Some preliminary comments on the Draft Global Tailings Standard from the ANCOLD Tailings Dam Guideline Working Party

1. Overall, ANCOLD supports the intent of the Draft ICMM Global Tailings Standard to improve the safety of tailings dams, as the first of three levels of guidance promoting this aim (the second level focussing on Governance and the third level focussing on technical issues). ANCOLD is currently assisting ICOLD to develop the technical document. ANCOLD has had comprehensive Guidelines on Tailings Dams since 1999, with updates in 2012 and 2019. These have served the Australasian region well with a history of tailings dam safety and no life loss or significant environmental impact. ANCOLD is prepared to revise our Guidelines to complement any reasonable Global Standard as promoted by ICMM.

2. ANCOLD recommends the use of the term "Tailings Storage Facility (TSF)" rather than "Tailings Facility", since the latter can have different meanings. A suggested definition may be: "tailings storage facilities are intended to store tailings to ensure physical and geochemical stability".

3. ANCOLD is concerned about the limited availability of sufficient technically competent professionals to cover the requirements for Engineer of Record (EOR) and Independent Technical Review. This could be improved by Requirement 2.2 requiring firstly an "Independent Senior Technical Reviewer", with an Independent Technical Review Board (ITRB) recommended for Very High or Extreme Consequence of Failure Classification (Dam Failure Consequence Category, as used by ANCOLD) dams, or if recommended by the Independent Reviewer to address specific concerns.

4. ANCOLD is strongly against Principle 4 as written: "Design, construct, operate and manage the tailings storage facility on the basis of the presumption that the Consequence of Failure Classification is 'Extreme', unless this presumption can be rebutted". While the intent of this Principle is understood to be making all levels of management aware of the potential risk posed by tailings dams, it may dilute and disguise the risks posed by more critical tailings dams, and spread too thinly the appropriate allocation of resources. If the intention is to have higher design, construction, operational and closure requirements for tailings dams that would be assessed as less than Extreme, then this can be achieved in other ways, such as by adjustment of Table 2 in the Draft (see later).

   ANCOLD proposes for consideration, a system whereby the Consequence of Failure Classification is assessed by robust and defensible methods, including consideration of possible changes to the facility and/or the environment of the facility over time, is approved by the Board, and that upgrades are implemented in accordance with appropriate industry risk reduction methodologies using ALARP principles.

   A suggested rewording of Principle 4 is attached. ANCOLD also draws to the attention of the GTRO the ANCOLD requirement that all Dam Failure Consequence Classification tailings dams be designed for Maximum Credible Earthquake (MCE) or Probable Maximum Flood (PMF) at closure, given the expected performance into perpetuity.

5. ANCOLD is concerned about the use of the word “minimize” in relation to risk, throughout the Standard, but particularly in Principles 6 and 7. Strictly, this could be interpreted as “reduce to zero”. As this is likely not the intent, the term “as low as reasonably possible (ALARP)” would be more acceptable.
6. Clearly, the liquefaction of loose, brittle, contractive materials causing catastrophic failure of tailings dams is partly responsible for this Standard being developed. However, ANCOLD considers that more clarity should be applied to Requirement 6.3, rather than just requiring “conservative design criteria and factors of safety”. “Conservative design parameters” are difficult to define without a comprehensive study. ANCOLD suggests that Requirement 6.3 require appropriate geotechnical investigation, material characterisation and geotechnical testing to determine the post-peak strength parameters. This could be dealt with more fully in the technical level document.
7. Risk assessments are mentioned in the Standard many times without any guidance. This critical topic is generally poorly understood and implemented. Again, this could be dealt with more fully in the technical level document.
8. Similarly, Requirement 6.2 requiring factors of safety that consider the variability and uncertainty of geologic and construction materials is a crucial area requiring specific detailed advice.
9. ANCOLD considers that the timing of the DSR under Requirement 11.4: (every 3 to 10 years, depending on performance and complexity, and the Consequence Classification of the tailings facility) is too long. ANCOLD would recommend more frequent review. Given this timing, the limited resources available in industry, and the arguable benefits of “a new set of eyes”, ANCOLD disagrees with the requirement for the DSR contractor being unable to conduct a subsequent DSR on the same facility.
10. ANCOLD are very concerned with Table 2, containing recommendations likely to be in conflict with a number of other existing standards, codes and guidelines. In some instances, the recommendations in Table 2 actually result in lower (less conservative criteria) than existing documents, including ANCOLD. It is recommended that Table 2 be deleted from the Standard, and included under the technical level document. ICOLD is actively considering this aspect.

PRINCIPLE 4: Design, construct, operate, manage **and close** the *tailings storage facility* in accordance with leading practice appropriate to the Consequence of Failure Classification determined by a robust, defensible and fully documented assessment in accordance with the provisions of Annex 2.

REQUIREMENT 4.1: Determine the Consequence of Failure Classification (see Annex 2, Table 1: Consequence Classification Matrix) of all new tailings storage facilities by a robust, defensible and fully documented assessment process and design, construct, operate, manage **and close** the facility accordingly. This assessment should make the following allowances:

a) The Consequence Category Assessment should consider the expected future development of the TSF and its environment over the life of the facility, including the closure and post-closure phases, and confirm that future upgrading of the Consequence Classification can be accommodated; and

b) Undertake a sensitivity analysis to suggest what future changes to the environment of the facility could trigger an upgrade of the Consequence Classification and put in place controls to prevent this; and

c) The Consequence of Failure Classification is reviewed by the EOR every year and again during any Dam Safety Reviews. Review should continue until the facility has been safely closed and achieved a confirmed “landform” status or similar permanent non-credible flow failure state.

REQUIREMENT 4.2: The decision to accept the Consequence Classification shall be taken by the *Accountable Executive* or the *Board of Directors* (the *‘Board’*), with input from an Independent *Senior Technical Reviewer* or the *ITRB*. The *Accountable Executive* or *Board* shall give written reasons for their decision.

REQUIREMENT 4.3: *Existing facilities* shall comply with Requirements 4.1 and 4.2. Where upgrading is required, the *Board*, or senior management (as appropriate based on the Operator’s organizational structure), with input from the *ITRB*, shall approve the implementation of measures to reduce the risks of a potential failure to as low as reasonably possible (ALARP), in accordance with leading practice tolerable risk methods.

Global Tailings Review Meeting

UQ SMI, Brisbane, 13 December 2019

Notes by Professor David Williams
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Overview by Dr Bruno Oberle:

- In 2011, the equivalent of 30 Gtpa of resources was consumed globally. By 2017, this had risen to 90 Gtpa, and by 2023 it is expected to rise to 180 Gtpa! How sustainable is this?
- At the same time, financiers, pension funds, insurers and other institutions are questioning the values of the mining industry and stepping away from mining failures.
- The response of the mining industry must be safer and more sustainable operations over the next 20+ years.
- An example is the Cyanide Code, which has regulated the safe use of cyanide in gold processing*. Another example is the cessation of the use of CFCs, due to their impact on the ozone layer. Interestingly, Dupont had 50% market share of the supply of CFCs and pre-empted their demise, resulting in Dupont now having a 60% market share in the replacement hydrochlorofluorocarbons (HCFCs), which deplete stratospheric ozone to a much lesser extent than CFCs and will ultimately be replaced by hydrofluorocarbons (HFCs).*
- The Global Tailings Standard, co-sponsored by ICMM, UNEP and PRI, is “one brick in the wall” to address the unacceptable rate of tailings dam failures – Guidelines are not enough.
- The intent of the Standard is to restore confidence and trust.
- Bruno, as Chair, brings a fresh perspective to tailings dam failure. He chairs a multi-stakeholder/disciplinary group, including tailings experts, social and community researchers, and legal experts, which I more broadly-based than most expected.
- The aim is to quickly implement the Standard, from March 2020, in less than 1 year.
- The accompanying Report will be drafted from October 2019 to February 2020.
- Regional differences (climatic, topographic, seismic and social settings) are recognised, but could be better incorporated into the Standard.

