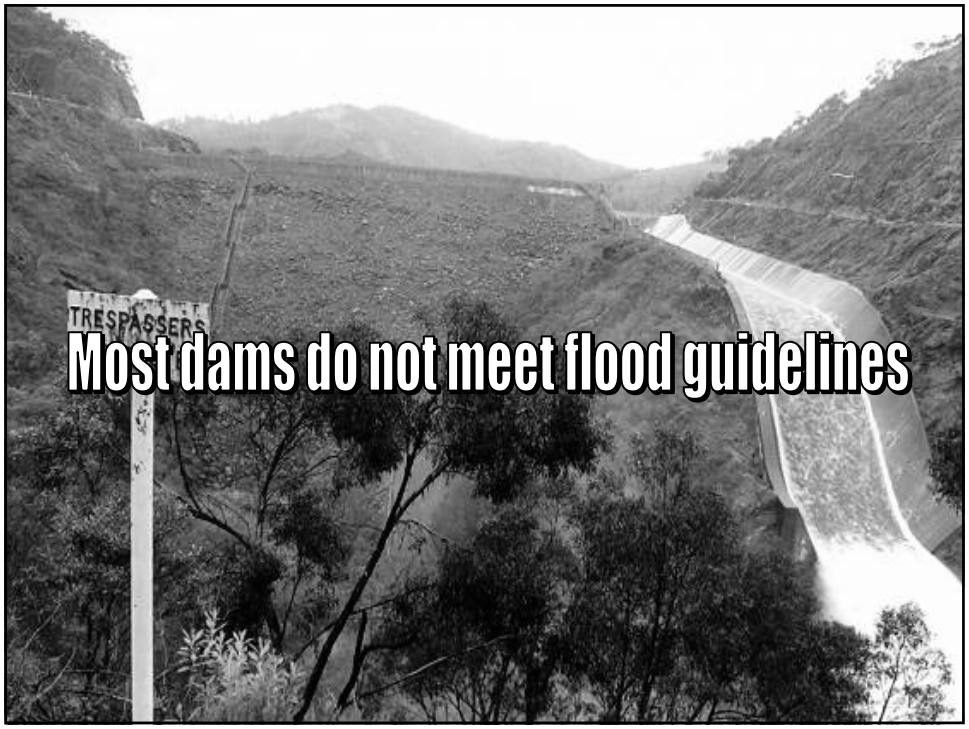

## PfRA Target Outcomes

Vary by owner

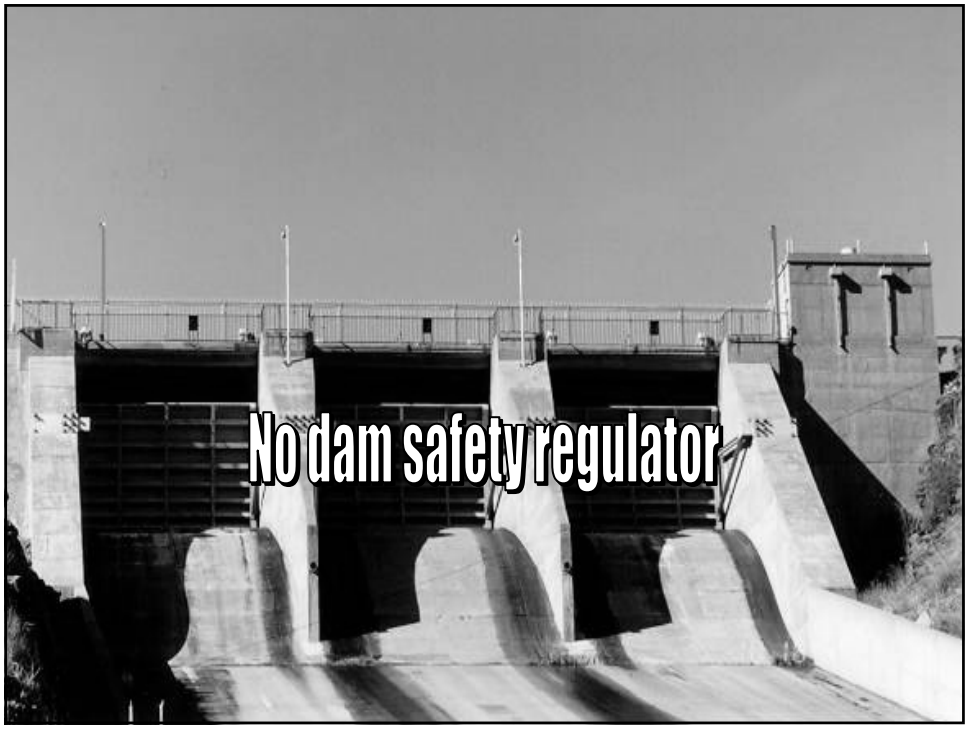
1) **Baseline Risk Profile and Updates**
   - potential failure modes identification, track knowledge uncertainty and risk reduction for dam safety issues.
2) Basis for evaluation, strengthening, and better integration of **Recurrent Dam Safety Management Program** activities.
3) Identify the need to consider urgent **Short-Term Risk-reduction Measures**.
4) Basis for developing and managing a **Dam Safety Improvement Program**
   - queues of investigations and risk-reduction measures, business and safety case justifications, and risk-reduction project formulation.
5) Information inputs to the **owner's Business Processes and for other stakeholders**
   - to achieve better integration of dam safety considerations.

