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Tailings Closure:

Planning, Implementation and Lessons Learned

5-8pm

6 Feb 20

Treasury Casino, Brisbane

FREE ENTRY

REGISTER NOW AT

thequeenslandtailingsgroup@gmail.com

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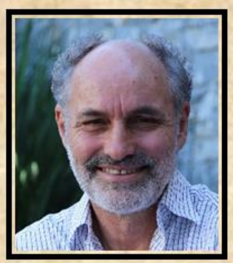
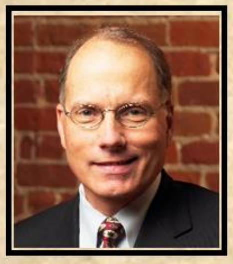


Prof David Williams
UQ



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Tailings Closure: Planning, Implementation and Lessons Learned

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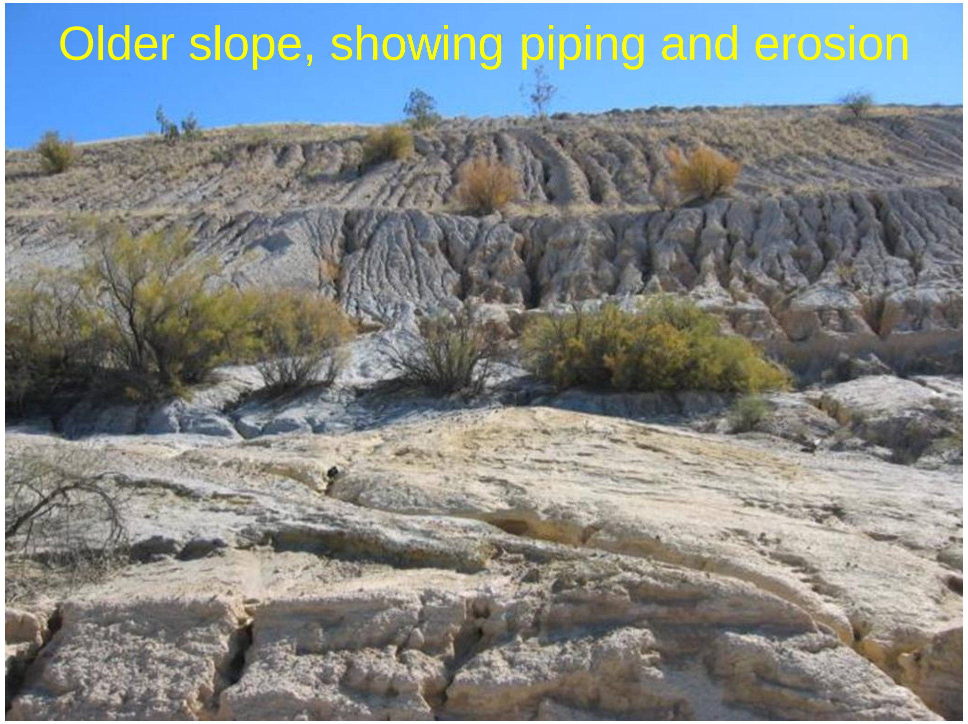
6 February 2020

Tailings Dams Rehabilitation and Closure at San Manuel, Arizona, USA

San Manuel Tailings Dams During Operation – Early 1970s

Unrehabilitated, (Cycloned) Coarse-Grained Tailings Slope



Observations of Tailings and Natural Slope Performance

- San Manuel's outer tailings slopes in Arizona's arid climate showed them to be prone to piping erosion

