

Environmental Compliance Conference, 2018

Dam Safety & Compliance

Topics

- Terminology
- Legal Requirements
- Roles of Regulatory Authorities
- Dam Safety Management
- New Zealand Dam Safety Guidelines
- Summary of Key Points

Terminology

Terminology

- Potential Impact Classification (PIC)
 - Considers damage levels, population at risk and potential loss of life
 - Low, Medium or High
- Population at Risk
 - Number of people exposed to inundation > 0.5m deep

Terminology (contd)

Assessed damage level	Population at risk (PAR)			
	0	1 to 10	11 to 100	More than 100
Catastrophic	High potential impact	High	High	High
Major	Medium potential impact	Medium/High (see note 4)	High	High
Moderate	Low potential impact	Low/Medium/High (see notes 3, and 4)	Medium/High (see note 4)	Medium/High (see notes 2 and 4)
Minimal	Low potential impact	Low/Medium/High (see notes 1, 3, and 4)	Low/Medium/High (see notes 1, 3, and 4)	Low/Medium/High (see notes 1, 3, and 4)

Terminology (contd)

- Inflow Design Flood (IDF)
 - Varies with PIC
- Safety Evaluation Earthquake (SEE)
 - Varies with PIC

Terminology (contd)

Hazard	PIC		
	Low	Medium	High
Inflow Design Flood (IDF)	1 in 100 to 1 in 1,000 AEP	1 in 1,000 to 1 in 10,000 AEP	1 in 10,000 AEP to PMF
Safety Evaluation Earthquake (SEE)	1 in 500 to 1 in 1,000 AEP	1 in 2,500 AEP	1 in 10,000 AEP

Terminology (contd)

- Appurtenant Structure
 - A structure that fulfils a dam safety function (e.g. spillway, intake structure)
- Large Dam
 - Dam with a height of 4m or more and holds 20,000 m³ or more of storage

Legal Requirements

Legal Requirements

- Resource Management Act (RMA):
 - Applies to all dams
 - Water permits (divert, take, use, discharge) obtained through RMA
 - Applicant needs to demonstrate that design, construction and operation will address hazards that have potential to impact on people, property and the environment
 - RMA enables conditions to be set for dam design, construction and operation

Legal Requirements (contd)

- Building Act:
 - Required for large dams
 - Governs dam design, construction and operation
 - Design - applicant needs to demonstrate that dam design complies with Building Act, Building Regulations and other relevant guidelines or codes of practice

Legal Requirements (contd)

- Building Act (contd):
 - Operation – Building Act includes a number of dam safety requirements:
 - Review of dam classifications (every 5 years)
 - Review of dam safety assurance programmes for medium (every 10 years) and high (every 5 years) PIC dams
 - Completion of annual dam compliance certificates for medium and high PIC dams

Legal Requirements (contd)

- Building (Dam Safety) Regulations:
 - Draft regulations prepared in 2008
 - Draft regulations provided framework for dam classification, and set out criteria and standards for dam safety assurance programmes
 - Draft regulations revoked by Minister of Building & Housing in 2015
 - Responsibility transferred to Ministry for the Environment
 - Unaware of current status, but.....

Legal Requirements (contd)

- Building Regulations:
 - A dam is a building, as defined in the Building Act
 - Regulations require all buildings to meet specific performance criteria, depending on building importance level
 - Performance criteria most relevant to dams are those that relate to the structure, the durability of the structure, access, safety from falling, warning systems and signs

Roles of Regulatory Authorities

Roles of Regulatory Authorities

- Design and Construction:
 - Issue of resource consents including any consent conditions
 - Issue of Project Information Memorandum (PIM) outlining planning and land use issues which relate to a building consent application
 - Issue of building consents including any consent conditions
 - Issue of code compliance certificates for work completed under building consents

Roles of Regulatory Authorities (contd)

- Operation:
 - Establishment and maintenance of dam registers
 - Approval or refusal of dam classifications
 - Approval or refusal of dam safety assurance programmes
 - Development, adoption and implementation of policies for dangerous dams, flood-prone dams and earthquake-prone dams
 - All without any dam safety regulations in place!

Dam Safety Management

Dam Safety Management

- The Ministry for the Environment has been preparing a consultation document for a proposed “National Environmental Standard for Dam Safety”
- The document was to be released for comment late in 2017, but....
- Dam safety has historically struggled and continues to struggle to make government legislative programmes, so the current status can be expected to continue for some time....