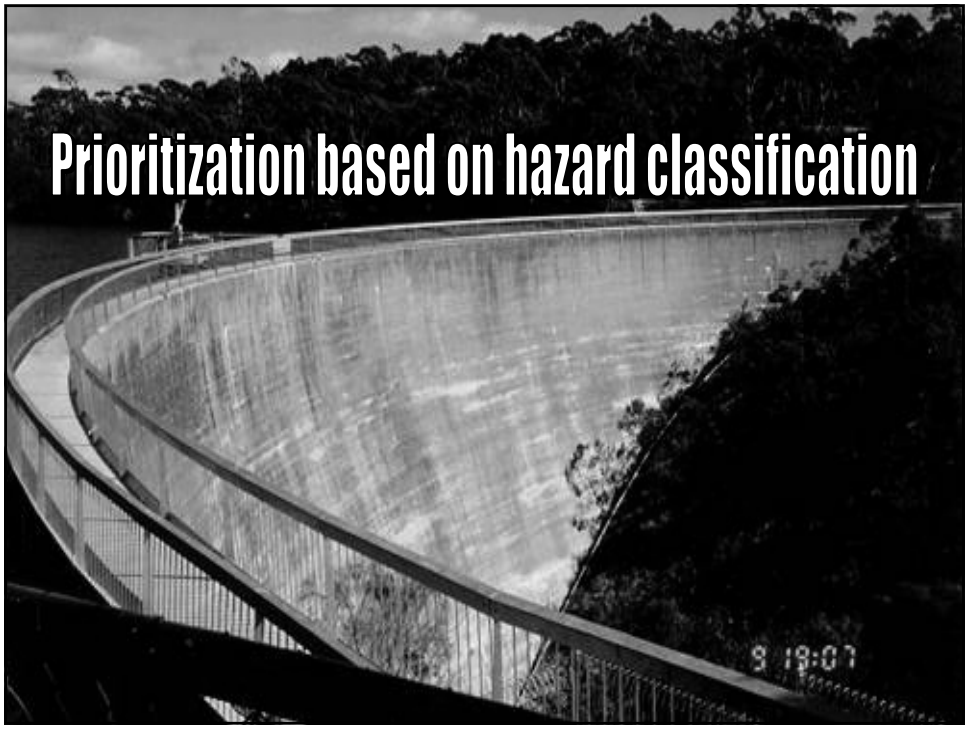

A PRA Case History
SA Water Portfolio Risk Assessment
- 17 Large Dams


More than half older than 75 years


TRESPASSERS
Most dams do not meet flood guidelines


Many do not meet current earthquake practice

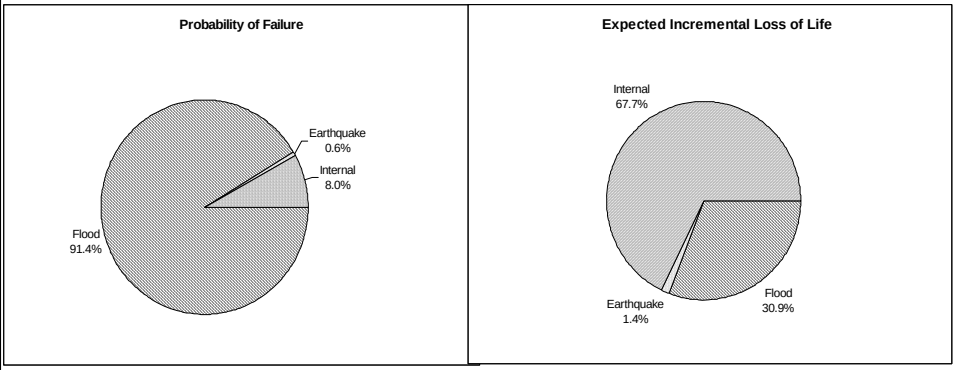

No dam safety regulator


Prioritization based on hazard classification


Risk Assessment

- Existing dams

