What Could Tailings Facility Engineering Look Like in 2030?

Version 5.0

Audience Input QR Code

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What is Tailings Facility Engineering?

Topics/Disciplines

- Tailings milling and processing
- Design of tailings storage facilities
- Closure design
- Geotechnical engineering
- Hydrogeological engineering
- Hydrotechnical engineering
- Geology
- Geochemistry
- Environmental protection
- Construction
- Operations
- Surveillance
- Risk Assessment
- Governance

Technical Inputs

- Engineering and scientific studies
- Field work (drilling, construction)
- Lab analyses (testing and interpretation)
- Modelling (simple to advanced)

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Organizations Supporting Tailings Facility Engineering

CDA ACB

UN environment programme

USSD U.S. National Committee of ICOLD

CIGB ICOLD COMMISSION INTERNATIONALE DES GRANDS BARRAGES INTERNATIONAL COMMISSION ON LARGE DAMS

UNECE

The Mining Association of Canada ADVOCACY STEWARDSHIP COLLABORATION

LANDFORM DESIGN INSTITUTE

ANCOLD

ICMM

CIM ICM Canadian Institute of Mining, Metallurgy and Petroleum

SIMSG ISSMGE International Society for Soil Mechanics and Geotechnical Engineering

SME Society for Mining, Metallurgy & Exploration

Swed COLD

World Mine Tailings Failures

CANBREACH

Universities, technical associations, etc.

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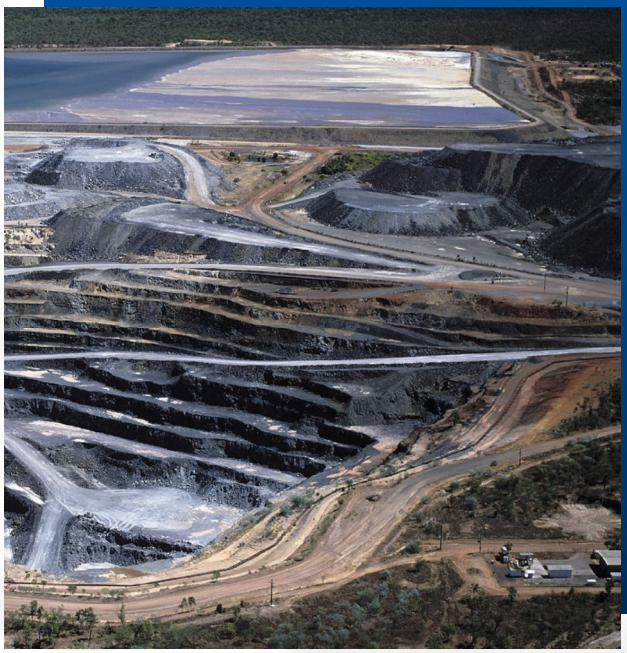
Some Mining Trends

- Grades of ore bodies are reducing
- Leads to more tailings (annual growth of mining/tailings about 3%)
- Leads to bigger tailings facilities and repurposing old facilities
- World-wide registry with over 24,000 TSFs (Rana et al, 2024) (ICOLD, TC L)
- There are insufficient human resources to meet the demand

Is the tailings engineering community matching the pace?



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Why 2030?

- Why not 2040 or 2050?
- "Next 6 years will go by in the blink of an eye"
- Reflect on some of what has happened in the past 6 years
- Start with guidance documents

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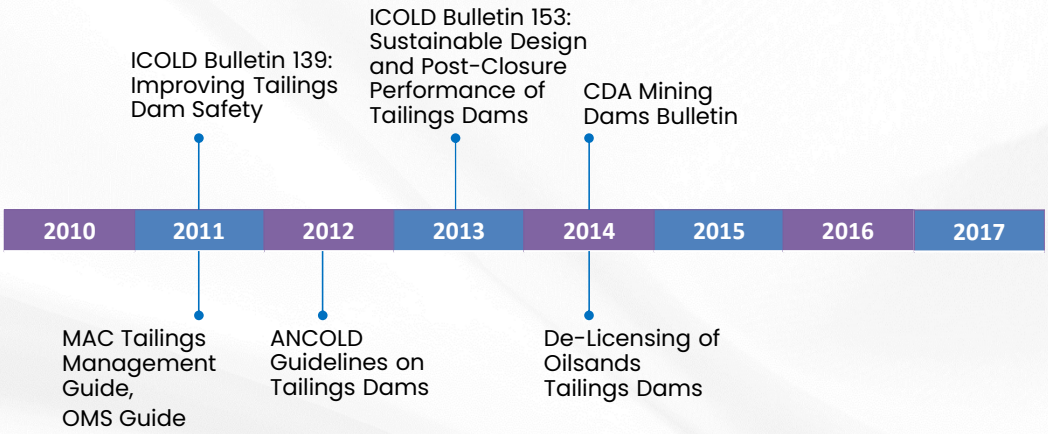
Why 2030? - Guides Supporting Tailings Facility Engineering