Dam Safety Management (contd)

- In the absence of firm legislation, how can regulatory authorities best fulfil their roles?
- Uncertainty can be minimised during the design/construction and operation stages by:
 - Having an awareness of historical dam performance, dam characteristics and important dam safety provisions
 - Relying on NZSOLD's Dam Safety Guidelines
 - Seeking timely advice from dam professionals
 - Applying appropriate consent conditions

Historical Performance of Dams

- Dam failure statistics over the period 1900 to 1975 indicate that:
 - 2.6% of concrete buttress dams built failed
 - 1.2% of embankment dams built failed
 - 0.7% of concrete arch dams built failed
 - 0.3% of concrete gravity dams built failed

Historical Performance of Dams (contd)

- Failures of embankment dams (as at 1986):

Mode of Failure	% Total Failures	% Total Failures pre 1950	% Total Failures after 1950
Overtopping	34.2	36.2	32.2
Piping through embankment	32.5	29.3	35.5
Piping through foundation	15.4	15.5	15.3
Spillways and gates	12.8	17.2	8.5
Downstream slide	3.4	6.9	0
Piping from embankment into foundation	1.7	0	3.4
Earthquake	1.7	0	3.4
Upstream slide	0.9	0	1.7
Total overtopping and appurtenant works	48.4	53.4	40.7
Total piping	46.9	43.1	54.2
Total slides	5.5	6.9	1.6

Historical Performance of Dams (contd)



- Overtopping Failure – Boykin Lake Dam, Texas, 1996

Historical Performance of Dams (contd)



- Internal erosion incident, Blackman Dam, Tasmania (2005)

Historical Performance of Dams (contd)



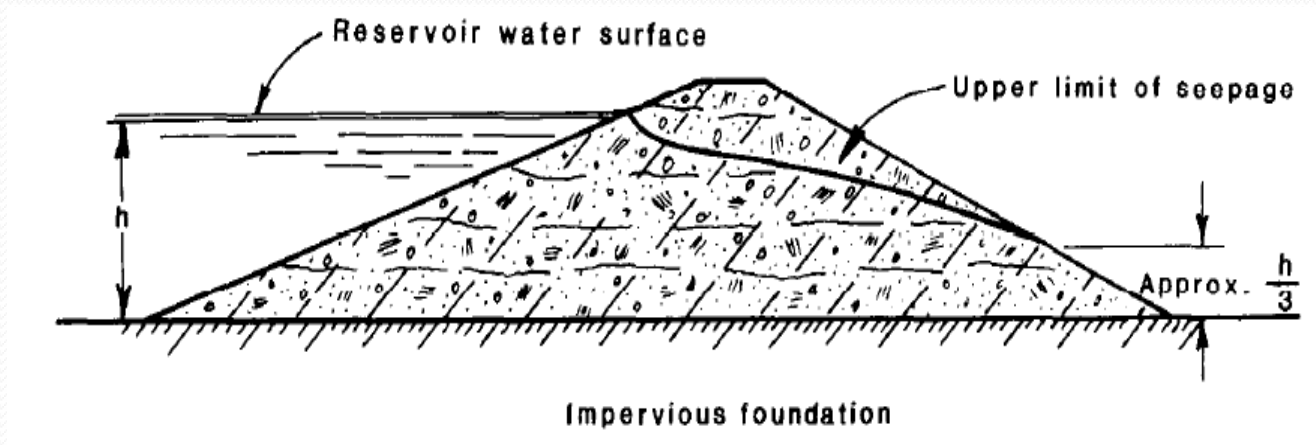
- Internal erosion failure – Teton Dam, Idaho, 1976

Embankment Dams

- Dam Types:
 - Homogeneous earthfill dam
 - Zoned earthfill dam
 - Rockfill dam with a central impervious core of earthfill
 - Rockfill dam with an impervious upstream facing
 - Flood protection dam