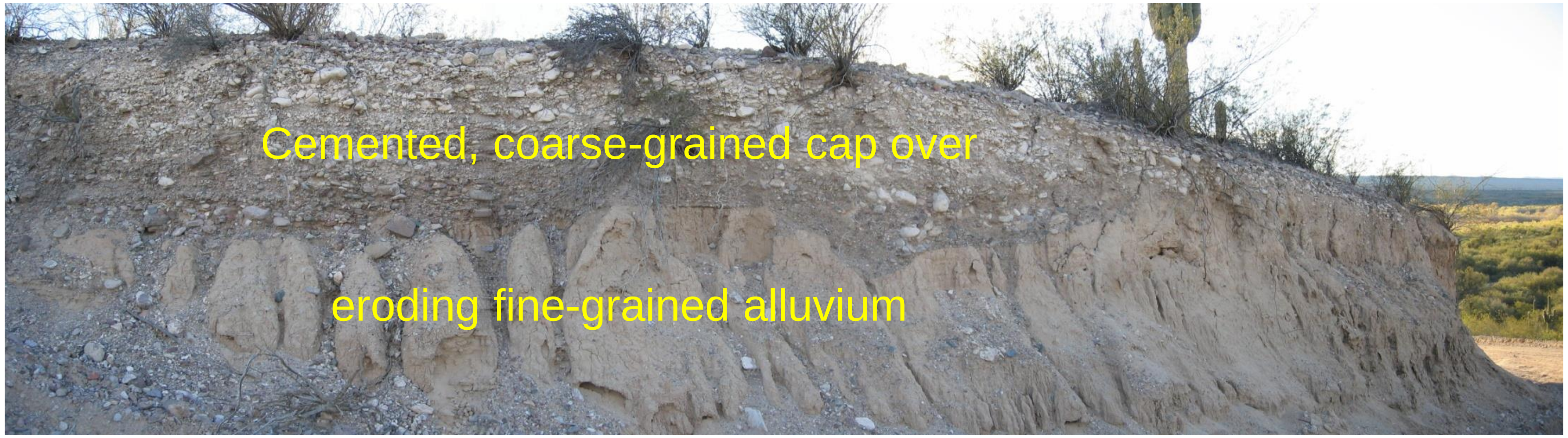
- Covers of natural fine and coarse-grained alluvium showed that alluvium suffered a washout of fines and sand during storms, leading to eventual loss of cover and piping erosion of exposed tailings

- Unless they are cemented or overlain by a dense, coarse-grained cap, natural alluvial slopes are also prone to erosion by storms

Gully Development in Tailings Outer Slopes

- Outer slopes of San Manuel tailings storages show gullying developed from tunnel erosion of tailings, which appears to follow sequence:
  - Initiation and development of tunnel erosion in tailings
  - Emergence of erosion tunnels downslope
  - Collapse of tunnels leading to gullies
  - Progression of gullies, ultimately extending over full slope height