ICOLD – International Commission on Large Dams
ANCOLD – Australia National Commission on Large Dams
CDA – Canadian Dam Association
MAC - Mining Association of Canada

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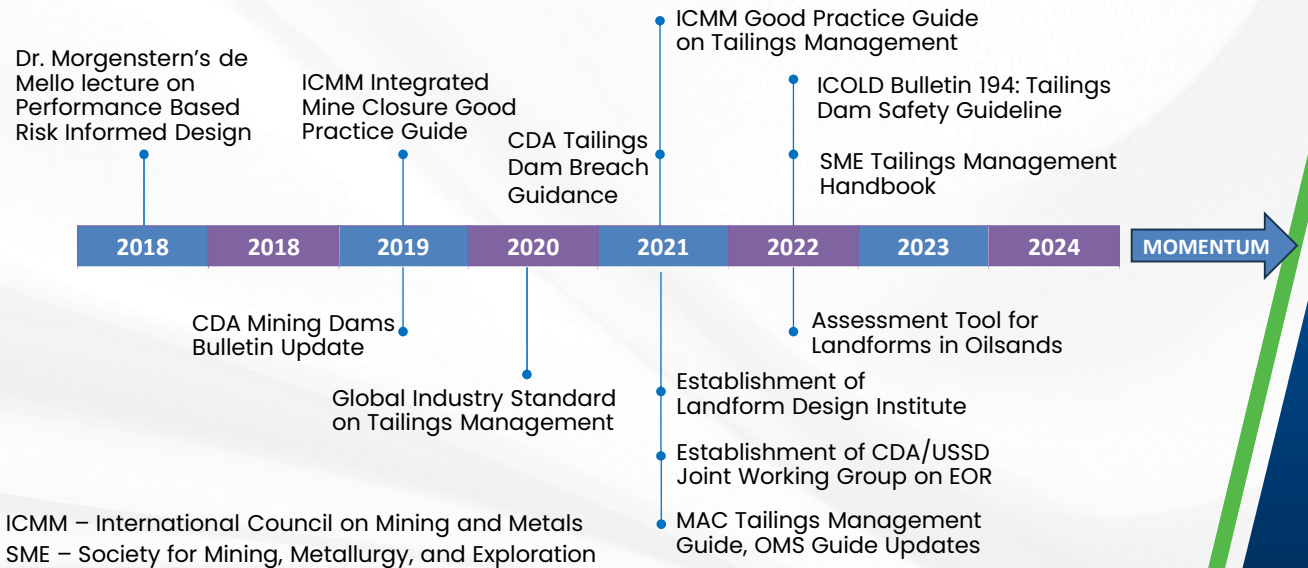
Why 2030? - Guides Supporting Tailings Facility Engineering



ICMM – International Council on Mining and Metals
SME – Society for Mining, Metallurgy, and Exploration
USSD – US Society on Dams

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Why 2030? - Reflection on some examples in the past 6 years

Topic	2018	2024
Engineer of Record	Significant trepidation	Young engineers are viewing this as a viable career path
Surveillance	Some automation	Extensive automation and innovative technologies
Artificial Intelligence	Not prevalent	Playing a bigger role

- Opportunity to maintain the momentum that has been built
- Opportunity for more than "continuous improvement"
- We believe in significant advances in the next 6 years

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Context

Positives

- Many risk reduction initiatives underway
- Moving in a good direction
- Reducing likelihood of catastrophic failures
- Owners and Consultants have created safe environments for young engineers
- Training programs
- Gain in computing power
- Artificial Intelligence
- TSF Registry (>24,000 TSFs catalogued)

Challenges

- Water scarcity
- Investors and insurance companies are paying a great deal of attention
- Significant demand for EORs, RTFEs, ITRBs
- Lack of engineers
- Loss of senior engineers
- Need to attract and retain talent
- Dealing with classic upstream facilities

How do we get ahead of some of these challenges?