## Portfolio Risks: Probability vs. Life Loss



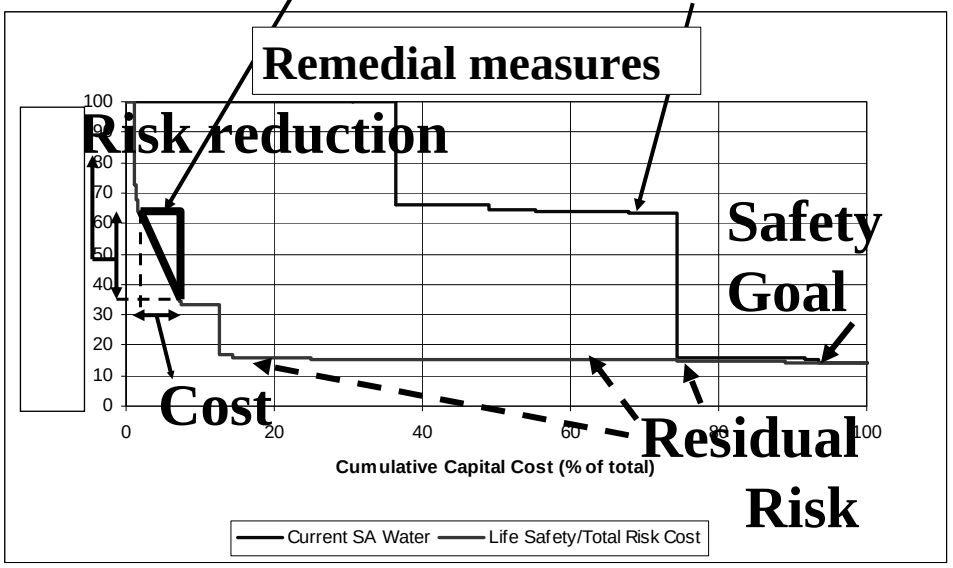

- FLOODS: 90% probability - 30% life loss
- "SUNNY DAY": 10% probability - 70% life loss

  - OFTEN LITTLE WARNING TIME

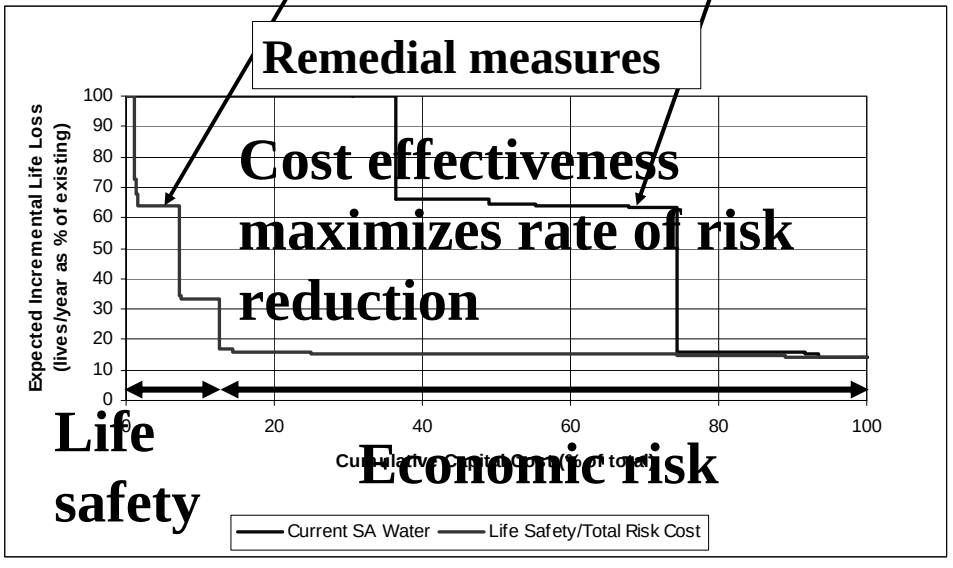
## Risk Assessment

- Remedial measures & Prioritization

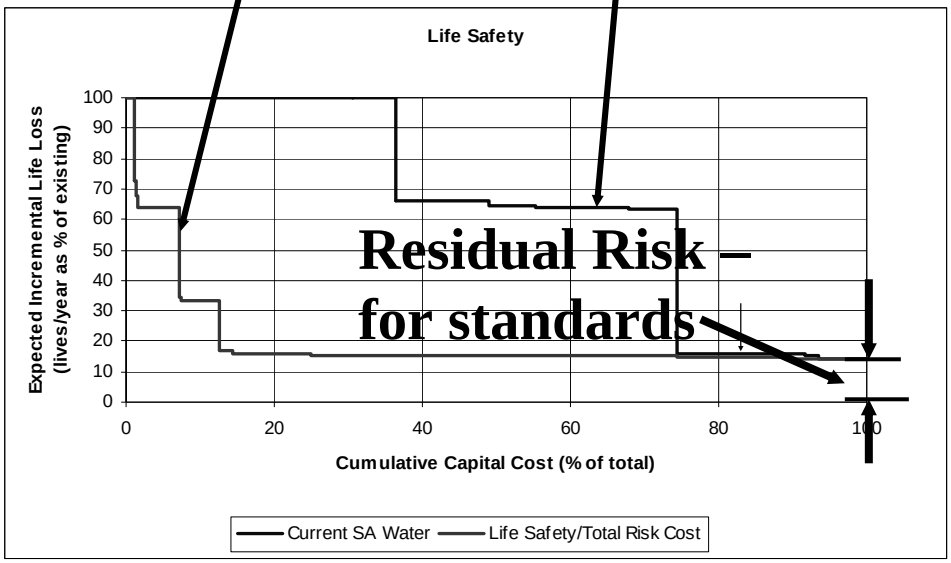
## Prioritization: PRA vs. Former SA Water Program
Risk Reduction Pathways



