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MEETING



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Committee on Dam Safety – Dam Safety Concepts, Principles and Framework

## DAM SAFETY CONCEPTS, PRINCIPLES AND FRAMEWORK

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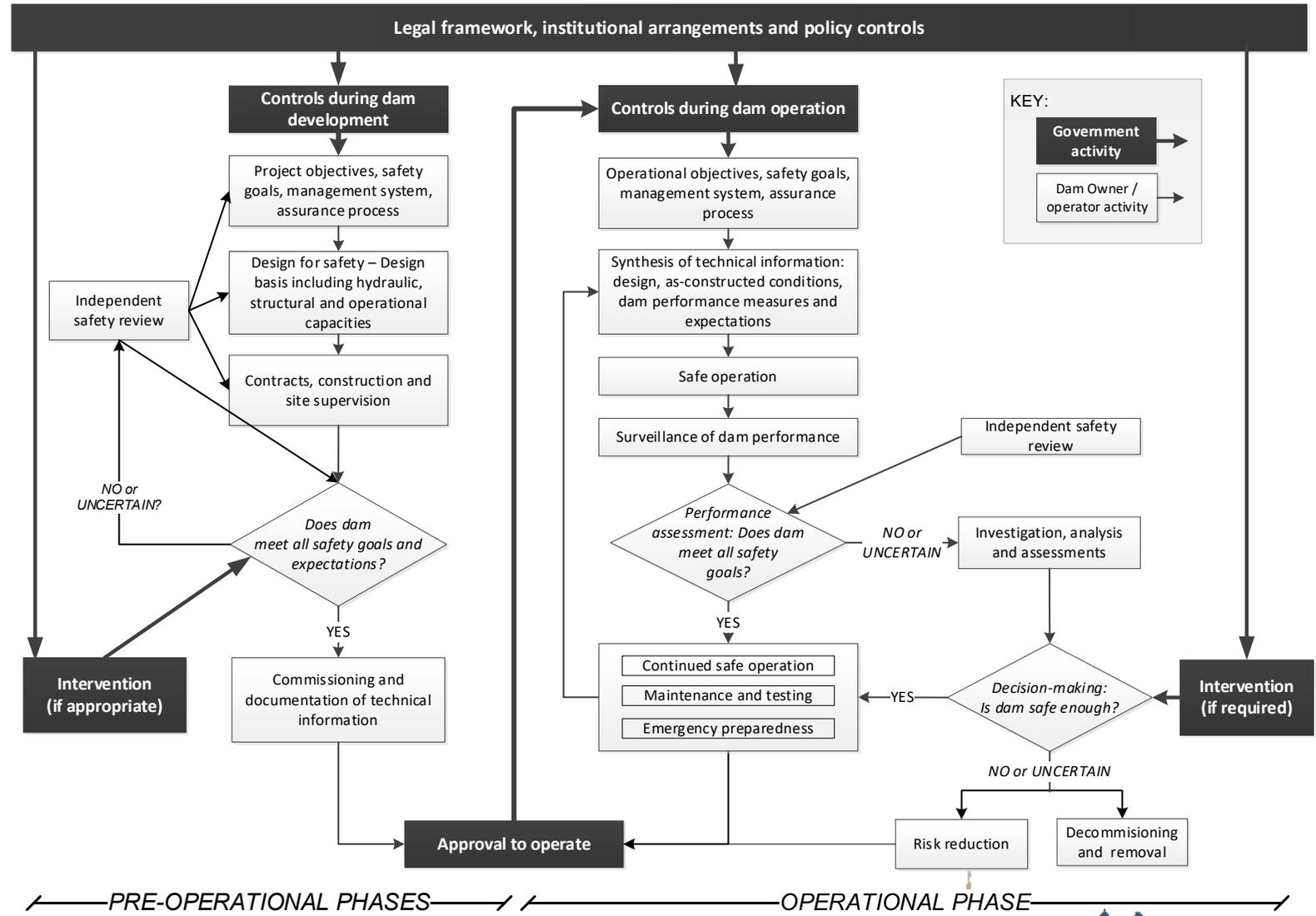
# Safe Dam

