

What Could Tailings Facility Engineering Look Like in 2030? Version 3.0

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Tailings Facility Engineering

- ▶ 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

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

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Future Tailings Production and Storage

- ▶ Mining expected to increase by about 3%/year
- ▶ Grades of ore bodies are reducing
- ▶ Leads to more tailings



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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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Guides Supporting Tailings Facility Engineering

2010	2011	2012	2013	2014	2015	2016	2017
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2011: ICOLD Bulletin 132: Improving Tailings Dam Safety

2012: ANCOLD Guidelines on Tailings Dams

2013: ICOLD Bulletin 153: Sustainable Design and Post-Closure Performance of Tailings Dams

2014: CDA Mining Dams Bulletin

2014: De-Licensing of Oilsands Tailings Dams

MAC: Tailings Management Guides, OMS Guides

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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Guides (cont'd)

2018	2019	2020	2021	2022	2023	2024
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2018: Dr. Morgenstern's DiMello lecture on Performance Based Risk Informed Design

2019: ICMM Integrated Mine Closure Good Practice Guide

2020: Global Industry Standard on Tailings Management

2021: ICMM Good Practice Guide on Tailings Management

2021: CDA Tailings Dam Breach Guidance

2021: Establishment of Landform Design Institute

2021: Establishment of CDA/USSD Joint Working Group on EOR

2021: ICOLD Bulletin 181: Tailings Dam Design, Technology update

2022: Tailings Management Handbook

2022: ICOLD Bulletin 194: Tailings Dam Safety Guideline

2022: Assessment Tool for Landforms in Oilsands

MAC: Tailings Management Guides, OMS Guides,

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Why 2030?

- ▶ Reflect on some of what has happened in the past 6 years:

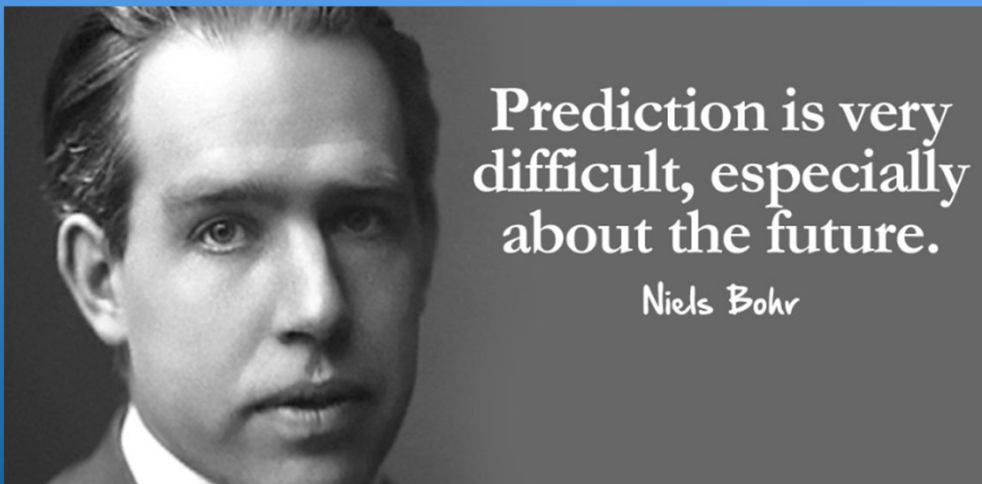
Topic	2018	2024
Engineer of Record	Significant trepidation	Young engineers are viewing this as a viable career path
Surveillance	Some automation	Extensive automation and innovative technologies, remote monitoring centres
Artificial Intelligence	Not prevalent	Playing a bigger role

- ▶ Opportunity to maintain the momentum that has been built
- ▶ Opportunity for more than "continuous improvement"
- ▶ We believe the next 6 years could continue to see significant advancements

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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

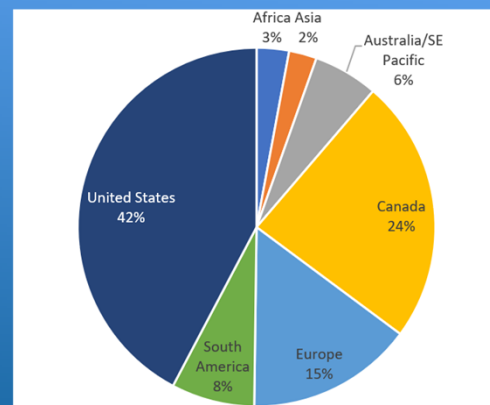
- ▶ Build the presentations with feedback from each session
- ▶ Preparing papers for ICOLD, T&MW, and ISSMGE
- ▶ Make presentations and papers available on One Drive that will be available through ICOLD - after September

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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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What Could Tailings Facility Engineering Look Like in 2030?