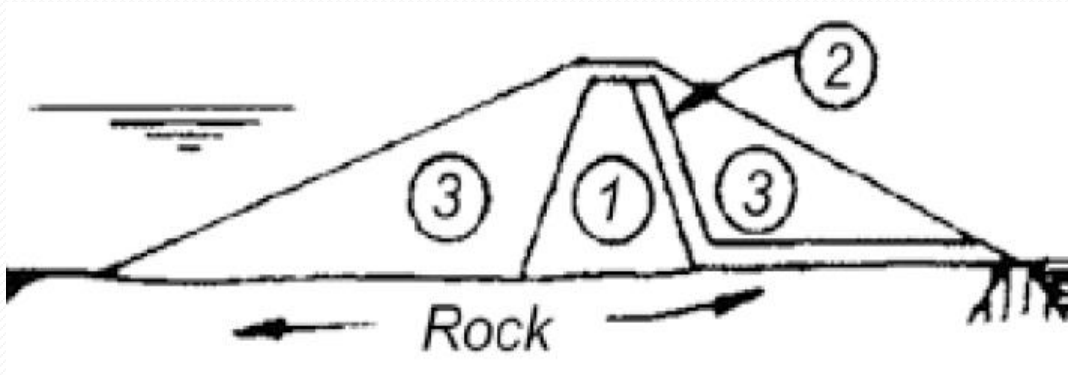
Embankment Dams (contd)

- Homogeneous earthfill dam



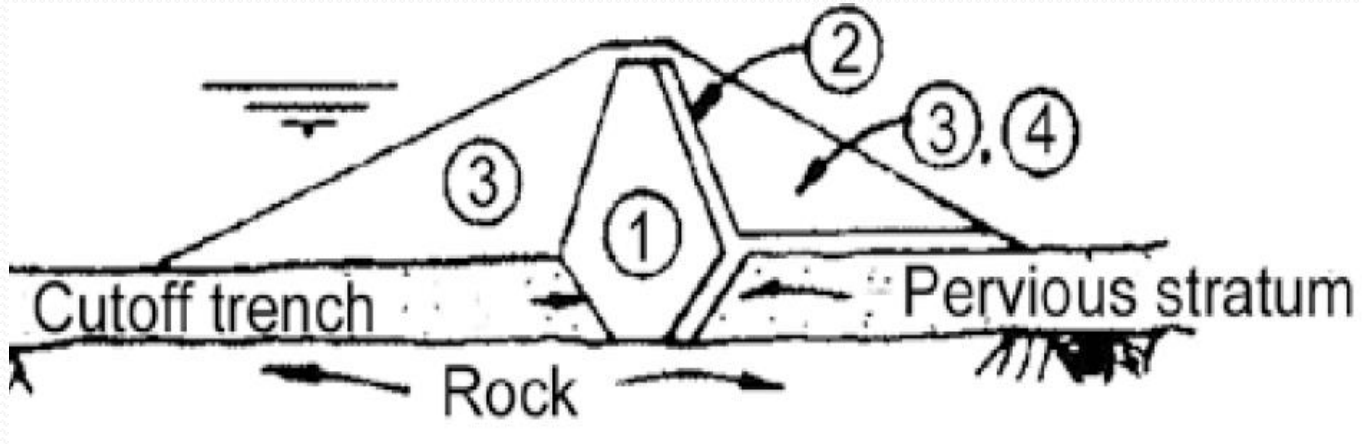
Embankment Dams (contd)

- Zoned earthfill dam on a rock foundation



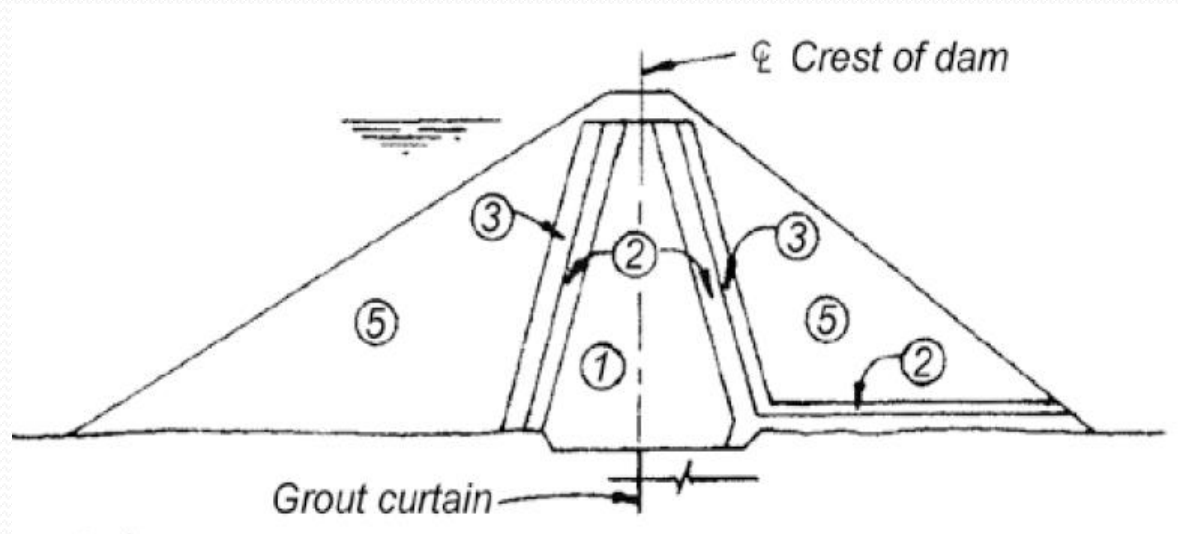
Embankment Dams (contd)