- *A safe dam will contain the stored volume of the reservoir, pass flows in a controlled manner, and protect the public, provided that the conditions for which the dam has been designed are not exceeded and the dam was constructed and operated as intended. This is achieved by designing and constructing the dam to conform to the generally accepted practices of the day, and then operating with sufficient surveillance, monitoring, maintenance, safety assessments and improvements, to preserve the safety status over the life of the dam.*
- *The assurance of dam safety requires legislative and administrative arrangements working together with engineering and management activities.*



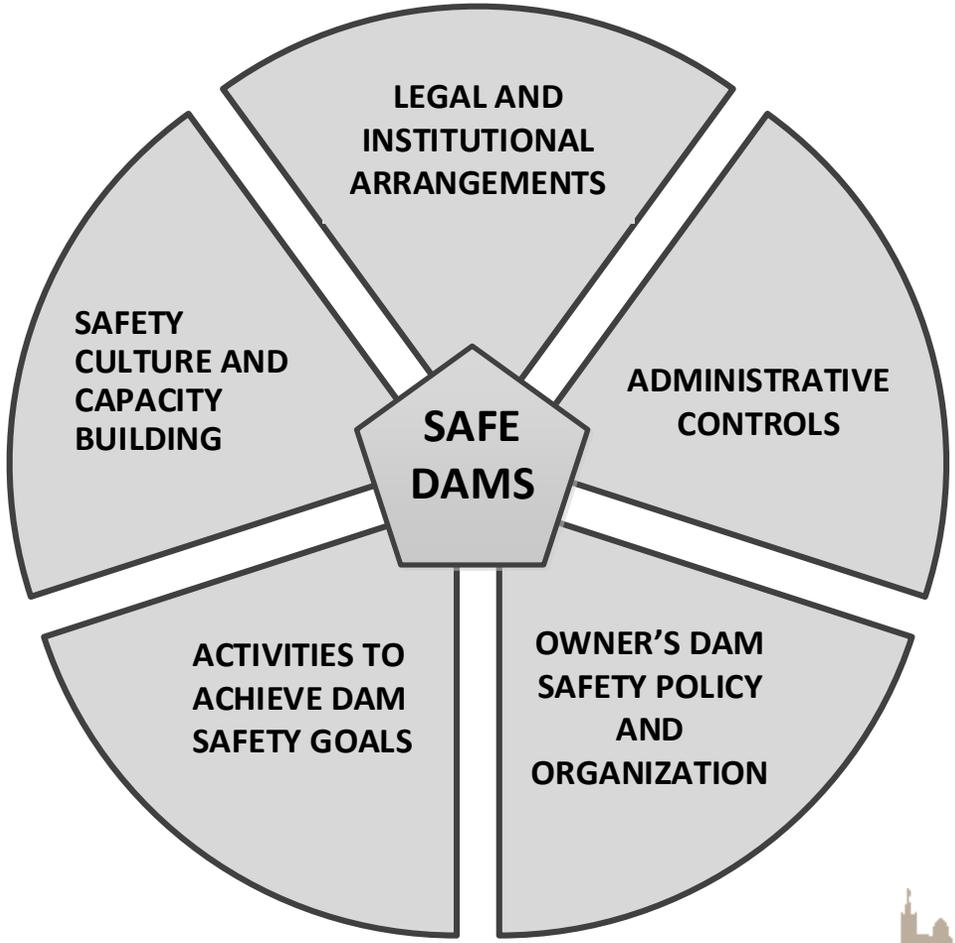


# Framework consistent with B154 & B175





# Concepts

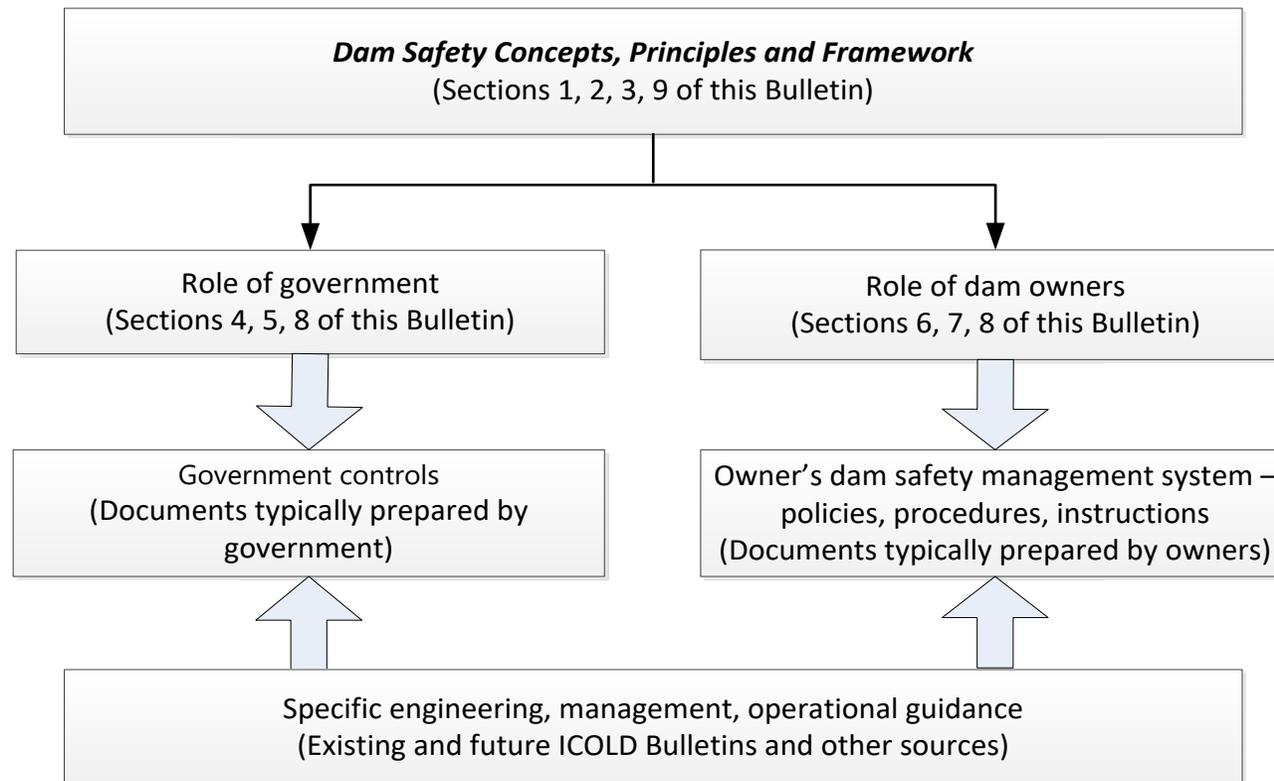


# Bulletin 1 – 9 Chapters

1. Introduction
2. Concepts and principles
3. Framework
4. Legal and institutional arrangements
5. Administrative controls
6. Owner's dam safety policy and organization
7. Owner's activities to achieve dam safety goals
8. Safety culture and capacity building
9. Conclusions



# Bulletin Structure



# Systems approach

- ***A dam, reservoir and river basin form a complex system of interacting parts, subject to a variety of inherently variable natural and operational conditions, operated by people and organisations. These form an engineered system that is set in a dynamic natural environment.***
- The river basin context may involve transboundary considerations that will influence the operation and the safety management of dams on the river system.





# Applicability

- Bulletin 1 outlines an overarching approach to assist governments and dam owners to achieve acceptably safe dams for the benefit of all stakeholders and the people whose lives and properties may be directly affected.
  - It can be applied in any country
  - It is applicable throughout the continuum of governance and ownership arrangements.