- ICOLD, ANCOLD, MAC/CDA and other national Guidelines., plus Company Standards, will not be superseded, and there needs to be compatibility between these and the Standard.
- The question as to what will govern; e.g., legally, is unknown. Logically, local Guidelines would govern. The standing of the Standard will depend om whether the operating company has endorsed it.
- The question of future review of the Standard has not been addressed, but is likely. The Standard is not perfect and will likely become outdated.

Professor Deanna Kemp on Topics I and II

- The Standard outlines the Scope and Roles, Logic, Interactions, and the broader context (beyond the technical).
- The Standard contains 6 Topics (each with an Overview statement), 17 Principles and 76 Requirements.
- Topic I (2 Principles and 10 Requirements) – Knowledge base:
    - The Overview omits "technical", but this is implied in Principle 1 and included in Principle 2.
- Topic II (1 Principle and 4 Requirements) – Affected communities (UNEP basis).

Professor Andrew Hopkins on Topics III to V

- Topic III (5 Principles and 25 Requirements) – Design, construction, operation and monitoring of tailings facilities:
    - "Closure" is missing from the Overview.
    - "Extreme" is the default Consequence Classification, unless rebutted, and is based on >100 deaths being likely in the event of failure of the tailings dam.
    - "Very High" is based on 10 to 100 deaths likely.
    - It was questioned whether the likely number of deaths was the most appropriate measure of consequence, and about the number of deaths likely.
- Topic IV (6 Principles and 26 Requirements) – Management and governance:
    - Elevating company responsibility beyond the Mine GM (who may be under other pressures) to as high as the Board.
    - The DSR (Dam Safety Reviewer) cannot be re-appointed (for reasons of potential complacency and conflict of interest). However, given the shortage of suitably qualified and experienced reviewers this would likely be impractical, and questions the necessary objectivity and professionalism of the reviewer.
    - The EOR (Engineer of Record) should be a firm, not an individual. The practice in Canada, where the EOR system is most well established, is to appoint an individual, who could be a member of a firm, even the Design Consultant.

    - Complaints can be made by anyone, with whistle blower protection. This could be restricted to those impacted to avoid vexation complaints.
- Topic V (2 Principles and 9 Requirements) – Emergency response and long-term recovery.

Professor Deanna Kemp on Topic VI

- Topic VI (1 Principle and 3 Requirements) – Public disclosure and access to information:
    - To any interested party – Broadly (as per the Church of England and PRI 20 questions). The industry has some difficulty with disclosure to opponents of mining.
    - Engage with Professor Margaret Armstrong, EMAp Fundacao Getulio Vargas, Brazil.

Professor David Williams Reporting on Discussion 1

- Standard versus Guideline:

STANDARD	GUIDELINE
Single document	Multiple documents for different jurisdictions
Implies enforcement	Not enforceable
Not replacing Guidelines, high level	De facto Standard, written onto some legislation over time
Does not capture regional settings	Captures regional settings – climate, topography, seismicity, societal, etc.
Includes “should” rather than “shall” or “must”	Includes “recommended minimum factors of safety”
Lacks implementation guidelines, placing the onus on operators, not focussed on “how”, rather on reducing “harm”	
To be tested	

- Design Criteria:
    - Decided by the company.
    - In compliance with local guidelines (sometimes in law).
- Endorsement of the Standard:
    - It is hoped that a compromise document will be developed that all stakeholders will endorse.
- Add “health”, “closure”, “chronic impact”, “technical” (consistently), “social” (consistently).
- Add “economic implications of Net Present Value (NPV) accounting and Key Performance Indicators”, which are production-focussed.
- Acknowledge the skills shortage and need for training in the tailings field.
- Who is to be responsible for data collection, management and funding?

  - The current expectation is on a company by company basis, but few sites are well advanced (Samarco is now, arguably, the best instrumented site in the world, following the failure).
  - Data/technology advances.
  - Consider standalone centralised monitoring data.
  - Independence?
  - Treatment of abandoned sites and relinquishment.
- Mining companies are averse to public disclosure, particularly to those opposed to mining.
- Positives about the Standard:
  - The Principles are sound, and no one would argue against them.
  - Affected communities should be considered.
  - Management and governance should be sound.
  - It could be argued that the mining industry should have been in compliance already, and broad is good.
- How will the Standard reduce tailings dam failures?
  - Does it/should it encourage dry processing and/or dry tailings disposal?
  - Does it/should it drive preferred tailings storage methods?
  - Should it use cost/penalties as a driver?
  - The Standard did not have this intent.
  - There is no “silver bullet”, and the Standard should not be prescriptive.
- The Standard and/or investors could provide incentives to change the NPV/KPI approach to “whole-of-life”, although investors have supported the NPV approach.
- Water dams are about two orders of magnitude more stable than tailings dams, driven by NPV accounting and KPIs!

Corrine Unger Reporting on Discussion 2

- Strengths of the Standard:
  - Inclusion of affected communities.
  - “Extreme” Consequence Classification default.
  - May promote change.
- Missing from the Standard:
  - “Closure”.
  - Post-closure land use.
  - Treatment of legacy/abandoned tailings (storage) facilities.
  - Health (short-term and long-term).
  - Definition of “failure”.

- General comments:
    - Need for a regulator engagement model.
    - Definition of emergency response.
    - Emergency response for remote sites.
    - Ownership and retention of knowledge.
- Specific comments:
    - Clarity about EOR.
    - Regulator interface and role.
    - Scalability.

Professor Anna Littleboy Reporting on Discussion 3

- General/overarching comments:
    - Challenges of the risk-based approach.
    - Avoid prescription.
    - Tie into ICOLD/ANCOLD/MAC, CDA, etc.
    - There are some inconsistencies in the Draft Standard.
    - Definition of "Extreme" Consequence Classification in terms of likely >100 deaths, rather than tolerance. What is the value of life?
    - Engineering versus social.
    - Treatment of workers at risk?
    - Consequence matrix.
    - Long-term/residual risk.
    - Definition of "post-closure", including the timeline and evolution over time.
    - There is little on technology in the Standard.
    - There is nothing in the Standard about limitations on what method of tailings management might be allowed/dis-allowed; e.g., deep sea or lake discharge, riverine discharge, etc.
    - What are the legal ramifications of the Standard with respect to liability, knowledge transfer, etc.
    - How would public disclosure be enforced?
    - What would be disclosed publicly?
    - How would data be made accessible?
    - Could case studies be added to demonstrate how the Standard would work?
- Specific comments:
    - "Meaningful" engagement?

    - Accountability.
    - Handling potential conflicts of interest.
    - Turnover and loss of corporate memory, particularly after closure.

General Questions

- The title "Global Tailings Standard" may be misleading or raise expectations.
- Order of risk – people, environment, operators. Should operators (lives) not come before the environment?
- "Indigenous peoples", who occupy about one third of the Planet, are mainly raised in footnotes, and should be more prominent in the text. The aim was to keep the text as simple as possible, with important details given in footnotes. Where would you stop?
- There is little mention of "informed consent", other than in a footnote.
- Format of comments online:
    - Via the Consultation Portal: https://globaltailings review.org/consultation or consultation@globaltailingsreview.org.