- Zoned earthfill dam on a gravel foundation



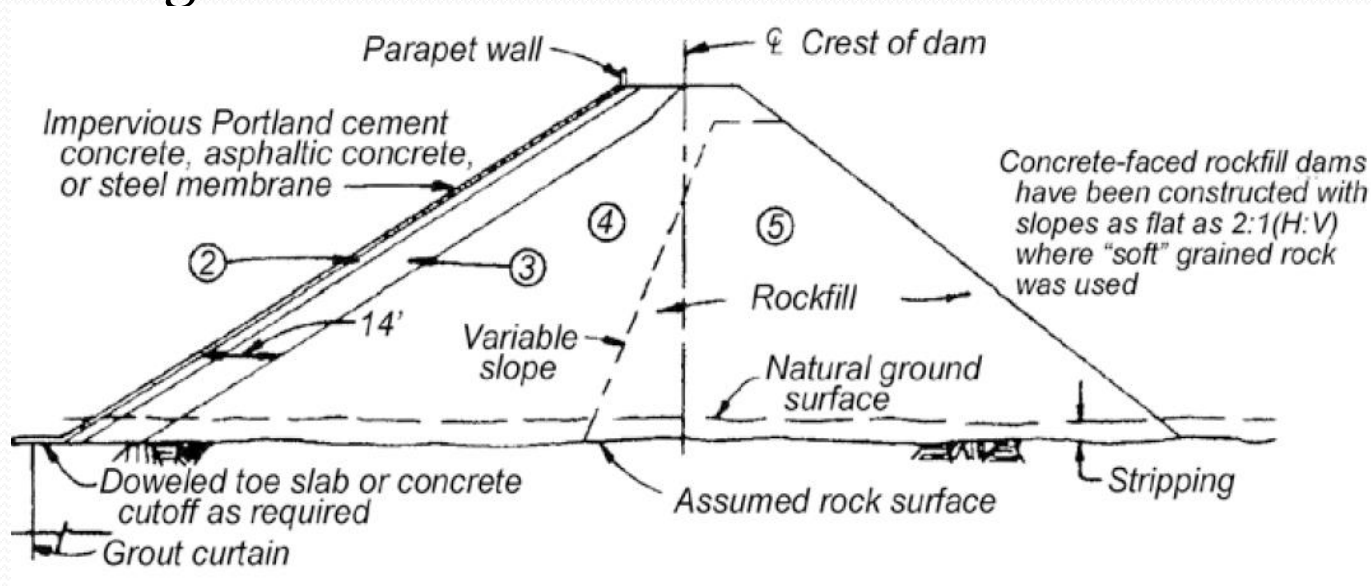
Embankment Dams (contd)

- Rockfill dam with a central impervious core of earthfill



Embankment Dams (contd)

- Rockfill dam with an impervious upstream facing



Embankment Dams (contd)

- Flood protection dams are different from other embankment dams in a number of ways:
 - A conduit is provided for the passage of normal flows
 - Stream bed load will normally continue past the dam
 - Storage is infrequent and significant storage is rare
 - Embankment is normally in a dry condition (unsaturated)
 - Debris has a high probability of affecting discharge
 - “Uncontrolled” commissioning

Embankment Dams (contd)

- Potential Failure Modes:
 - Overtopping
 - Piping through embankment
 - Piping through foundation
 - Piping from embankment into foundation
 - Instability of downstream shoulder
 - Instability of upstream shoulder
 - Erosion along embankment/structure interfaces