1. Technical Items:
 - 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**
 - c) Regulatory competency and capacity

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Part 2b – Training and Development

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2b – Tailings Management Professional

- ▶ Establish the discipline of Tailings Management Professional
- ▶ 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.

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2b – Tailings Management Professional (cont'd)

- ▶ 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

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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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Part 1 - Technical Topics

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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



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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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1a – Tailings Technologies – 2030?

- ▶ Less tailings stored
- ▶ More focus on circular economy approach - value-added products and recovery of strategically important critical minerals

MIT Global Summit on Mine Tailings Innovation

RESEARCH THEMES

- Re-use**
 - What is the economic value of metals and minerals embedded in tailings?
 - What new or existing technologies can be applied to recover these resources?
 - How can tailings be repositioned as raw materials in other industries?
- Re-duce**
 - What technologies or processes can be used to reduce the volume of tailings and associated costs?
 - How could policy and finance incentives help to accelerate significant reductions in volumes of tailings?
- Re-imagine**
 - How might we consider and achieve true circular innovation of tailings?
 - What new knowledge gaps and obstacles do we need to address?

September 19-20, 2024

A first of its kind conference hosted by the Massachusetts Institute of Technology (MIT) in collaboration with ICMM to convene researchers, industry experts, innovators and start-ups, manufacturers, and government and regulatory officials around a single goal: accelerating the development of solutions for Re-use, Re-duce and Re-imagine mine tailings.

With a focus on research that can be rapidly translated to practical applications and technology solutions across any stage of the mining lifecycle, the conference will provide a forum for top global experts to exchange ideas, advance thinking and make progress on significantly reducing tailings that will ultimately benefit people and the planet.

SUSTAINABLE MANAGEMENT OF MINING WASTE AND TAILINGS
A Circular Economy Approach

EDITED BY ALOK PRASAD DAS, ERIC D. VAN HULLEBUSCH, AND ATA AKÇIL

CRC Press
Taylor & Francis Group

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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 – Path Forward

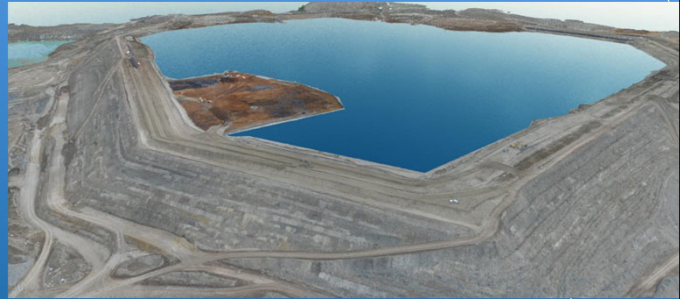
Vision for 2030	Action	Organizations	Role
Tailings Closure Handbook	"Begin with the end in mind. Closure should not be an afterthought. - closure design considerations/ criteria, - safe closure - landform design - governance - relinquishment - cost estimating / bonding"	SME	SME to lead development of 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 – Char. of Tailings and Foundation Soils – 2030?

- ▶ 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 conservatism 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.

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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

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Part 2 – Competency and Capacity

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2a – Guidance Documents

- ▶ Some said: “We have enough guidance documents, use what we have!”
- ▶ Guidelines in review/being updated:
 - ▶ MAC
 - ▶ CDA
 - ▶ USSD (FEMA)
 - ▶ CDA/USSD EOR
 - ▶ ICOLD Bulletin 194
 - ▶ Others

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2a – Guidance – Path Forward

Vision for 2030		Organizations	Role
Preferred definition of Credible Failure Modes	Objective guidance on thresholds for physical possibility and negligibility	CDA	Lead development of guidance, supported by other organizations
Landform Design Guidance	Develop comprehensive guidance for landform design	LDI	Lead development of guidance with support from other organizations
ICOLD Bulletin 194 Version X	Additional guidance on hydrogeology and hydrology, undrained stability analyses, brittleness stability, spillways, characterization	ICOLD	Lead preparation of guidance with input from other organizations

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Summary

- ▶ 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"!

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Being a Tailings Management Professional is and will be very interesting!



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End of Presentation

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