ANCOLD WORKSHOP

Tailings Liquefaction Triggers and Monitoring
12 November 2019, Perth

Professor David Williams

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Manager, Large Open Pit Project

The University of Queensland, Brisbane, Australia

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AUSTRALIAN NATIONAL COMMITTEE ON LARGE DAMS

Key Causes of Tailings Dam Failures and Industry Threats

- Most tailings dams that fail have marginal stability
- Most tailings dam failures involve "water", making drainage, clay cores and water management of key importance
- Many tailings are potentially liquefiable
- Another cause can be a weak (often unidentified, possibly moving from over- to normally-consolidated on progressive raising) foundation layer
- Industry threats are coming from:
  - Investors; e.g., Church of England
  - Insurers
  - Regulators; e.g., outlawing upstream construction, which happened in Chile following earthquake-induced failures in 1965, and will follow in Brazil (wet climate and failures)

Susceptibility of Tailings to Liquefaction

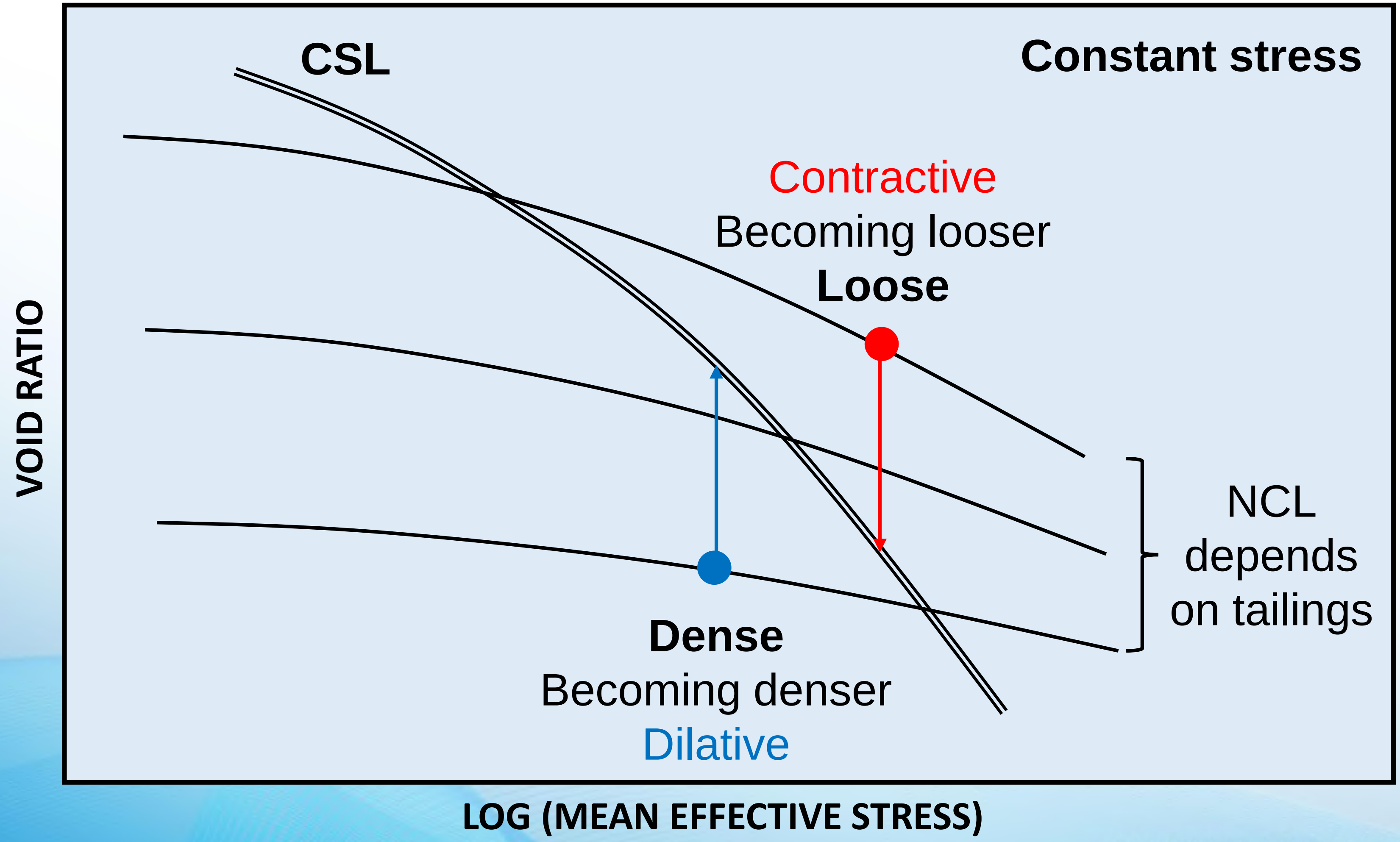
- Earthquake-induced liquefaction susceptibility:
  - Silty sand or sandy silt-sized tailings **– √**
  - Loose (brittle [collapse beyond peak], contractive [more so at higher stress]) state **– √**
  - Near-saturated **– √**
  - Earthquake magnitude > 5.5 and peak ground acceleration > 0.13g ***– ?***
- Static or flow liquefaction, triggered by:
  - Loss of containment due to dam/upstream raise instability
  - Overtopping and erosion of dam/upstream raise
  - Rise in phreatic surface due to heavy rainfall or fresh tailings

  } Undrained unloading

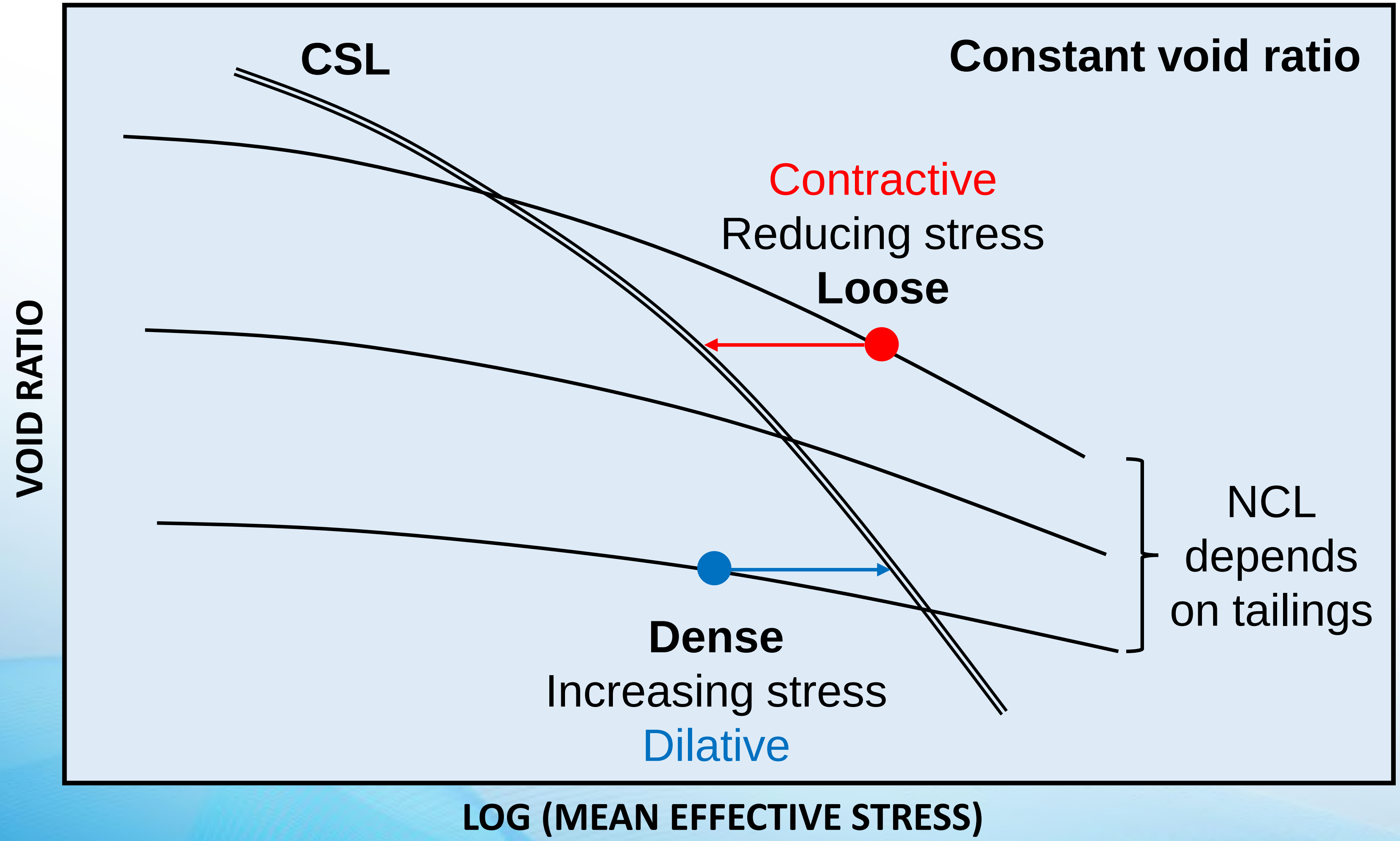
  - Pore water pressure increase due to dam raise, recharge or blocked drains – Undrained loading