Embankment Dams (contd)

- Important dam safety provisions for protection against overtopping:
 - Sufficient freeboard to dam crest during IDF
 - Sufficient spillway capacity (primary and auxiliary)
 - Appropriate spillway type
 - Appropriate spillway design details
 - Multiple spillway gates
 - Backup spillway gate power supplies and operating systems

Embankment Dams (contd)



Free overflow spillway

Embankment Dams (contd)



Bellmouth and
tunnel spillway

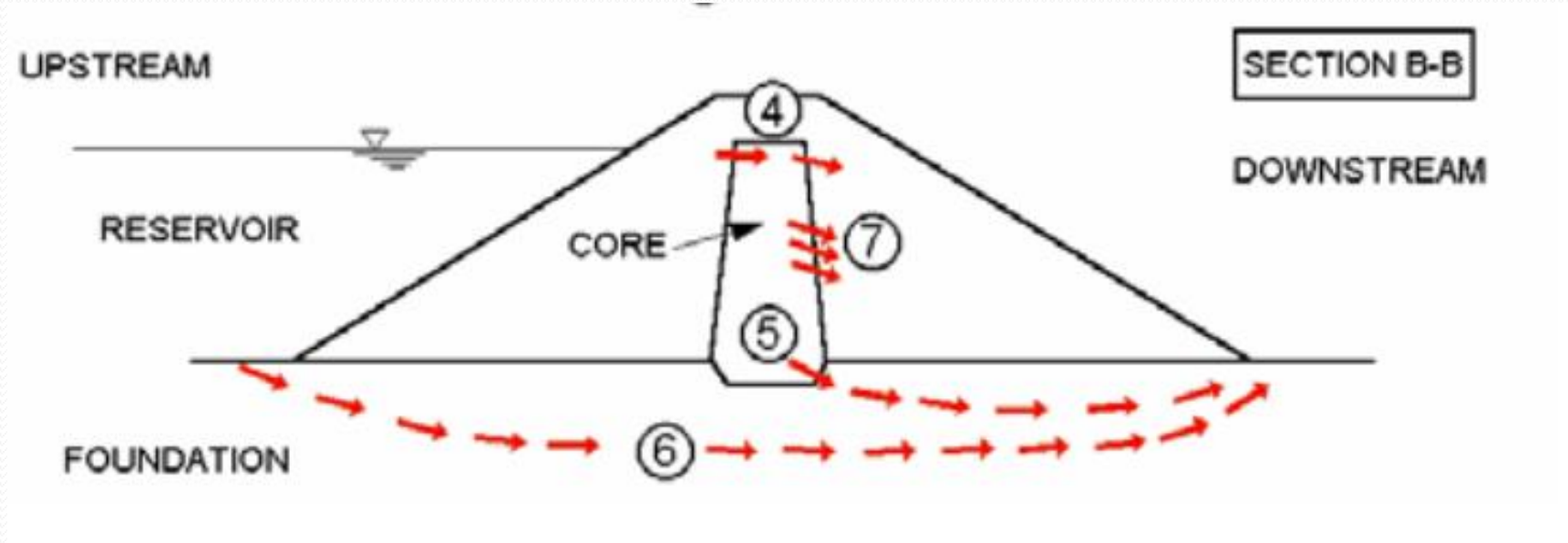
Embankment Dams (contd)