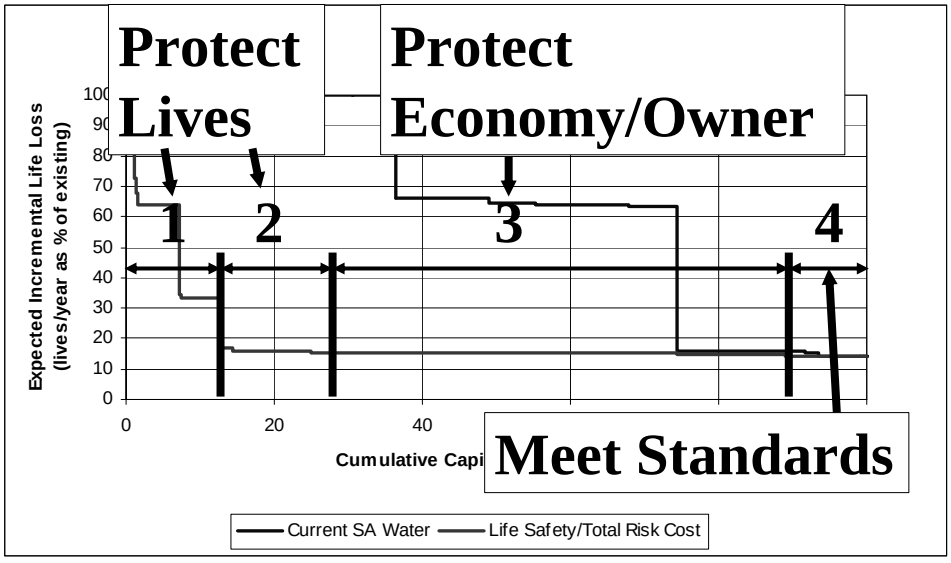

## Prioritization: PRA vs. Former SA Water Program
Life Loss Risk Reduction



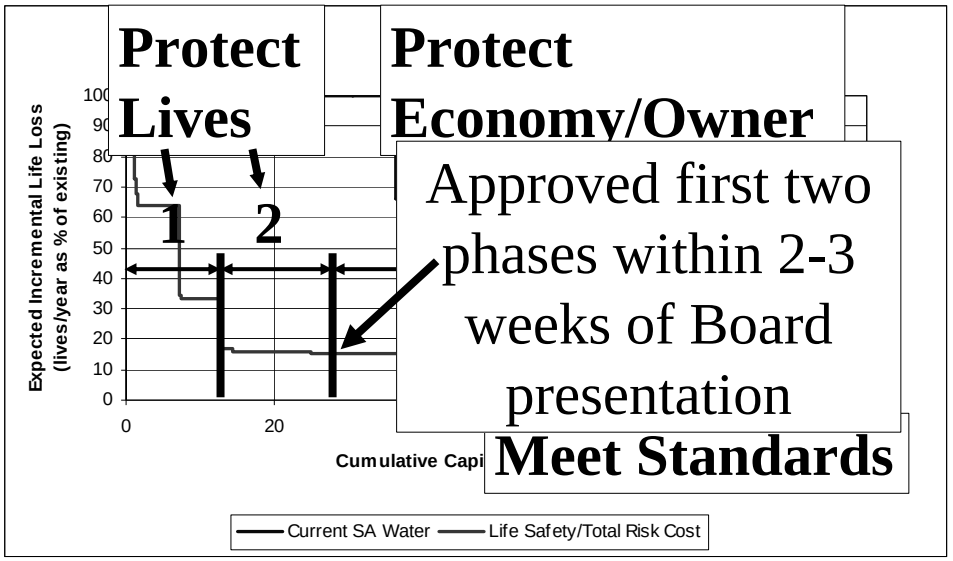
## PRA Prioritization vs. Current SA Water Program
## Life Loss Risk Reduction