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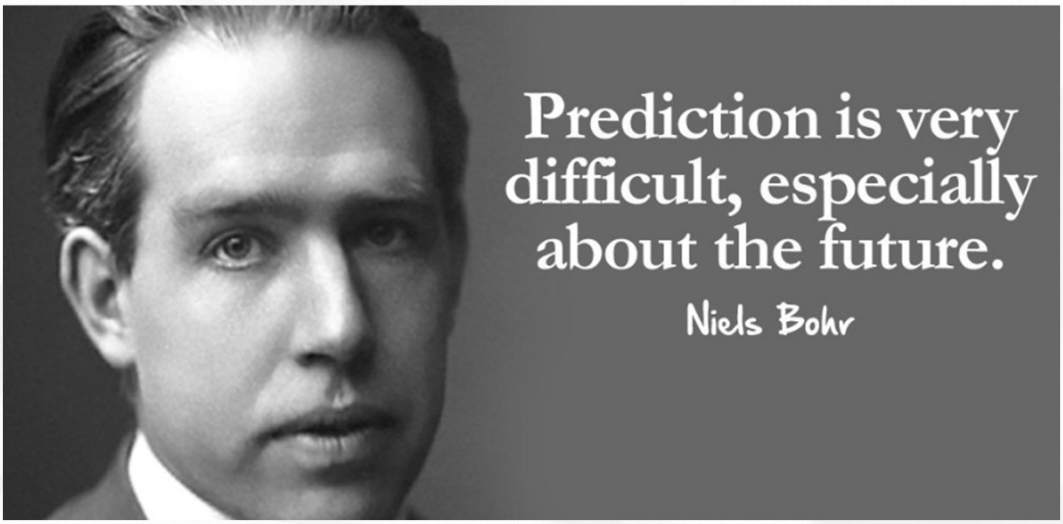
Visioning to 2030



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What Could Tailings Facility Engineering Look Like in 2030?

1. Technical:
   a) Tailings technology and deposition strategies
   b) Closure strategies
   c) Characterization of tailings and foundation soils
   d) Design
   e) Surveillance
2. Competency and Capacity:
   a) Guidance documents
   b) Training and development of Tailings Facility Engineers
   c) Regulatory competency and capacity

Governance is a key item that is also evolving, but beyond our scope

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Intended Audience

- Owners and Operators
- Consultants
- Academia
- Suppliers
- Regulators

- Geotechnical, geological, hydrotechnical, hydrogeological, and civil engineers

- Young engineers who are interested in tailings facility engineering, but would like to know where we are headed

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Papers and Presentations

Version	Forum	Location	Deliverable	Date (2024)	Presenter
1.0	Calgary Geotechnical Society	Calgary	Presentation	May 14	Andy
2.0	Edmonton Geotechnical Society	Edmonton	Presentation	May 16	Andy
3.0	Mining Society of Nova Scotia	Nova Scotia	Presentation	July	Andy
4.0	ICOLD	India	Presentation and paper	September	Annika
5.0	Tailings and Mine Waste	Denver	Presentation and paper	November	Andrew
6.0	International Society of Soil Mechanics and Geotechnical Engineering	Chile	Presentation and paper	November	Andy

- Make presentations and papers available on publicly accessible drive

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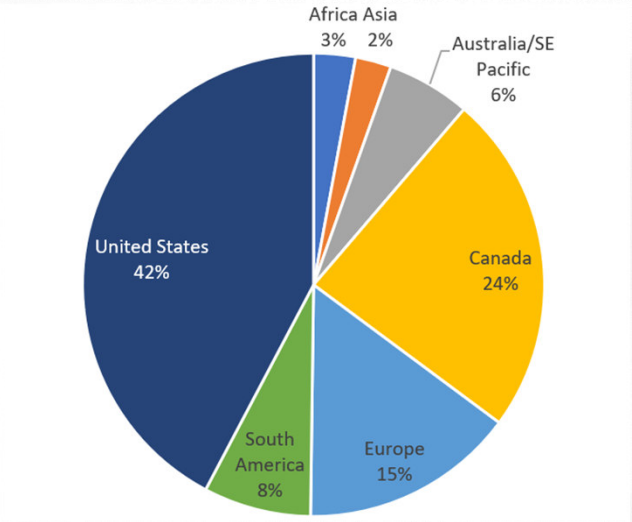
Questionnaire to Colleagues/Leaders