# General safety philosophy

- Describes what we mean by safe, and how safety in the context of this bulletin is intended to be interpreted.
- It is written in simple language terms so that it can be:
  - understood by a diverse audience
  - useful in support of dam owners and their engineers to explain to the authorities and the public what they are doing to ensure dam safety
  - similarly useful to the public as a source of reliable information to support public consultation and debate about dams and their safety
  - translated into a wide range of languages



# Guiding Principles set out at the beginning of each chapter

A significant development over B59 and a development since B154 and B175



# Safety Goals

- **Dam safety should be defined in terms of safety goals that state how the dam should be designed, constructed, and operated to ensure safety of the dam, the public, property and the environment.**
  - The safety goals should include policy, physical, and managerial considerations that are verifiable.
  - The goals should be set in the context of a dam development that is financially viable, delivers the expected net benefits, and is environmentally and socially sustainable in the long term.



# Design, Construction and Maintenance

- ***Each dam is a unique structure, designed and constructed to meet specific needs and site conditions. It is appropriate to consider each dam as a one-of-a-kind prototype that is designed in accordance with engineering principles and state-of-the-art practices applied appropriately to suit the particular site conditions and intended purposes of the dam.***



# Safe dam principles

- ***General principles for safe design of engineered systems, that have evolved over many years in many industries, are relevant to design, construction, and maintenance of dams. These include provisions for:***
  - ***Inherently safe design***
  - ***Reserves of capacity/safety margins***
  - ***Failure to a safe condition***
    - ***(not achievable in all cases)***
  - ***Procedural safeguards to ensure safe operation in accordance with design intent***



# Safe Operation

- **Safe operation of a dam involves maintaining the condition of the dam in accordance with the design intent, operating and controlling the reservoir elevation and outflows within the specified limits, and making safety improvements when appropriate.**
  - *Procedural safeguards should be designed and implemented to protect the dam, the public, and the upstream and downstream environments from the harmful effects of loss of control of the reservoir, unintended outflows during operation, and in extreme cases, dam failure.*