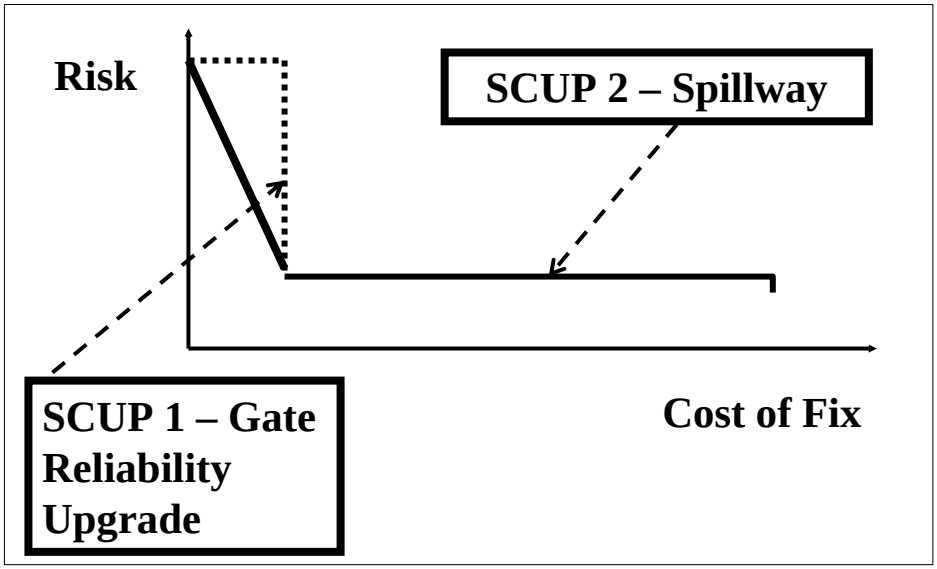

## Dam Safety Improvement Program - Four Phases
## Life Loss Risk Reduction



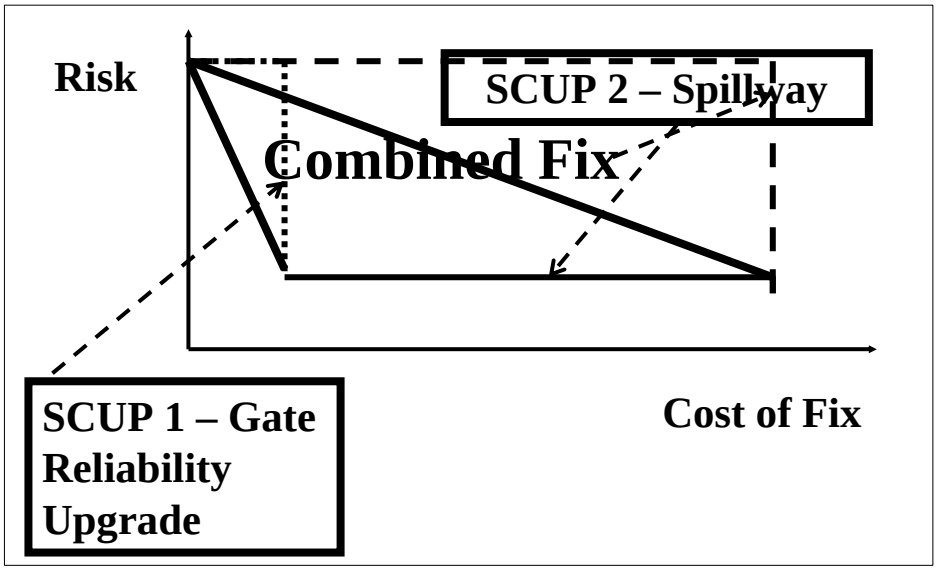
## Dam Safety Improvement Program - Four Phases
## Life Loss Risk Reduction