Gated spillway

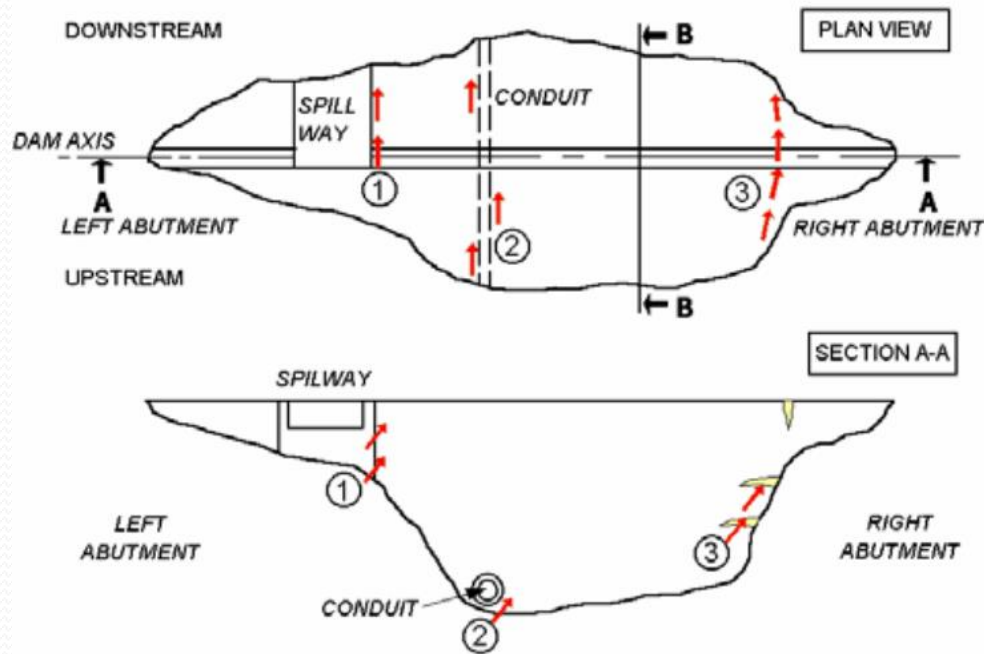
Embankment Dams (contd)

- Piping mechanisms



Embankment Dams (contd)

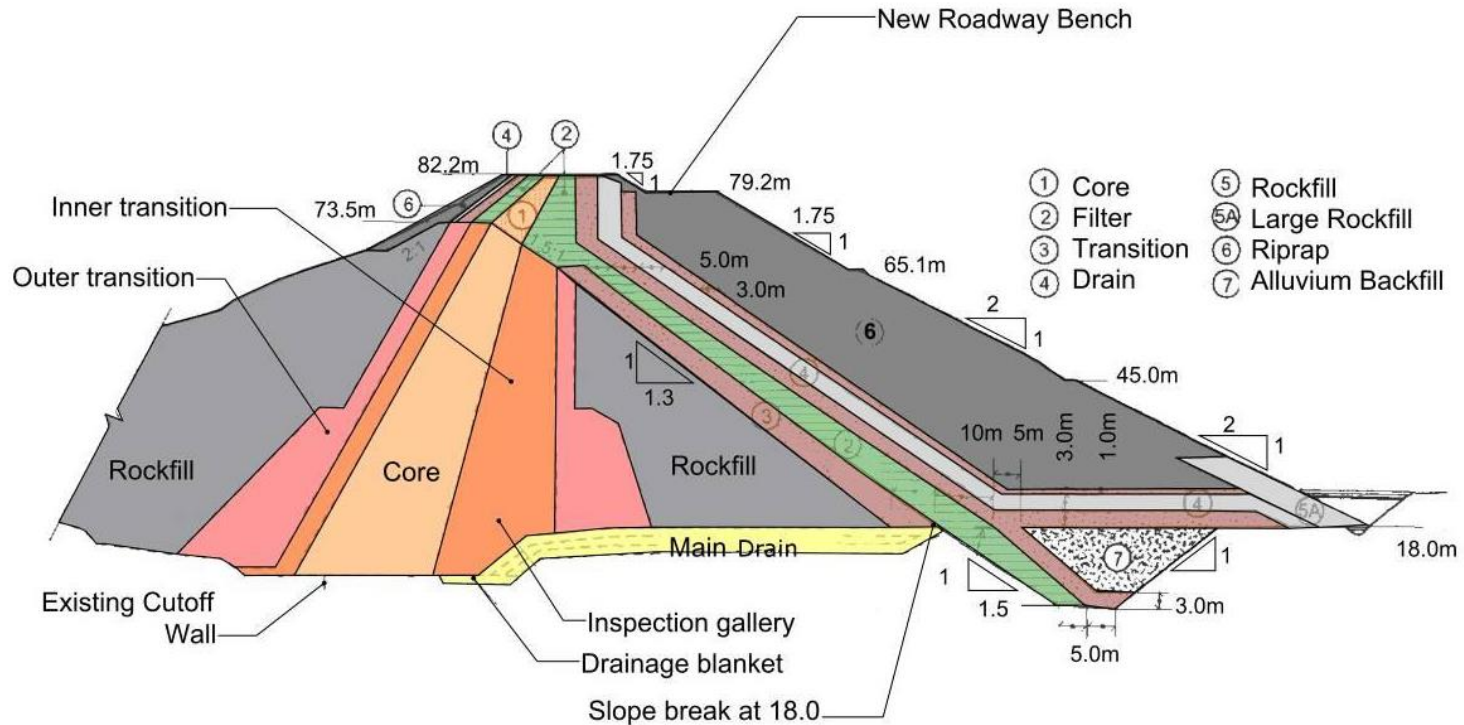
- Possible locations for the initiation of piping