Susceptible tailings can behave in an undrained, contractive, strain-softening manner, and liquefy or flow

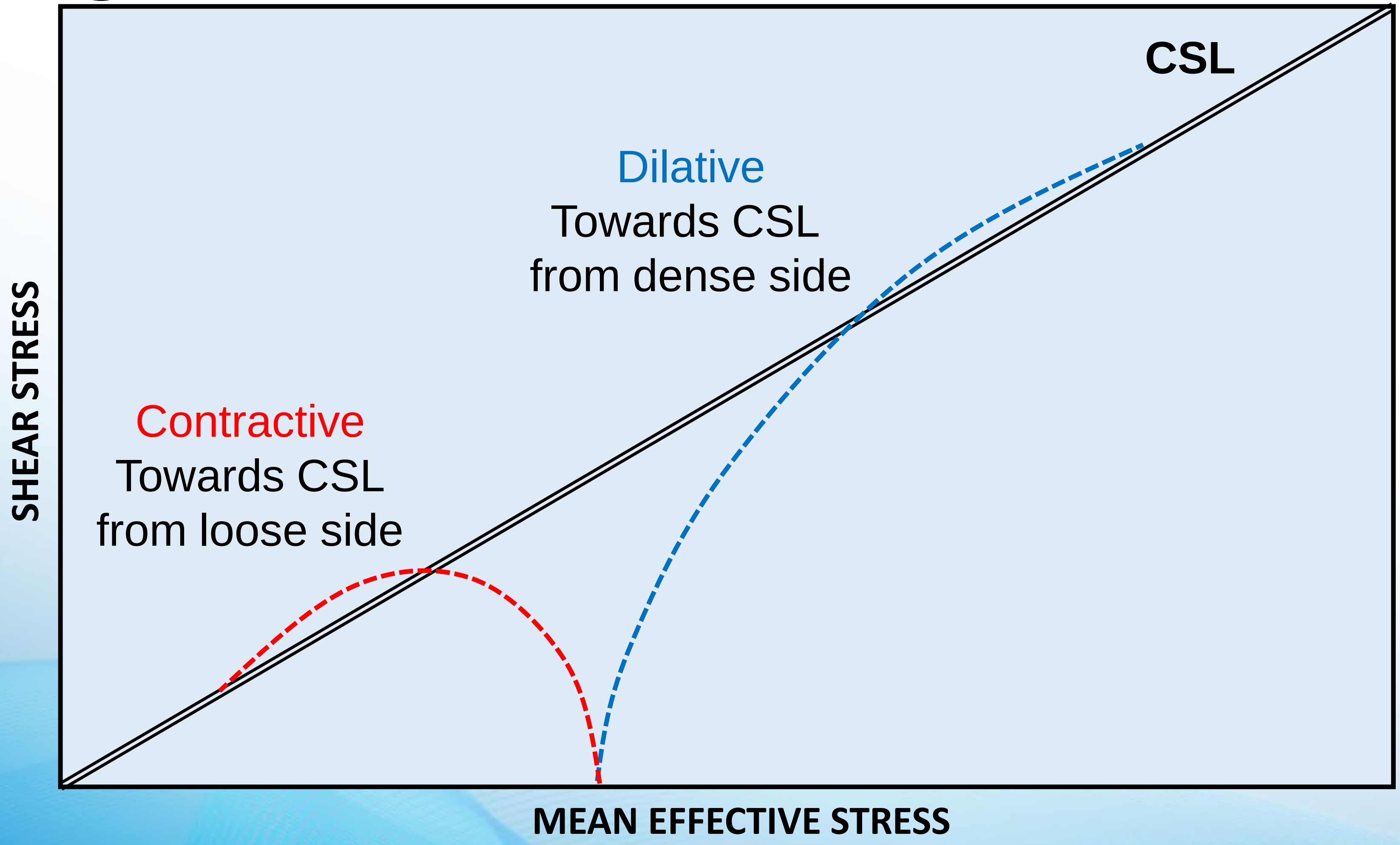
Critical State Soil Mechanics Framework – Drained Shearing of Tailings