- To support development of the presentations and papers
- Issued to over 240 colleagues around the world
- Over 60 responses
- Lots is happening, this presentation provides some of the highlights



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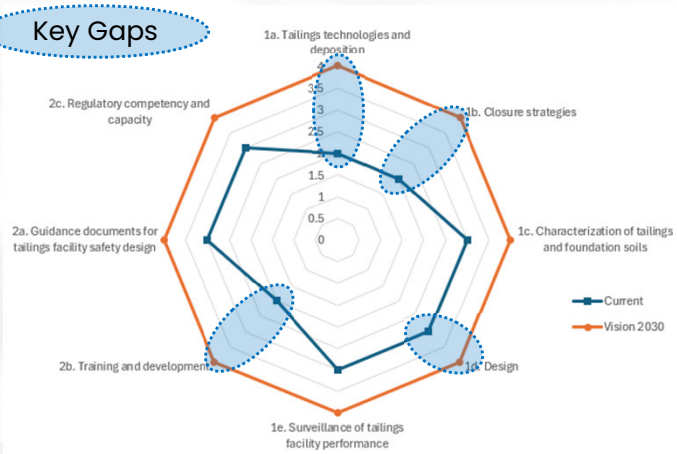
Estimated Situation For Each Topic

Key Gaps



0 = not implemented / used / known

1 = implemented in research / regarded as future (pilot test) / known by few

2 = implemented in a few operations / used in a few places / known by few but regarded as an option

3 = implemented in most operations / used in most places / known by many

4 = implemented in many operations / used in many places / known by most

5 = implemented in "all" operations / best possible use / fully known

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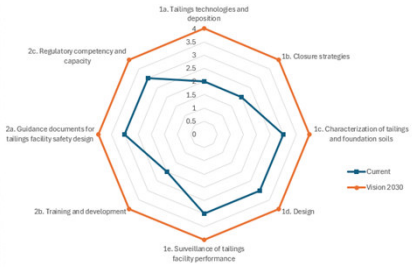

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2b: Training and Development – 2030?

- Establish the discipline of Tailings Management Professional (TMP)
- Tailings management includes the design, construction operation, and closure of systems that are used to produce tailings and the facilities that are constructed to store tailings
- Tailings structures include:
  - Conventional slurry, thickened, paste, filtered tailings stacks, etc.
  - Co-disposal with waste rock
  - Sludge and sediment containment facilities from process, water treatment plants, or runoff.
- TMP positioned to interface with all the "ologies".

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2b: Training and Development - Path Forward

Vision for 2030	Action	Organizations	Role
Tailings Management Professional	Develop scope for this discipline and embrace usage	ICOLD	Lead development, work with ICMM, SME, CDA, ANCOLD, universities, etc.
Decision w.r.t. certification of Tailings Management Professional	Study this issue and land on a decision	ICOLD	Form working group to explore this issue. Work with ICMM, SME, CDA, ANCOLD, universities, etc.
Coordinated training	Develop Tailings Training Portal that reflects available training in the world. Use the Portal to support developing a coordinated training program.	SME	Host for the portal, supported by several organizations
Tailings cohorts in post graduate programs	Develop Masters-level program focused on training engineers to enter the tailings profession	Colorado State University	Lead development of this initiative, supported by other universities

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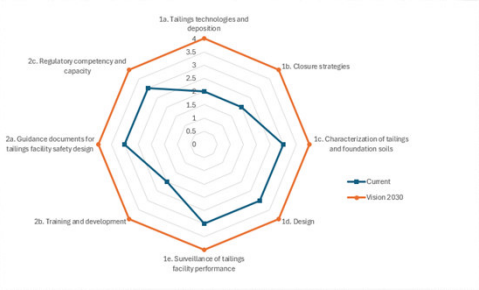

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1a: Tailings Technology – 2030?