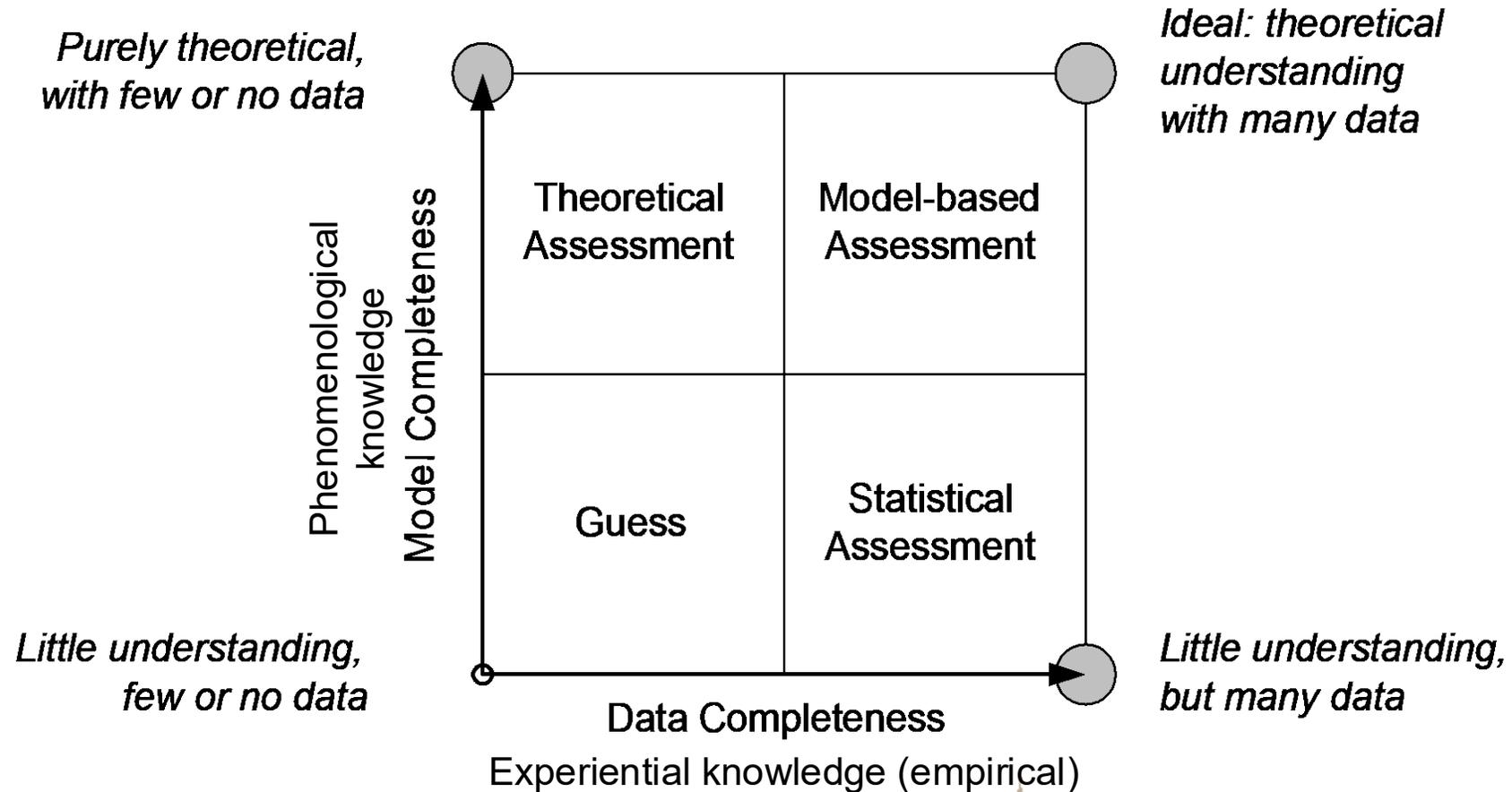


# Variability and Uncertainty

- ***.... are inherent factors that must be considered in dam design, construction, operation, and safety assessments, in large part due to the natural settings of dams and their long service lives.***
  - Typically addressed using a conservative engineering philosophy in the design of key components, that errs on the side of safety by a considerable margin.
  - Traditionally, sensitivity analyses are used as a check.
  - Methods such as risk assessment continue to evolve as a means of providing a more systematic approach to understanding, characterizing, and controlling the effects of variability and uncertainty, in a broader context.



# Uncertainty and what we know.



# Legacy uncertainty

- In the safety management of existing dams, and particularly older dams, there may be considerable uncertainty in the understanding of the as-built and existing condition due to limited information and documentation.
- Such deficiencies in information need to be identified and addressed by additional investigations and studies to provide sufficient understanding of the dam construction and behavior to allow the dam to be maintained and operated safely.



# Financial and human resources

- ***Achievement of dam safety requires that adequate financial and human resources be provided at all times.***
  - The responsible government organization or regulatory authority, and the dam owner, must both have adequate resources dedicated to dam safety activities within their own organizations during all phases of the lifetime of the dam.
  - A strong safety culture that seeks and achieves continuous improvement in safety management should be present in the regulatory authority, dam owner's organization, and professional community.