Critical State Soil Mechanics Framework – Undrained Shearing of Tailings



Stress Paths for Undrained Shearing of Tailings

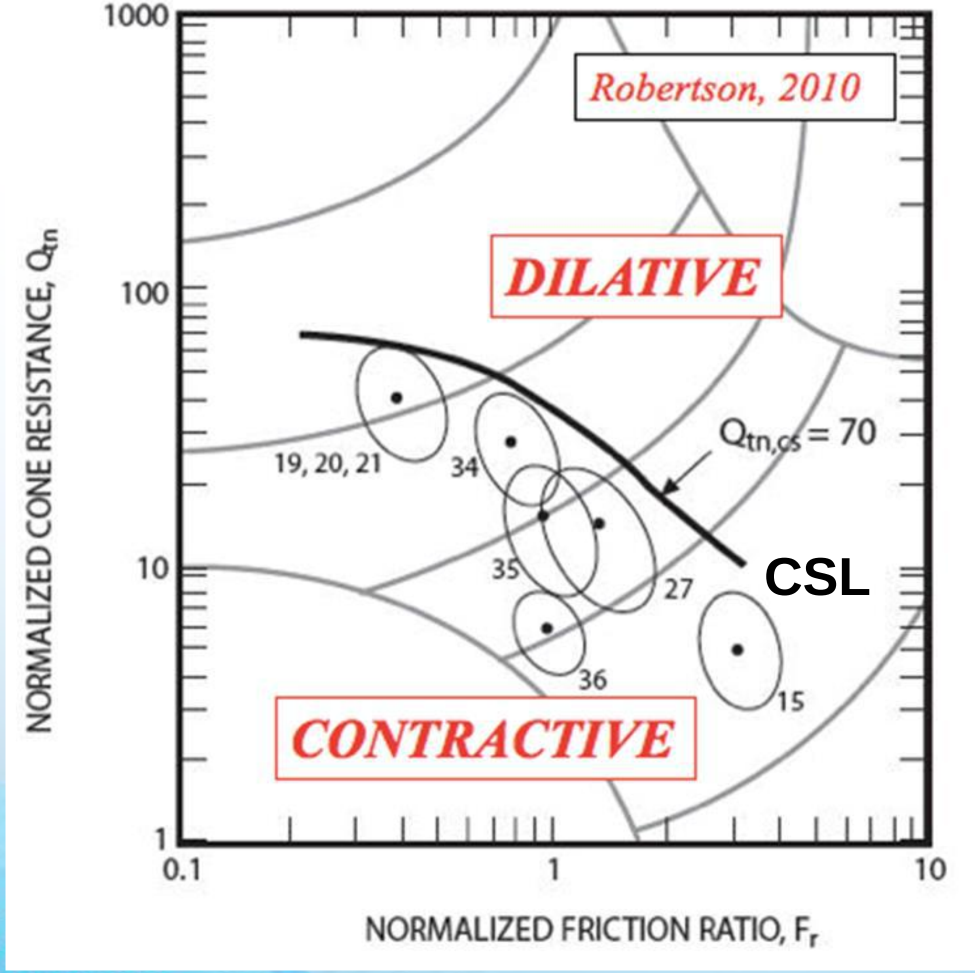


Susceptibility of Tailings to Liquefaction

- Moisture content << Liquid Limit suggest that tailings will not liquefy
- However, tailings state (loose or dense) *in situ* is difficult to determine, particularly if tailings are loose:
  - They can't be sampled at their *in situ* state, if at all (an indicator of liquefaction)
  - CPTu data plot in bottom left-hand corner of log-log SBT Chart, where few correlation data exist
  - Some past use was made of SPT, now largely superceded by CPTu
  - Some use is made of "simple shear" testing, but samples may not be at *in situ* state

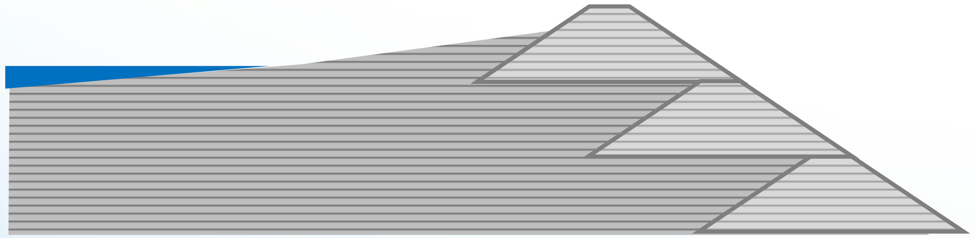
In absence of laboratory test data, liquefaction susceptibility and post-liquefaction shear strength may be estimated based on correlations between liquefaction case histories (notably mainly in natural, uncemented soils) and CPT cone resistance

CPTu Soil Behaviour Type Chart for Defining State

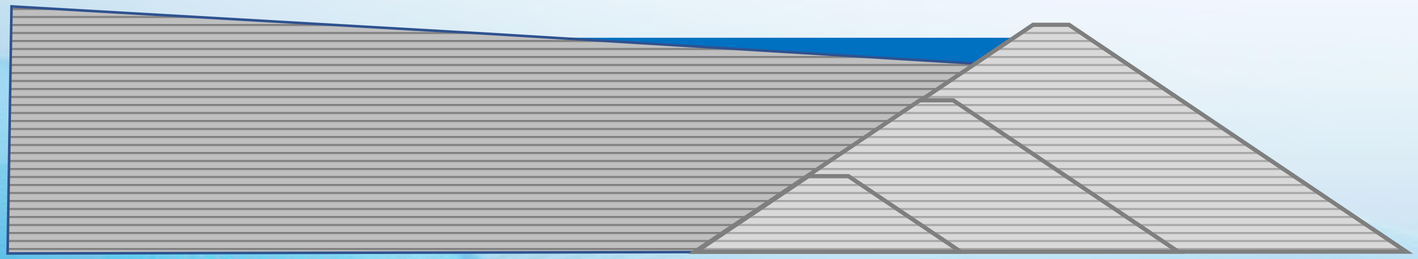


Tailings Dams Susceptible to Liquefaction

Upstream tailings dams founded on potentially liquefiable beached (uncompacted) tailings, and/or constructed using potentially liquefiable tailings, are prone to seismic or static liquefaction if not designed with an adequate FoS for possible loading/unloading conditions



Downstream tailings dams, with tailings discharged towards them, lead to super-elevated tailings, which are susceptible to liquefaction



Upstream Construction – Australia versus Brazil

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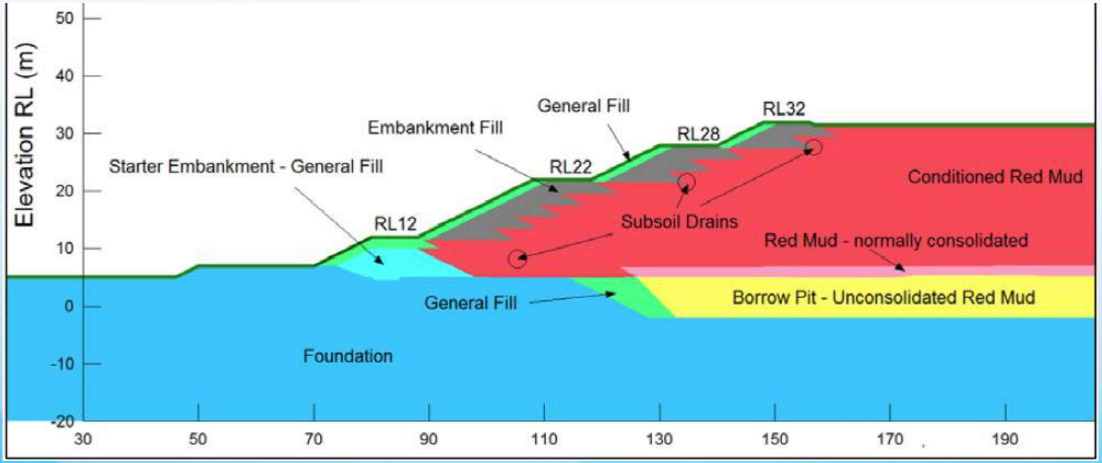
SEMI-ARID AUSTRALIA	HUMID BRAZIL
• Dry climate, with limited inflow to TSF	• Seasonally wet climate, with inflows to TSF
• Minimum FoS = 1.3 to 1.5 for peak strength, 1.0 to 1.2 for seismic	• Minimum FoS = 1.3 to 1.5 for peak (Nov 2017), previously set by designer (> 1.05)
• Rate of rise < 1-2 m/year	• Rate of rise can be order of magnitude higher
• Deposition in thin layers and cycled to facilitate consolidation and desiccation	• Deposition can be rapid and in thick layers (<< desiccation)
• Possible to avoid liquefaction-prone tailings foundation	• Potentially liquefiable tailings foundation
• Possible to have a wide wall raise on an adequate foundation	• Typically a narrow wall raise possibly on a wet foundation (marginal stability)