- Conventional/slurried tailings:
  - Still will be the majority of tailings systems with focus on centerline and downstream dams
  - No more classical upstream dams being constructed in the world
  - High degree of confidence in slurry tailings facilities
- Filtered tailings will play a larger role
  - Embraced as a companion technology to conventional/slurried tailings

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1a: Tailings Technology - Path Forward

Vision for 2030	Action	Organizations	Role
Guidance on Filtered Tailings	Comprehensive, publicly available guidance document that addresses process and geotechnical aspects, but also, possibly enhanced financial models	Filtered tailings industry	To lead the development of the guidance. Supported by ICOLD and other organizations.
MAA that considers the whole mine, not just the tailings. Includes the mining plan, water restrictions, closure, circular economy.	Work with mining companies and MAC/ICMM to promote this concept. Also, develop financial models that can support better closure decisions.	Lead to be determined	To be determined
Co-disposal of tailings and waste rock more prominent	To develop		
High level of confidence in safety of conventional/ slurried tailings systems	Continue training and development	All	Continue solid engineering

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1b: Closure Strategies – 2030?

- Consensus between all parties of an effective definition of Safe closure/ Responsible closure
- Defined and standardized design criteria for closure, incl. transfer of ownership
- Less water in the tailings and impoundments
- Financial models that benefit good practices
- Long-term monitoring with remote methods and AI
- Established the role of reclamation designer of record (RDR) working in parallel with EOR.

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1b: Closure Strategies – Path Forward

Vision for 2030	Action	Organizations	Role
Tailings Closure Handbook	"Begin with the end in mind". Closure should not be an afterthought. - closure design considerations/ criteria, - safe closure - landform design - governance - relinquishment - cost estimating / bonding"	SME	SME to lead development of handbook. The book editors are engaging with other organizations (e.g., USSD, CDA).
Risk Informed Closure Design	Develop guidance on "safe" or "responsible" closure.	CDA	CDA to lead with input from ICOLD, USSD, SME, ICMM, etc.

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1c: Site Characterization - 2030?

- "*tools are already available today, but the toolbox could be better organized, and the tools sharpened*"
- Use of nuclear magnetic resonance well logging and other in-situ technologies on CPTs for water content estimation
- Ability to estimate in-situ void ratio
- Improved characterization of liquefaction potential and post liquefaction strength
- Initiatives underway by academia, industry, and suppliers

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1d: Design – 2030?

- Performance Based Design for Slope Stability Assessment:
  - PB design integrates advanced computer modelling with actual performance to reduce uncertainty and conservatisms in design
  - From Dr. Morgenstern: "Further recognition of the value of Performance Based Design and significantly greater prominence in its use."
  - Integration of complementary roles of PBD and classical approaches
  - Fully coupled deformation and seepage models
  - Regulatory capacity will still be a limitation to implementation
- Dam breach analysis that can be relied upon.

1d: Design – Path Forward

Vision for 2030	Action	Organizations	Role
Greater use of Performance Based Design	Education, case studies	ICMM, CDA, and industry	ICMM and CDA – training Industry – case studies on PB design
Reduced uncertainty for dam breach analyses	Research to improve models and characterization and enhance guidance	CANBREACH CDA	CANBREACH – research CDA - guidance
No water covers required for geochemistry reasons	Desulphurization of tailings in the mill. Enhanced financial models. MAA for the mine, not just tailings.	MAC or ICMM?	ICOLD will monitor

1e: Surveillance– 2030?

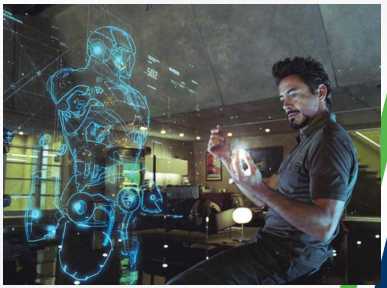
- Increased use of “area” measurements (e.g., InSAR, fibre optics, “Smart” geofabrics, ERT cables, drones, etc.)
- Surveillance programs/systems developed based on risk assessment and failure modes
- Widespread automation with improved user interfaces
- Integration of collected data directly into engineering models
- Data scientists employed to manage the reams of data
- Increased use of AI for data review/screening
- Being implemented by owners and providers

Summary

- This is a fraction of the initiatives that are happening in the world
- Many other good initiatives are underway, pleased to include in our paper
- Let’s maintain the momentum and go beyond just “continuous improvement”!

Yesterday

Today



Tomorrow?

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Questions & Discussion

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