# Framework

Establishing the essential structures to succeed



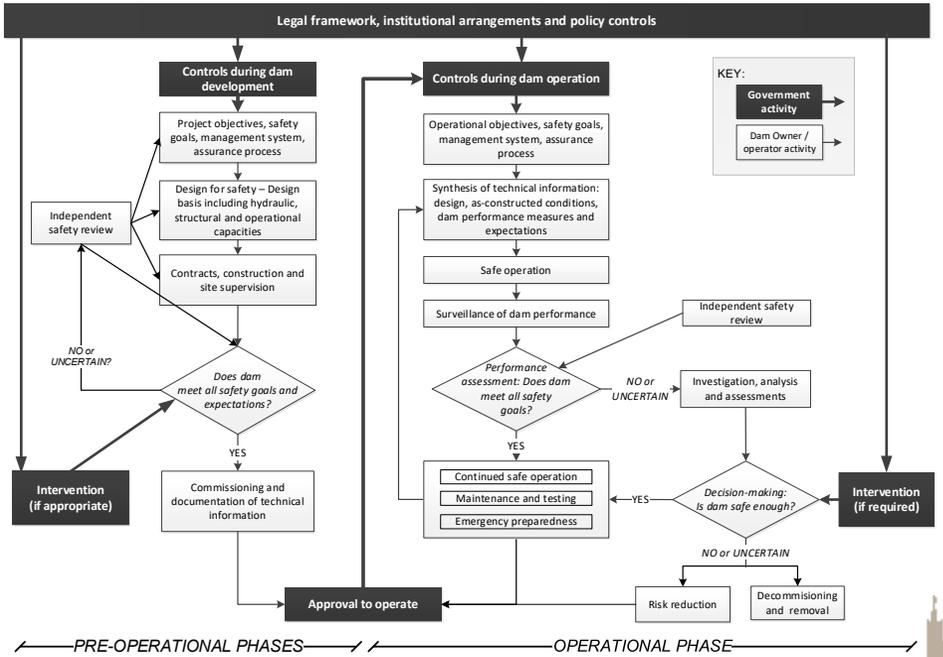
# Efficiency and effectiveness

- ***Efficient and effective safety management of dams requires that all relevant considerations be brought together in an integrated framework that identifies the roles of government and dam owners over all phases of the life of a dam.***
  - ***Dam safety is founded on appropriate governance, responsible ownership, and diligent engineering, implemented through a process that is transparent and open to reviews and audits.***
    - ***Dam safety is much more than engineering criteria for physical and hydraulic capacity***



# Systematic process

- ***Dam safety management elements should be organized in a systematic framework that establishes the relationships and interdependencies for an effective overall process.***



# Dam Safety Assurance

- *....involves demonstrating that the desired level of safety management has been achieved. This is done by regularly verifying the effectiveness of every stage of the safety management process.*
- *Governments and dam owners both have essential roles in providing assurance of the safety of dams under their control.*





# Legal and Institutional Arrangements

After a dam failure retrospective judgment of compliance with the law is the ultimate demonstration of having met safety goals



# Role of Government

- ***Governments may utilize or permit utilization of dams to achieve social and economic advancement of their societies, recognising that there are both benefits and risks from dams.***
- ***Governments have responsibilities for protecting the public interest from the potential wide-ranging social, environmental, and economic consequences of dam failure.***
- ***Governments discharge their responsibilities with respect to dam safety in ways that vary considerably, even across a single country, depending on the applicable governing arrangements, legal systems, and other factors.***

# Legal Arrangements

- ***Government policies frame the enabling legal arrangements and responsibilities for dam safety decision-making in all phases of the life of a dam.***

# Robust institutional arrangements

- ***Establishment and sustainment of the institutional arrangements requires adequate organizational and financial resources, human resources, and technical capacity.***
  - Transboundary dams require special consideration





# Administrative Arrangements



# Continuum of administrative options



# Administrative options

- ***The continuum of administrative options for assuring dam safety during design, construction, operation, and decommissioning, includes situations where:***
  - ***Government permits self-regulation by dam owners***
  - ***Government as regulator, shares responsibility for dam safety with dam owners***
  - ***Government takes command and assumes control of dam safety***



# Controls during dam development

- ***Dam safety control mechanisms during the development of a dam should provide a means of:***
  - ***Setting and documenting acceptable safety goals***
  - ***Ensuring that the safety goals are properly accommodated***
  - ***Overseeing achievement of safety goals***
  - ***Verifying that the safety goals can be achieved during operation and be maintained over the life of the dam***



# Safety controls during the operational phase

- *....should provide a means of ensuring that:*
  - *Safety goals remain current and adequate, and are updated as appropriate*
  - *Operation and safety management arrangements are appropriate*
  - *Physical performance goals and operational safety goals are being achieved*
  - *Corrective and remedial measures are carried out as necessary*





# Intervention

- ***Government should have the authority to intervene in the design, construction, operation and decommissioning of a dam, in response to safety concerns.***