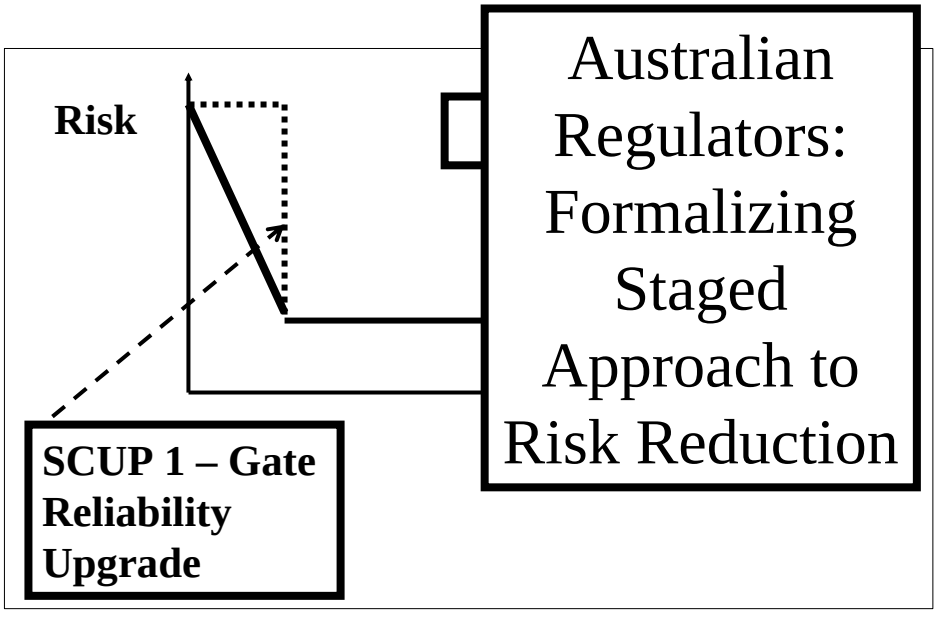

## Staged Fixes - SCUPs



Staged Fixes - SCUPs




Staged Fixes - SCUPs

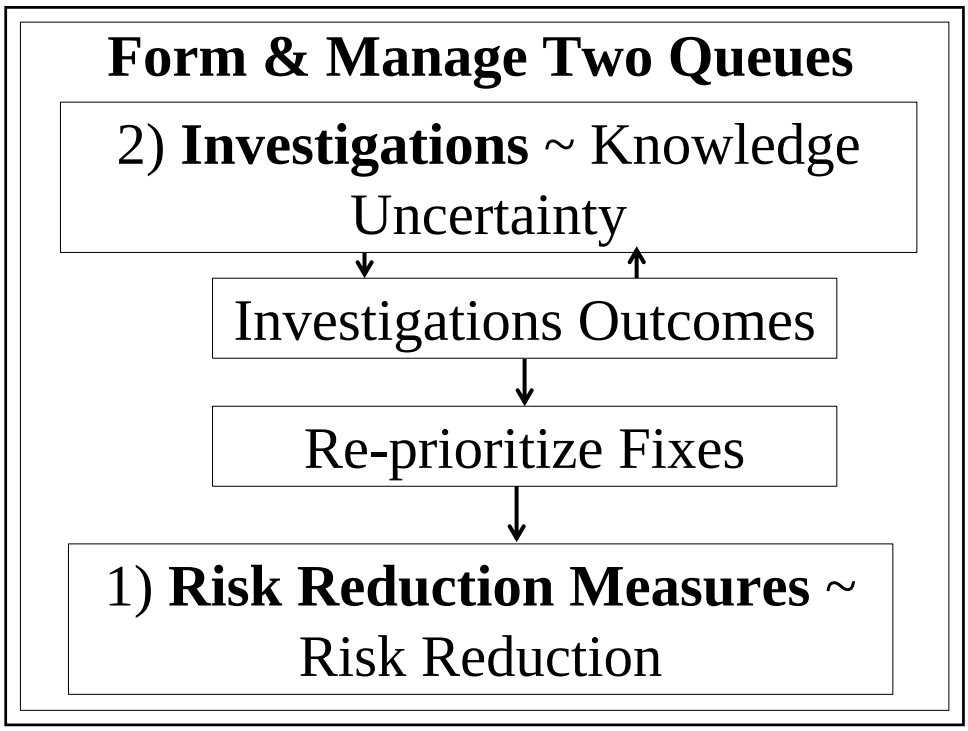


## Benefits of SA Water PRA

- *Insights* into dam safety issues
- Overall dam safety *status*
  - engineering standards/current practice
  - risk criteria/guidelines
- *Phased approach*
  - justified highest priority measures
  - used for budgeting and asset management
  - basis for defensible risk reduction strategy for corporate governance/due diligence

## Benefits of SA Water PRA (Cont'd)

- *More rapid risk reduction pathway* than traditional approach
- PRA outcomes readily integrated into
  - overall *business planning*
  - all aspects of *dam safety program*
- *Can still choose standards-based remedial measures*




Since introduction of PRA in 1996 …

- Has become a “standard of practice” in Australia
- U.S. Army Corps of Engineers
- Growing application in the UK over past 5 years
- Several other countries planning applications

## PRA approaches for Large Portfolios

1) Screening to stage PRA implementation
   - Screening must be carefully developed
2) Develop process and procedures on representative subset of dams
   - Apply proven procedures to entire portfolio
3) Sampling
   - If need overall status of entire portfolio, not individual dams
   - Limited insights on individual dams

Consider linking baseline implementation (& updating) to periodic dam safety inspections

## A Recent European PfRA

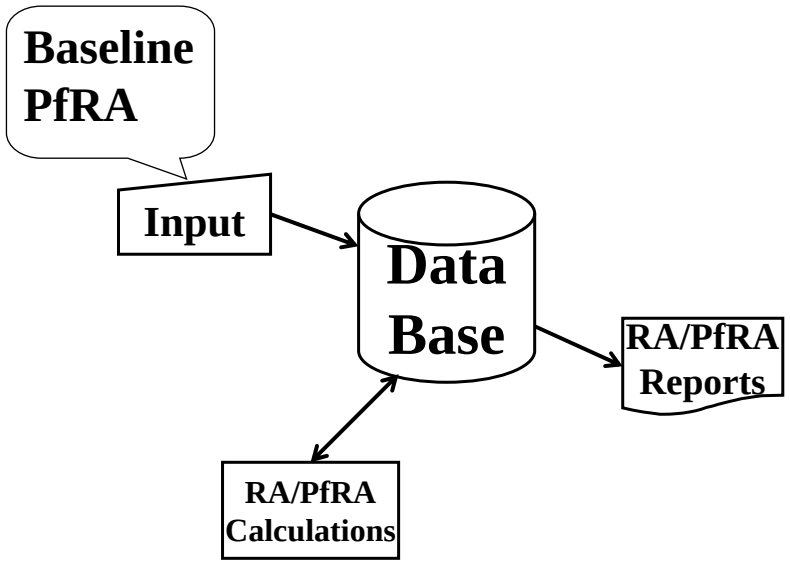
- JUSTIFIED more than tripling their CAPEX Dam Safety Risk Reduction Budget for next 5 years
- Received letter of commendation from Economic Regulator for an innovative approach
- OUTCOME TARGETING was critical
  - CEO, Board, Safety Regulators, Licensing Agency, Technical Staff, etc.
- Developing a Management Information System for PRM