Typical Upstream Construction in Australia



Typical Upstream Construction in Brazil

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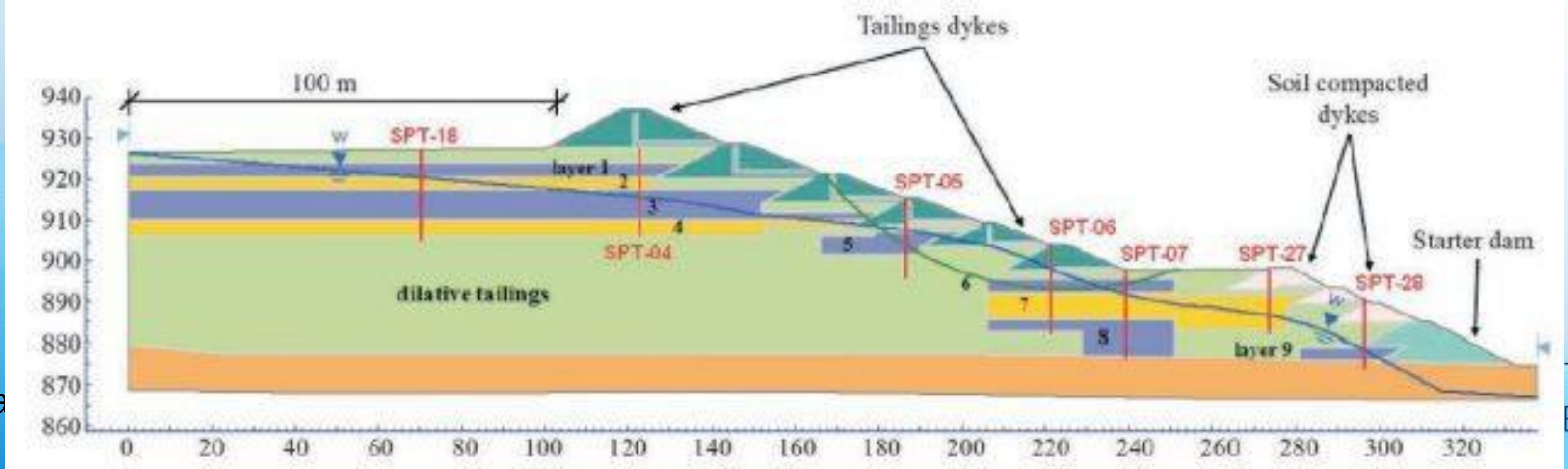

Relative Peak, Post-Liquefaction & Flow Shear Strengths of Tailings

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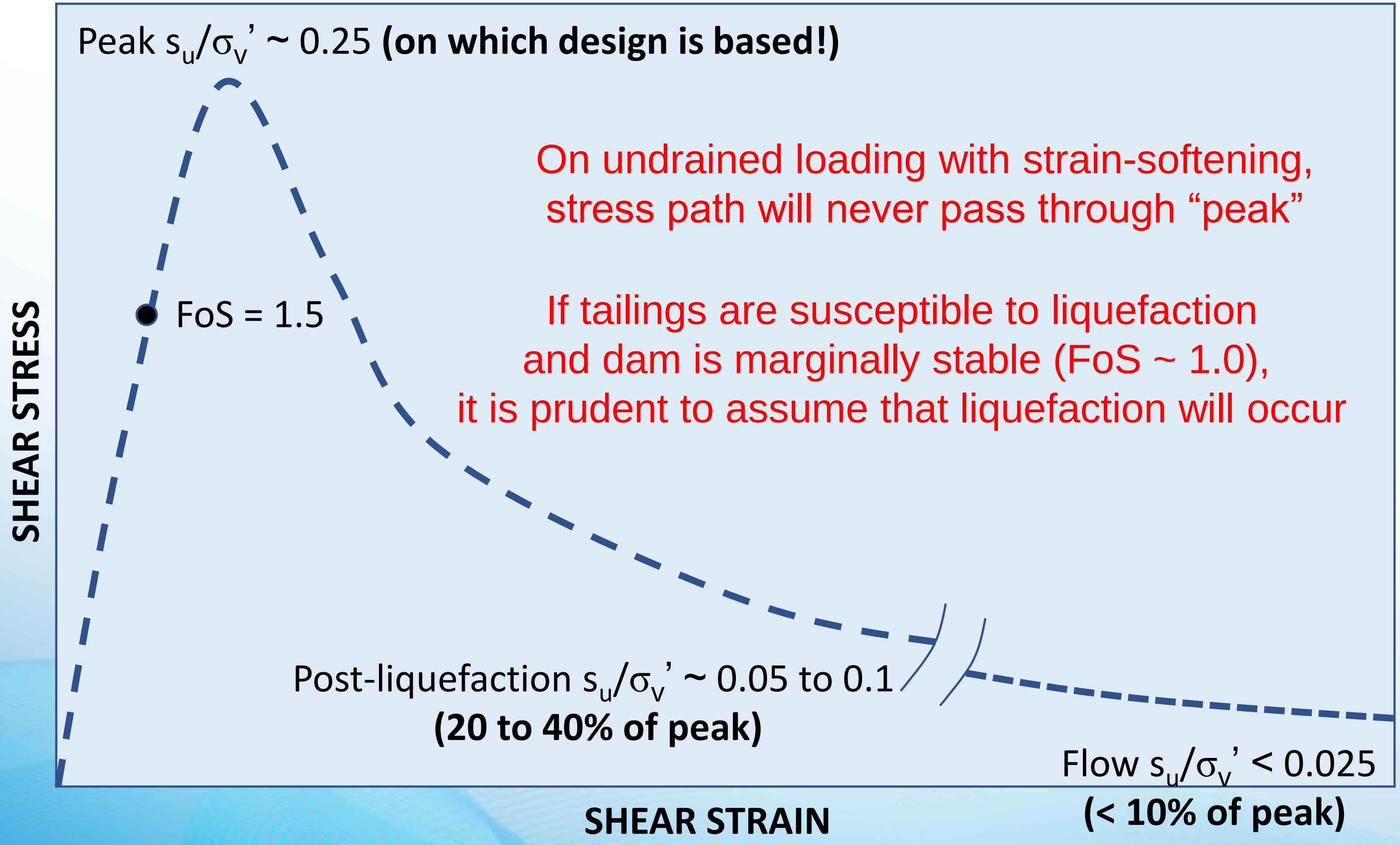
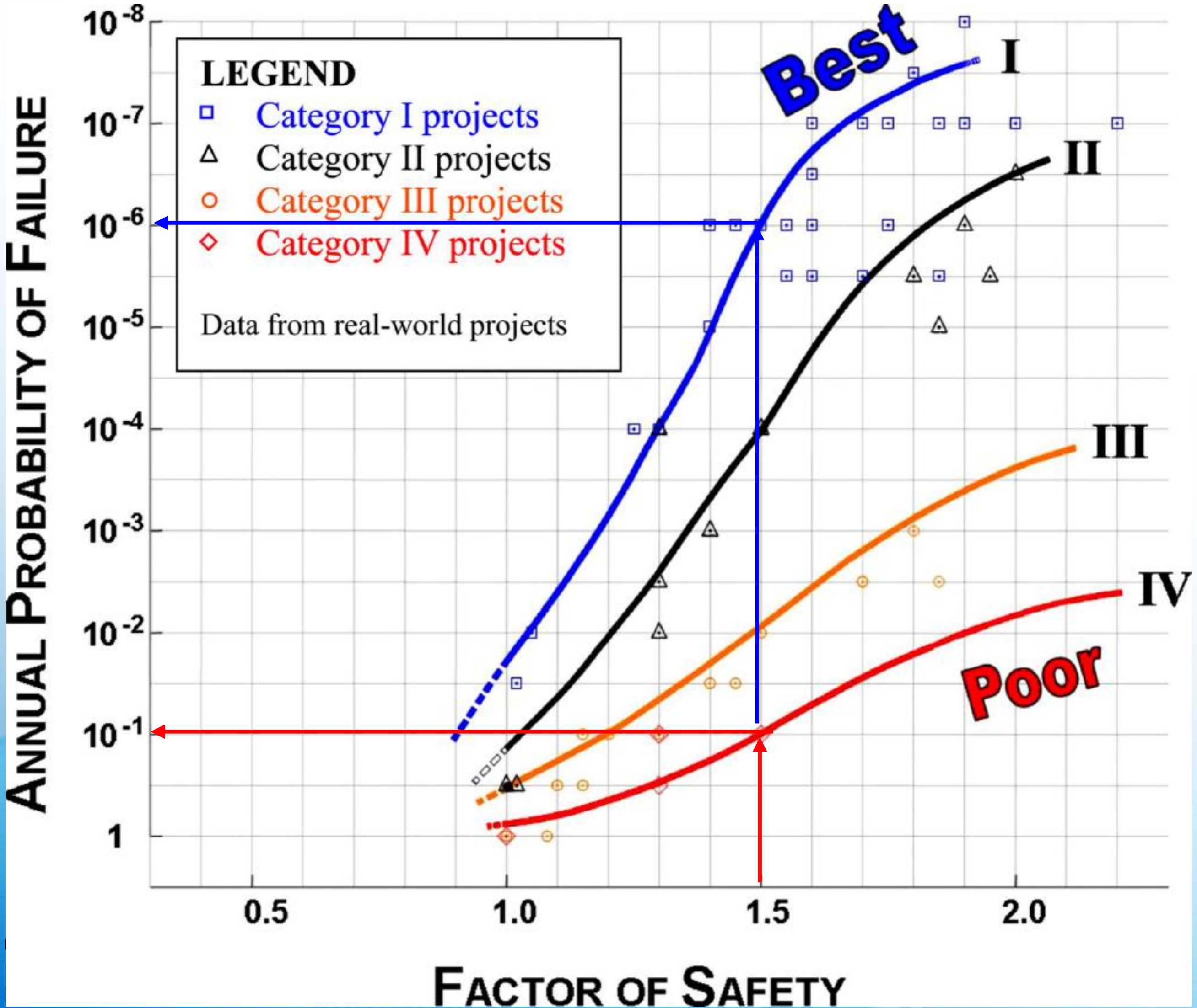