# Entry to service

- ***The regulator should establish a process whereby consent to commission and commence operation, or continue to operate a dam development, is provided to dam owners.***



# Decommissioning

- *....or removal of a dam at the end of its useful life may require specific provisions in the regulatory arrangements.*





# Owner's dam safety policy and organisation

The first part of Bulletin 3





# Dam Owner's Responsibilities

- *The dam owner has primary responsibility for the safety of a dam through all phases of the life of the dam.*
- *To meet this responsibility, the dam owner needs a strong, auditable governance structure through which the leadership of the organization is responsible for guiding and providing oversight for all matters pertaining to dam safety.*



# How to get there

- ***The dam owner should establish and implement a comprehensive and sustainable dam safety risk management program that includes clear lines of authority, access to necessary resources, capacity, and direction, to meet the safety goals.***
- ***The dam owner should establish a safety assurance process whereby those responsible for dam safety management demonstrate the effectiveness of the dam safety program, to the owner's leadership, the government, and the public.***



# Policy and Safety Goals

- ***The dam owner should establish a dam safety policy statement that sets out the safety goals and how they are to be achieved within the overall objectives of the dam development.***
- ***This policy should be established and documented at the design stage, implemented before commissioning, and updated as appropriate over the operational life of the dam.***



# Contractual issues

- ***Dam safety goals, objectives and requirements should be embodied as appropriate in the contracts that the dam owner establishes for development and operation of a dam.***



# Management System and Assurance

- ***The dam owner should establish an overarching management system to assure that the functions necessary to achieve the safety and other objectives are carried out efficiently and effectively.***
- ***The management system should include documented structured policies, processes and procedures to be used in a systematic and coordinated way by the dam owner and any other responsible organizations engaged by the owner.***





# OWNER'S ACTIVITIES TO ACHIEVE DAM SAFETY GOALS

Making the right things happen on the ground



# Overall approach – in design

- ***The dam owner must implement a comprehensive program of activities that are integrated and documented in a systematic way to achieve the dam safety goals.***
- ***Dams should be designed and constructed in accordance with the best practices of the day, to ensure that they can meet or exceed the safety goals.***



# Overall approach – in operation

- ***Dams should be operated to meet or exceed the safety goals, with sufficient repair and maintenance such that there is no significant deterioration in the safety performance throughout the project lifetime.***
- ***The safety of a dam should be managed within a structured framework and process that includes surveillance, testing, safety inspections, reviews, assessments, emergency preparedness, and decision-making, so that any physical or procedural deficiencies are identified and addressed.***



# Designing for Safety

- ***To meet the safety goals, a comprehensive design basis should be established, fully documented, and maintained, and applied through the life of the dam by all parties.***
- ***The design should include specification of operational procedures, instrumentation and surveillance arrangements, and maintenance requirements and schedules.***



# Supervision during construction

- ***Construction supervision provides an essential link between the dam owner, designer and the contractor and is a key factor for ensuring the quality and safety of the completed dam.***
- ***Construction supervision should provide quality assurance and verify that the as-constructed project, and any corrective measures are consistent with the design intent.***



# Quality of information

- ***Adequate engineering and technical information and documentation form an essential component of every dam safety program and must be available at all phases to provide an understanding of the dam, its functions, modes of operation and potential modes of failure.***
  - In the absence of adequate information, additional investigations may be necessary.



# Knowledge management – vitally important!

- It is essential that data management and archiving of documentation of this technical information be secure and quality assured over the life of the dam.
- The information must be updated and maintained current over the life of the dam.