# An Emerging Approach – Portfolio Risk Management

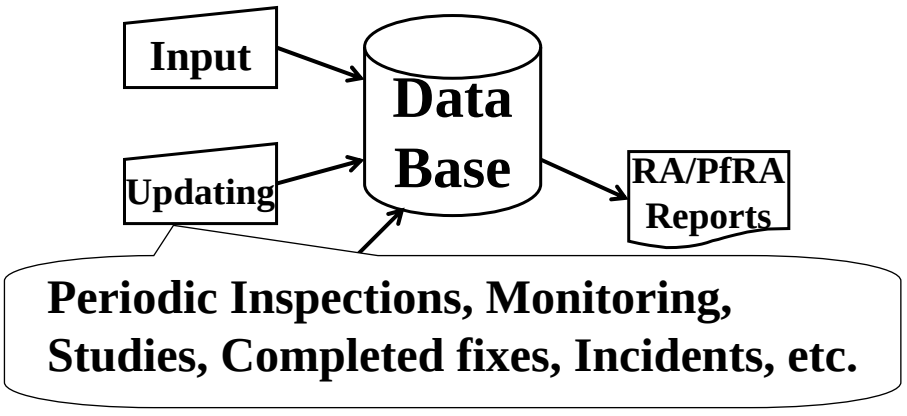
## An Emerging Approach to "Risk-informed" Dam Safety Management - PRM

- Very high probability risks addressed most rapidly
- Life safety risks given highest priority
- Phasing, Staging, Benchmarking & Hedging
- More detailed investigations and risk assessments (including consequences estimates)
- Residual risk management
  - Evacuation preparedness planning
  - Monitoring and surveillance
- PRA updating
- Community consultation

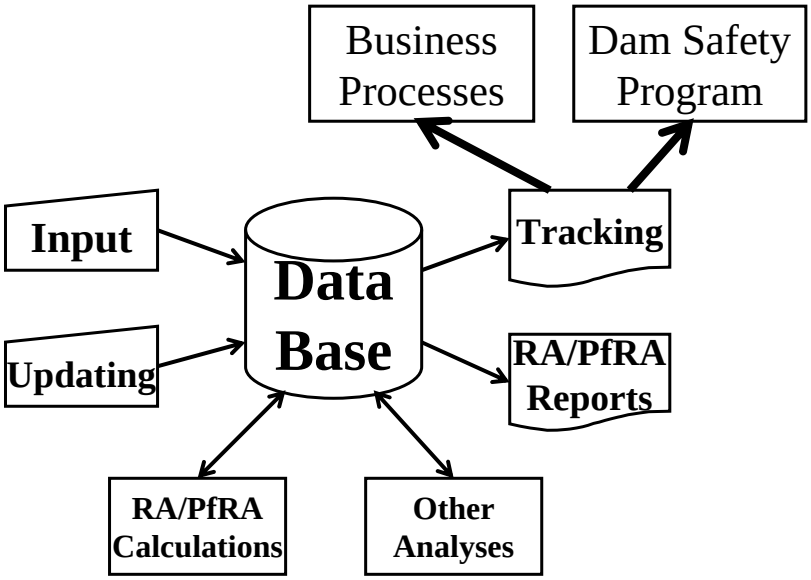
Management Information System for PRM



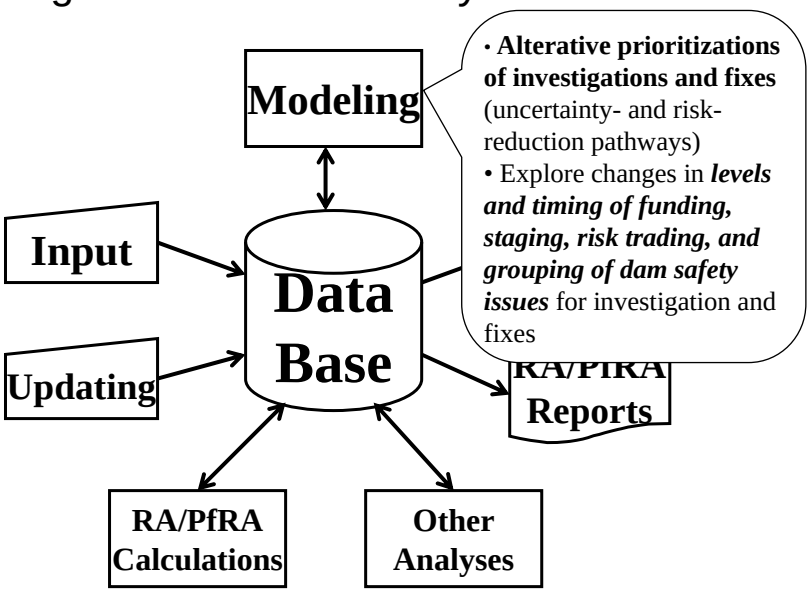

Management Information System for PRM



## Management Information System for PRM




## Management Information System for PRM



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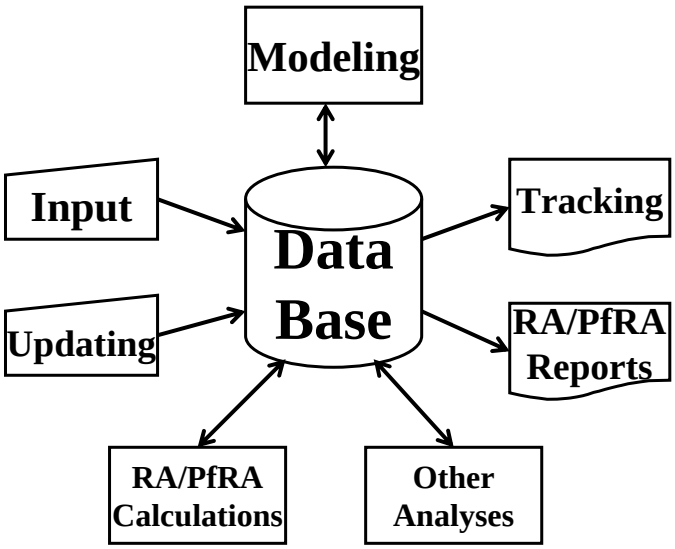