Commentary on Geotechnical Design Parameters

PARAMETER	TYPICAL RANGE
Angle of repose of waste rock	37± 3° (depending on weathering and durability)
Annual Rainfall	± 50% of average annual rainfall
Design peak ground acceleration	Perhaps ± 20% for operations to ± 50% for closure?
Undrained cohesion	± 50%
Undrained shear strength ratios: Peak Residual	 0.25 0.05 to 0.10, or lower
Drained cohesion	Often assumed = 0, but suction on desiccation will induce some apparent cohesion
Drained friction angle	± 3° (~ 6° higher than angle of repose, implying a Factor of Safety = 1.24)
Unit weight	± 10% (typically has little impact)

What are error bars on calculated Factor of Safety? – Certainly >> 1 decimal place!

Annual P_f versus FoS (Silva, Lambe and Marr, 2008)



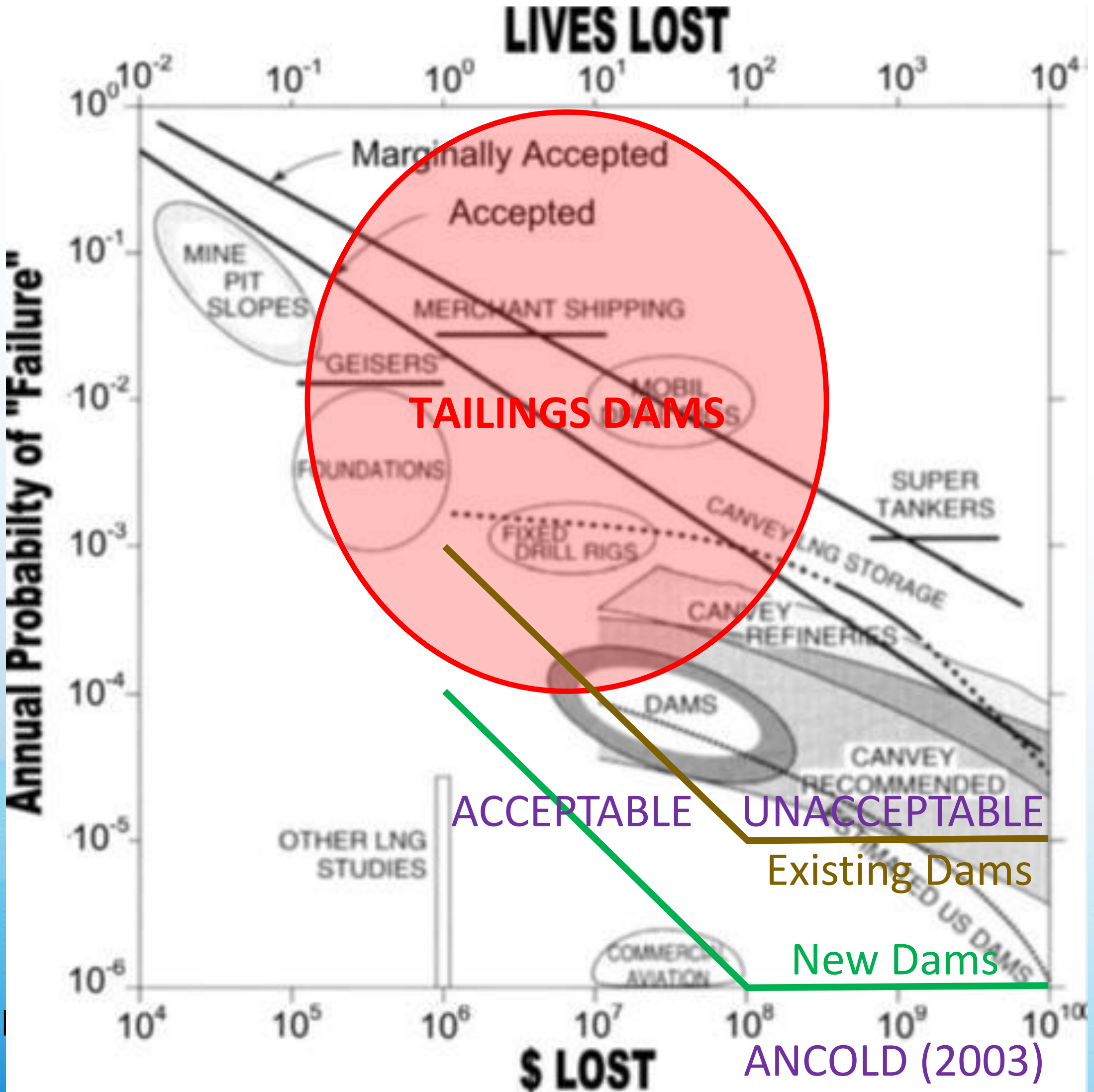
Design and Construction

Design and Construction

Way Forward

- Risk assessments are common-place – Including static liquefaction is difficult
- Defining what is an ***“acceptable”*** risk level is difficult
- Ongoing rate of tailings dam failures is ***unacceptable*** (100 x that of water dams!)
- Approaches to tailings management need to improve
- Tailings minimisation and dewatering need to be pursued
- Design, construction, operation and closure of TSFs need greater reliability and resilience
- Monitoring and interpretation of tailings dams needs to be more comprehensive, and in real-time, linked to triggers:
  - Green, for safe operation
  - Amber, requiring assessment by a Geotechnical Engineer
  - Red, initiating Emergency Response Plan

Acceptability of Tailings Dam Risk? (After Silva, Lambe and Marr, 2008)



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Emerging Tailings Dam Surveillance Methods

METHOD	COMMENTS
• Drone surveillance	• Aiding visual inspection and LiDAR surveys
• Nested Vibrating Wire Piezometers	• Recording and analysing phreatic surface and hydraulic gradient in real-time
• V-notch weirs for monitoring flows	• Recording and analysing flows in real-time
• Settlement monuments and inclinometers	• For correlation with Radar and InSAR – Must be high resolution
• LiDAR (above water) and bathymetry (below water)	• For density estimation, and evaporation estimation
• Ground Radar	• Potential “noise” issues due to short wavelength, rapid scanning, and lack of visible targets
• Satellite Radar (InSAR)	• Fortnightly/weekly fly-over for line-of-sight deformations (potentially to $\pm$3 mm/year), wet spots and vegetation
• Environmental monitoring	• For water quantity and quality
• Optical fibres and future “Smart” geofabrics	• In tailings beach, or under upstream raises