# Measures of safety performance

- ***Measures of the physical and operational performance as they relate to dam safety should be established to provide a basis for assessment and documentation of the safety of a dam, so that appropriate decisions can be made.***



# Structural, hydraulic and discharge issues

- ***Structural and hydraulic considerations,***
  - ***Margin of the capacity of the dam over the structural and hydraulic performance demands that might be made over its life provide quantitative measures for structural and hydraulic safety.***
- ***Discharge systems***
  - ***Reliability verified through testing and reported in terms of failure rates, provides a quantitative measure of operational safety of discharge systems***



# Other performance and managerial issues

- ***Degree of conformance of a dam to engineering design and construction guidelines and standards provides qualitative measures for physical aspects of safety that are founded in well-proven experience.***
- ***Degree of conformance of dam safety activities to the expectations and requirements provides qualitative measures of managerial performance.***



## ***During the operational phase,***

- ***...dam safety requires conformance to the operational procedures as set out in the design basis or subsequently modified.***
- ***Safety management system includes***
  - ***Surveillance of dam performance***
  - ***Maintenance and testing***
  - ***Public safety management***
  - ***Emergency preparedness and response plans***
  - ***Safety reviews, assessments, decision-making and risk reduction***



# Dam surveillance should include....

- ***.visual inspections, field measurements, instrument monitoring, and testing of surveillance equipment and monitoring instrumentation. Once collected and verified, all data should be analysed, assessed and assured for quality, and archived. The assessment should include any required recommendations related to maintenance, remediation, and upgrading works to maintain dam safety.***



# Maintenance and testing

- ***All components and systems should be maintained in a fully serviceable condition throughout the life of the dam.***
  - Maintenance and testing objectives, requirements, procedures and schedules for all mechanical and electrical systems, drainage systems, gates and stoplogs, should be set out in the design basis and implemented during the operational phase in a systematic way.



# Appropriate Emergency Preparedness

- *.... and response plans and arrangements should be established and maintained to address and minimize adverse consequences in the case of a dam safety incident or failure.*



# Independent Reviews

- ***Independent reviews of dam safety should be carried out during the design and construction prior to commissioning of new or rehabilitated dams.***
- ***Periodic and comprehensive independent dam safety reviews should be carried out throughout the operational life of dams***



# Investigation, analysis and assessment

- ***If the dam does not meet all safety goals, the necessary investigations, analyses, and re-assessments should be carried out to clarify the safety status of the dam and gather information for decision-making and risk reduction.***



# Decision-making..

- ***Owner is responsible for ensuring that there is an effective and transparent process for making decisions about the need for risk reduction measures when it is found that a dam or its operation does not meet the safety goals.***
  - Dams that are considered to be satisfactory typically continue in the normal cycle of operation, maintenance, and emergency preparedness.
  - Otherwise must address the need for risk reduction, including interim measures before any necessary longer-term improvements are completed.
- For transboundary dams, decision processes should be coordinated between the different jurisdictions.



# Risk reduction

- ***If the design, construction, or performance of the dam is found to be inadequate, the dam owner should implement appropriate risk reductions, rehabilitation, and operational improvements***
- ***Establishing adequate dam stability and control of the hydraulic operations is essential to ensure dam safety before and during risk reduction projects.***
  - Owner is responsible for developing and implementing a suitable follow-up action plan to control the identified risks and improve safety. Risk reduction should consider both operational and physical options, including decommissioning in some cases.



# Decommissioning

- ***Dam safety must be assured during and after the decommissioning***
  - Decommissioning can be a complex process requiring the full range of specialist capabilities that are required in the design, construction, and operation of the dam.
  - Adequate control of inflows and the stored volume is required during the decommissioning process.
  - Decommissioning activities may temporarily reduce safety margins, in which case appropriate mitigation measures should be established.





# Safety culture

Attitude and commitment of everyone involved



# A vital ingredient...

- ***Achievement of the dam safety goals requires a strong safety culture with commitment and involvement at all levels of government, the dam owner, professional organizations, emergency responders, and the public.***
- ***Building and maintaining the organizational capacity and human capability of governments, dam owners, and professions, to design, operate and maintain dams over the long term is an essential part of dam safety management.***





# Conclusion



# Safety of dams depends on .....

- ***...a dynamic integrated process within a framework that involves governments, dam owners and the public. This requires the application of science, engineering, economics, social policies, and environmental policies, set in the context of national laws and transboundary and international agreements.***