Embankment Dams (contd)

- Important dam safety provisions for protection against piping:
 - Good foundations
 - Appropriate foundation shaping and treatment
 - Good quality construction materials
 - Appropriate filter and drainage protection – no geotextiles in body of dam
 - Good design details at embankment/foundation and embankment/structure interfaces

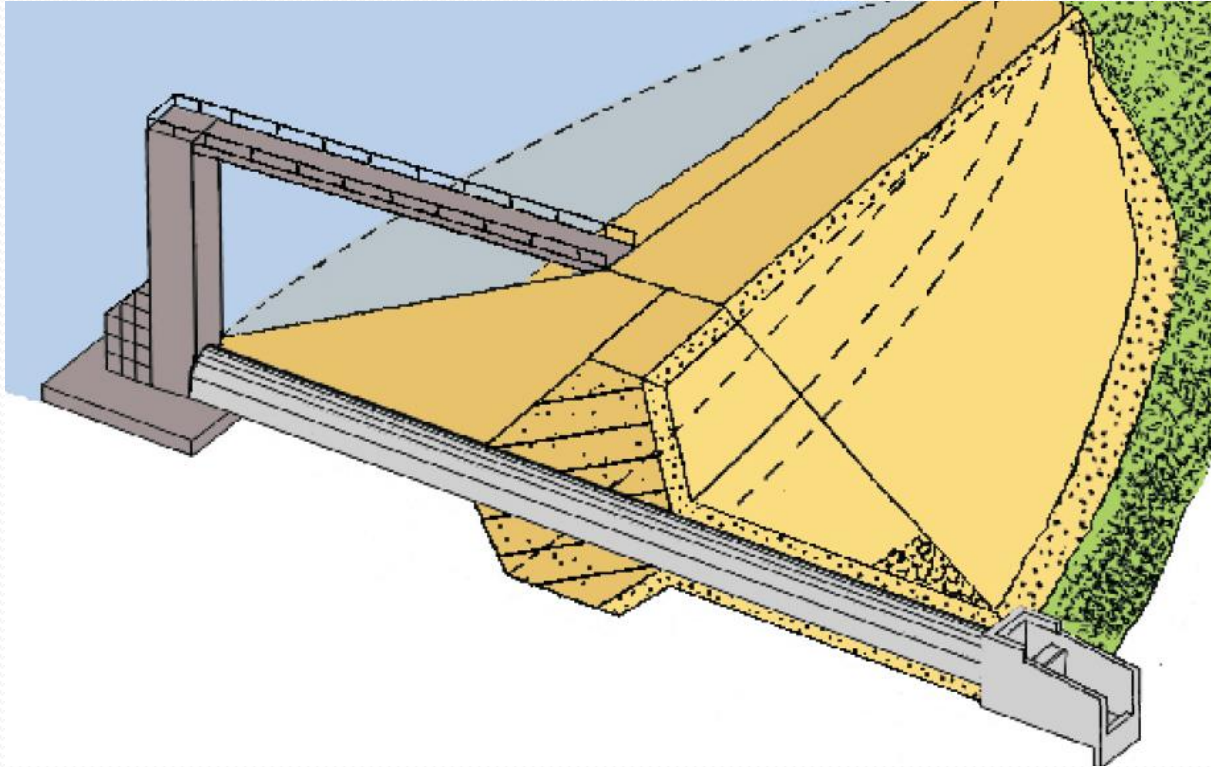
Embankment Dams (contd)



Embankment Dams (contd)



Embankment Dams (contd)