## Index /Risk Ranking Approaches *2003 ASDSO report on "Risk Characterization for Dams"*

- Less effort
  - But, more limited outcomes
- Typically do not use a valid risk metric
  - Can significantly distort relative risks
- Cannot compare with Tolerable Risk Guidelines
- Cannot consider cost effectiveness of risk reduction (ALARP – disproportionality)
- DO NOT PROVIDE FUNDING JUSTIFICATION

## Trends in PRA Applications

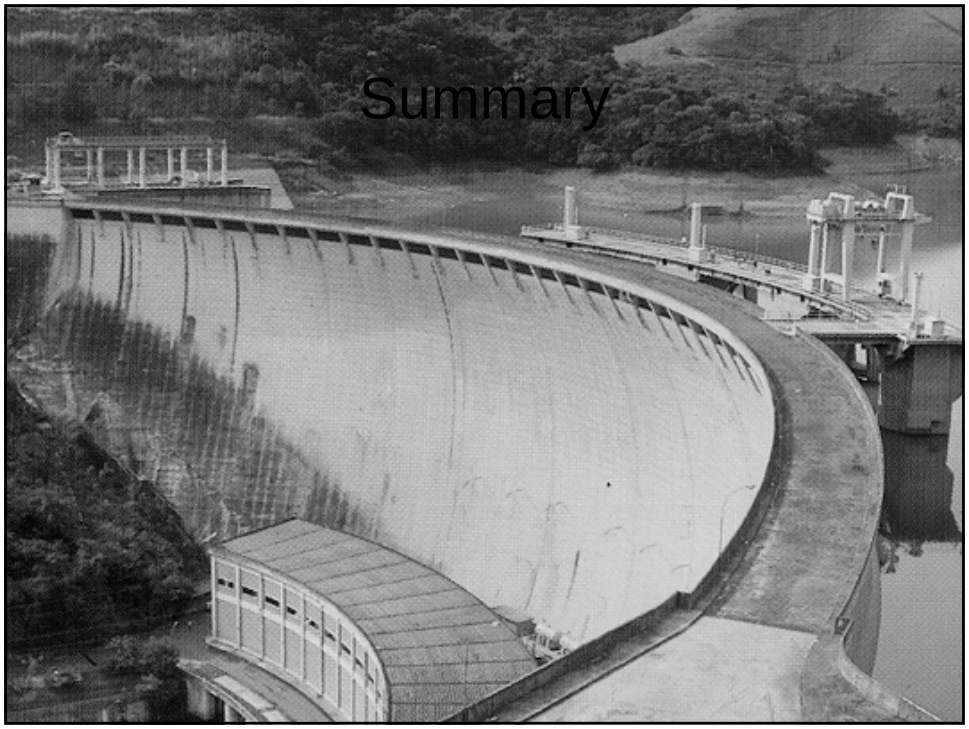
- Increased emphasis on **Failure Modes Identification**:
  - Proper understanding of failure processes
  - Meaningful estimates of likelihood of failure
  - Facilitates identification of partial fixes (SCUPs) for interim risk reduction
  - Basis for improved instrumentation, monitoring and surveillance
  - Informs site investigations for remedial works
- **Gate reliability and spillway blockage by debris**
- **Cross fertilization** from RA to traditional practice

## Limitations

- Engineering and Risk evaluations from Initial PRAs often only indicative
  - Long-term risk reduction decisions require more detailed TA and RA
- Role of subjective judgment
- Limited engineering inputs available for older dams
- Updating is required to keep PRA current
  - Living Document
- Challenge of integration into other business processes
- Most of these limitations also apply to Traditional Approach

# Portfolio Risk Assessment in PRM

A decision-support tool for portfolio dam safety risk management.



## Most Dam Safety Programs Have ...

1) W*ell defined dam safety* ***goals***
   - Standards, guidelines, criteria
2) BUT a *poorly-defined risk (& knowledge uncertainty) reduction* ***pathways*** for achieving those goals
3) AND *poor* ***integration***
   - across *dam safety management* activities
   - of dam safety with the *owner's business*
4) AND *difficulty* ***justifying*** *dam safety funding*

## Portfolio Risk Management

A risk-informed framework for improved management of dam safety (issues) for a portfolio of dams in the context of the owner's business.

*not an additional activity to be added to an existing dam safety management program,*

*it is an improved approach to the owner's entire dam safety management program.*

## Conclusions

- PfRA is not just about Prioritization
- Focus on Dam Safety Issues – *"Are we working on the right things?"*
  - Identify and Manage Dam Safety Issues
  - Leads to two queues:
    - Investigation – knowledge uncertainty reduction
    - Fixes - risk reduction
- Dam Safety depends on People and Safety Management Systems
- PfRA must be updated - MIS
- Outcomes Targeting
- Important to use proper risk metric