Radar Frequencies (Source: GroundProbe)

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PARAMETER/BAND	L-BAND	S-BAND	C-BAND	X-BAND	Ku-BAND
FREQUENCY (GHz)	1-2	2-4	4-8	8-12	12-18
WAVELENGTH (cm)	30-15	15-7.5	7.5-3.75	3.75-2.5	2.5-1.67
COMMON USES	Radio/Mobile communications	Airport surveillance	Satellite communications	Wireless communications	Microwaves, affected by moisture
InSAR; e.g.	JERS ALOS PALSAR ALOS2		ESA Sentinel RADARSAT1/2	TerraSAR-XCOSMO-SkyMed	
	Not much used for InSAR		Long-term, large area deformation		
GROUND-BASED				GBRAR (Real)	GBSAR (Synthetic)
				Rapid, targeted scanning; e.g., of pits Application to tailings dams affected by moisture, vegetation and rapid scanning	

Monitoring to Provide Adequate Stability and Warning of Failure

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Above all, design, operate and close a tailings dam ensuring an adequate FoS against geotechnical failure

- Avoid, where possible, people at risk downstream of a tailings dam
- Aim to provide at least 24 hours warning to evacuate any people downstream of a tailings dam
- Install redundant monitoring systems, recorded and analysed in real-time, and linked to triggers and responses, including:
  - Daily inspections for wet spots, cracking, deformation, etc., aided by drones
  - Phreatic surface and hydraulic gradient – Nested VW Piezometers confirmed by regular CPTu
  - Deformation – Combination of automated total station prisms, inclinometers, Radar (long wavelength), and InSAR
  - Flows and water quality monitoring – Automated V-notch weirs and sampling

Innovations in Tailings Management To Reduce Liquefaction Risk

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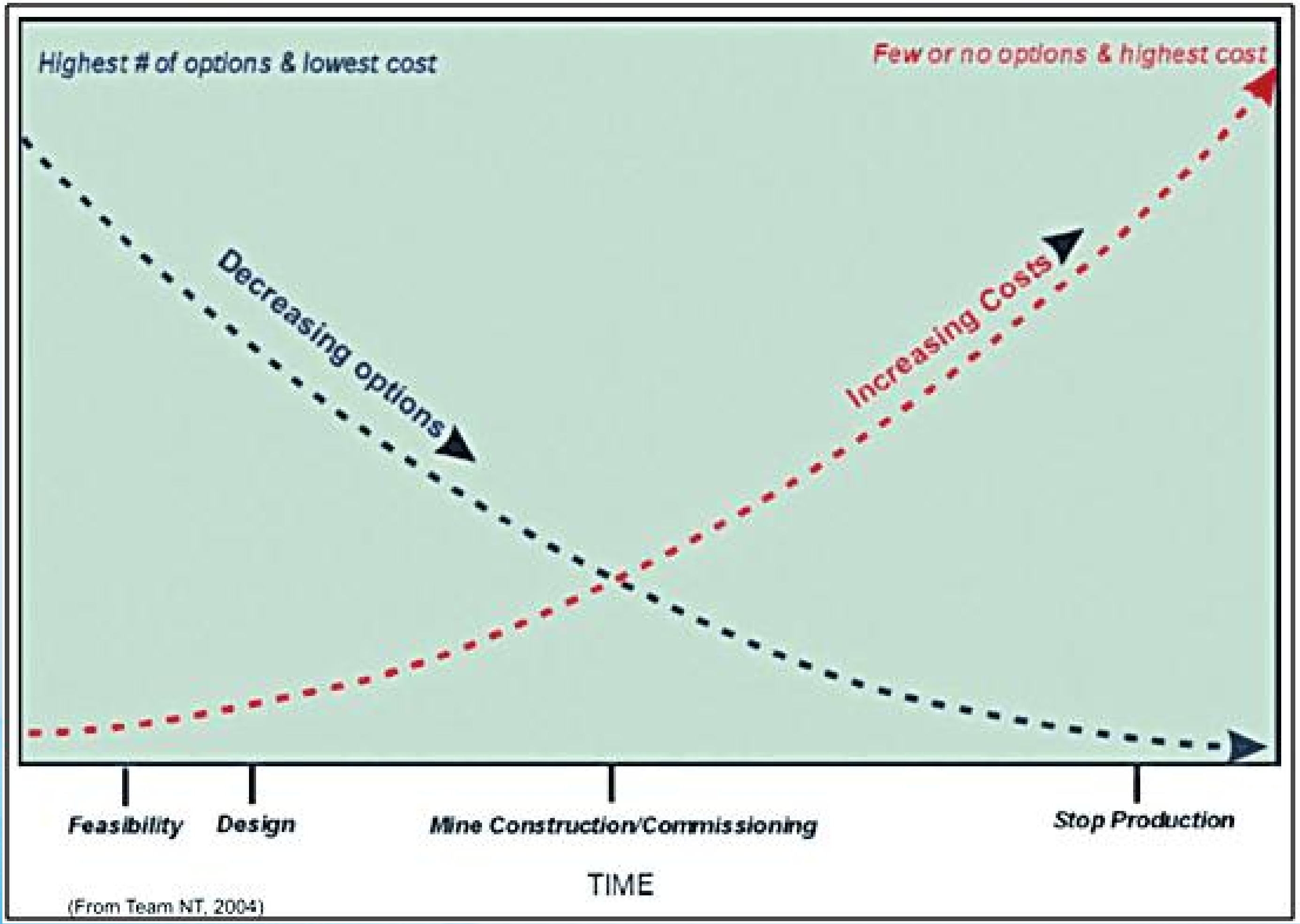
- Thickening, paste disposal and dry stacking of filtered tailings (e.g., La Coipa)
- "Co-disposal" of tailings and coarse-grained wastes; e.g., pumped co-disposal of coal washery wastes in Australian Eastern Coalfields from 1990s – Poorly-applied
- In-pit disposal; provided that resource is not lost
- Integrated Waste Landforms; e.g., Kidston in-pit, Fortescue, and proposed for numerous new projects
- "Paste rock", patented by Golder Associates, has been trialled in Canada for mine waste covers
- "GeoWaste", patented by Goldcorp, incorporates filtered tailings and screened or crushed waste rock

Limited take-up due to perceived costs

Barriers to Implementation of Leading /Innovative Tailings Management

- NPV Accounting and use of a High Discount Factor (6 to 10%; 3 to 5 times CPI), which favours tailings management options that are cheap (particularly CapEx) in short-term, and delayed expenditure, which in turn are likely to exacerbate impacts and blow-out rehabilitation costs
- Perceived high costs, supported by NPV accounting, of alternative tailings management options, such as mechanical dewatering and co-disposal
- Perceived and real technical difficulties (e.g., high clay mineral content, and handling coarse-grained wastes) of mechanical dewatering and co-disposal
- Resistance to do other than what we have always done
- Uncertainty of new approaches

Options Decrease and Costs Increase with Time (GARD, 2009)



This is somewhat counter to NPV Accounting with a high Discount Factor (6 to 10%)

Geotechnical Closure Risks and Challenges for TSFs

- Dam geotechnical instability – Tailings are expected to drain down on cessation of deposition, but may be recharged by high rainfall (in absence of a spillway)
- Dam erosional instability, particularly in a dry climate if slope is flattened and topsoiled
- Differential settlement, affecting slope profile and drainage
- Poor water quality (saline, and/or acidic, or alkaline), after a lag:
  - Ponded water, and runoff leading to ponding below dump
  - Emergence of seepage at low points around toe
  - Infiltration to any groundwater resource

Few TSFs have been successfully rehabilitated, with reprocessing and in-pit disposal being considered – Aim to add value post-closure