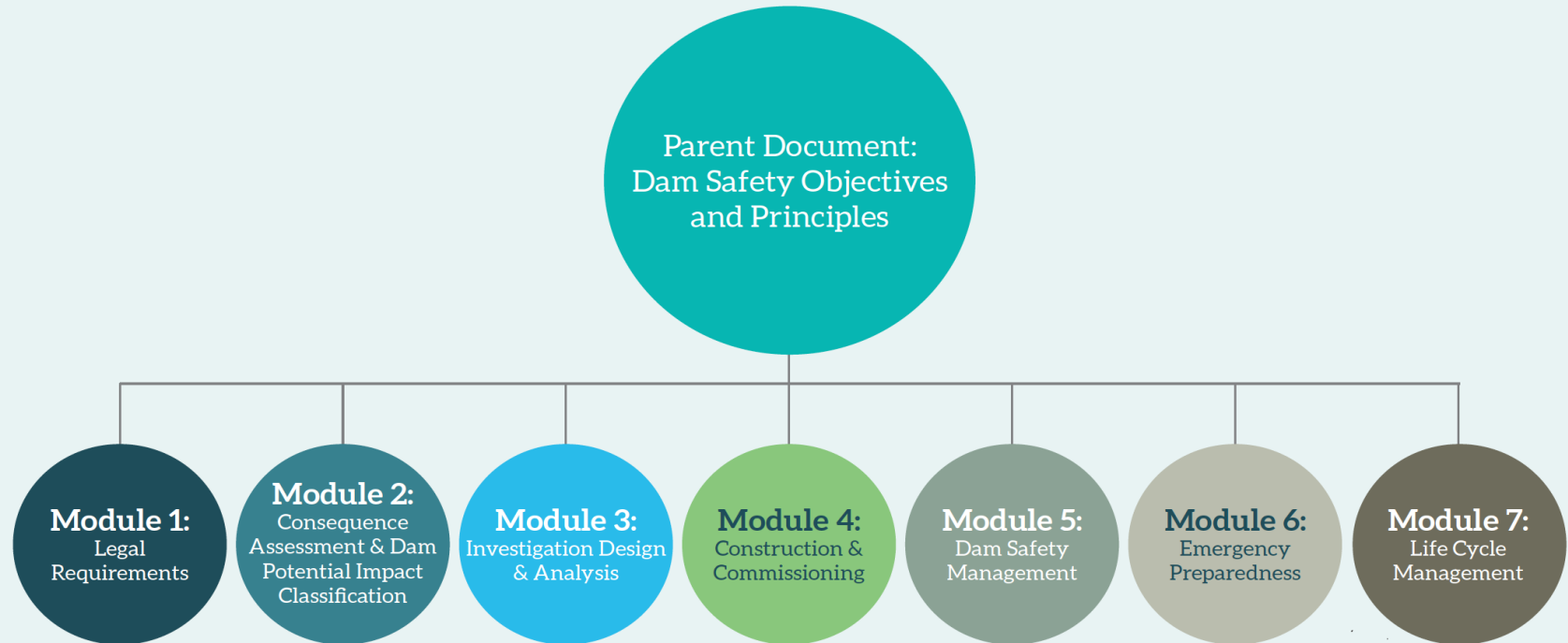


NZ Dam Safety Guidelines

NZ Dam Safety Guidelines

- Developed by NZSOLD (a Technical Society of IPENZ)
- Prepared from ICOLD technical bulletins and other internationally recognised references on dam engineering
- Provide recommended practices for investigation, design, construction, commissioning, safety assessment, upgrade and operation of large dams in New Zealand
- Can be downloaded free from www.ipenz.org.nz/nzsold

NZ Dam Safety Guidelines (contd)



Summary of Key Points

Summary of Key Points

- Resource consents:
 - Utilise experienced dam professional during consent hearings for medium and high PIC dams
 - Set appropriate consent conditions (e.g. formal peer review during design and construction for medium and high PIC dams)

Summary of Key Points (contd)

- Building consents:
 - Ensure design has been completed and reviewed by appropriately experienced engineers
 - Ensure formal peer review of investigation and design is completed for medium and high PIC dams
 - Ensure regulatory reviews are completed for all dams
 - Set appropriate consent conditions (e.g. formal peer reviews of construction, Commissioning Plan, Emergency Action plan, Dam Safety Management System)

Summary of Key Points (contd)

- Dam operation:
 - Ensure dam classifications are reviewed by dam owners at frequency in Building Act, and approve or refuse as appropriate
 - Ensure Dam Safety Management Systems for medium and high PIC dams are reviewed by dam owners at frequencies in Building Act, and approve or refuse as appropriate
 - Ensure Emergency Action Plans are reviewed by dam owners at recommended frequencies in NZ Dam Safety Guidelines, and approve or refuse as appropriate
 - Utilise dam engineering professionals for advice