Performance of Natural Alluvium Landforms



Preliminary Closure Design for Tailings Outer Slopes

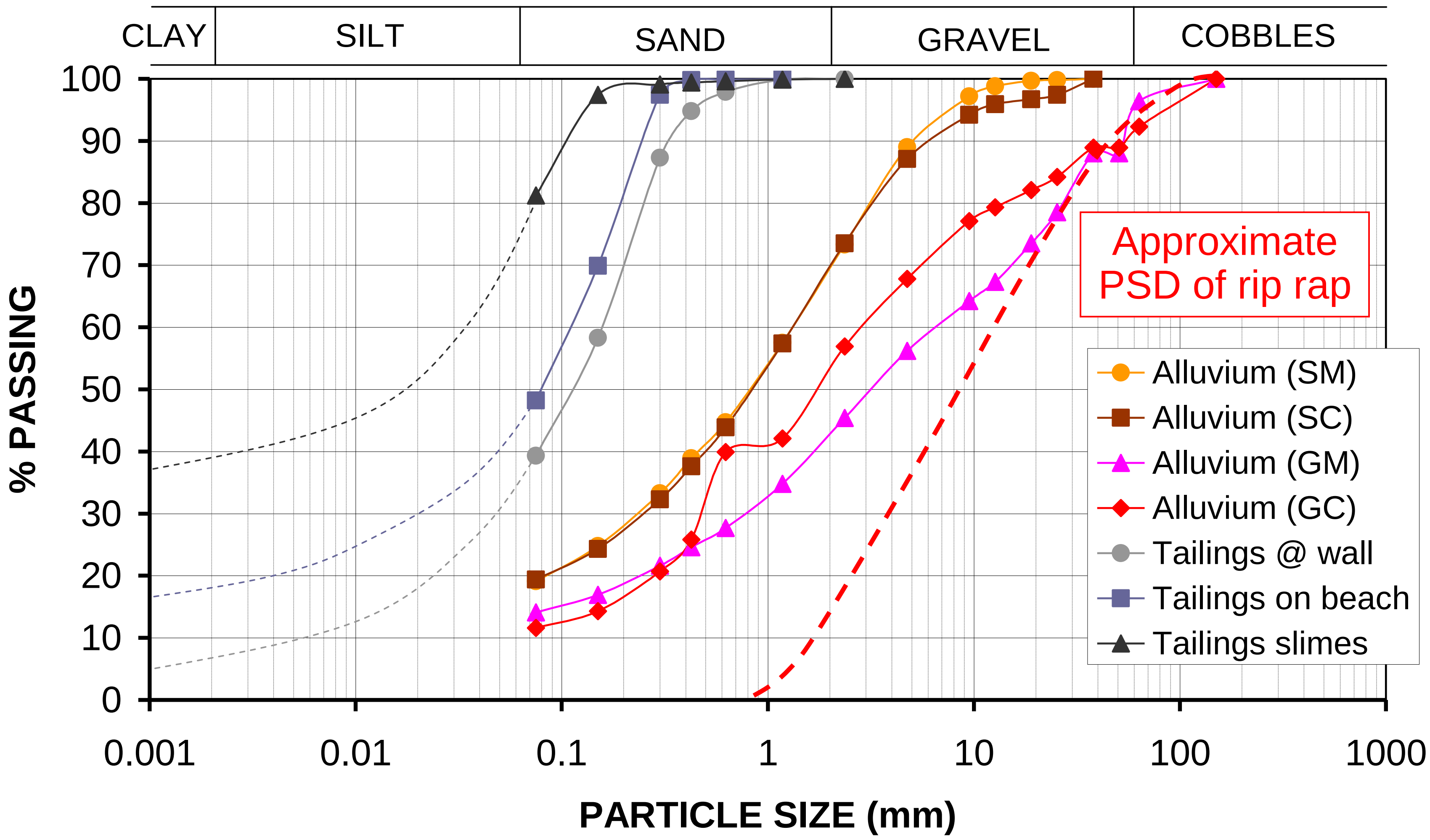
- Overall slopes of 3(H):1(V), up to 90 m high
- Removal of upper benches that pond rainfall runoff
- Rip-rapped drainage benches at 45 m intervals, over 0.3 m of fine-grained alluvium (30% of slope)
- Rock-lined downslope drains at 300 m intervals
- Cover over tailings between drainage benches comprising 0.3 m of coarse-grained alluvium over 0.3 m of fine-grained alluvium (70% of slope)
- Reliance on revegetation of cover for some protection against surface erosion

Potential Problems with Preliminary Closure Design

- Coarse-grained alluvium cover between drainage benches would promote only poor revegetation, and would be prone to rilling erosion, with the potential for concentrated infiltration into the underlying tailings, leading to piping erosion
- Drainage benches and downslope drains would concentrate runoff and would also be susceptible to undercutting
- Also, drainage benches would be prone to silting up and differential settlement, which would lead to ponding of water, and/or overtopping

Performance of Revegetated Alluvium Cover Over Time

Particle Size Distributions for Tailings and Alluvium



Erosion Trials

Coarse-grained alluvium – showing extensive wash-out

Rip rap – showing negligible erosion

Original versus Revised Rehabilitation

ORIGINAL PROPOSAL

- Rip-rapped benches @ 45 m, over 0.3 m of fine-grained alluvium (30%)
- Rock-lined downslope drains @ 300 m intervals
- Cover between benches 0.3 m coarse-grained alluvium over 0.3 m fine-grained alluvium (70%)
- Reliance on revegetation for erosion protection

REVISED PROPOSAL

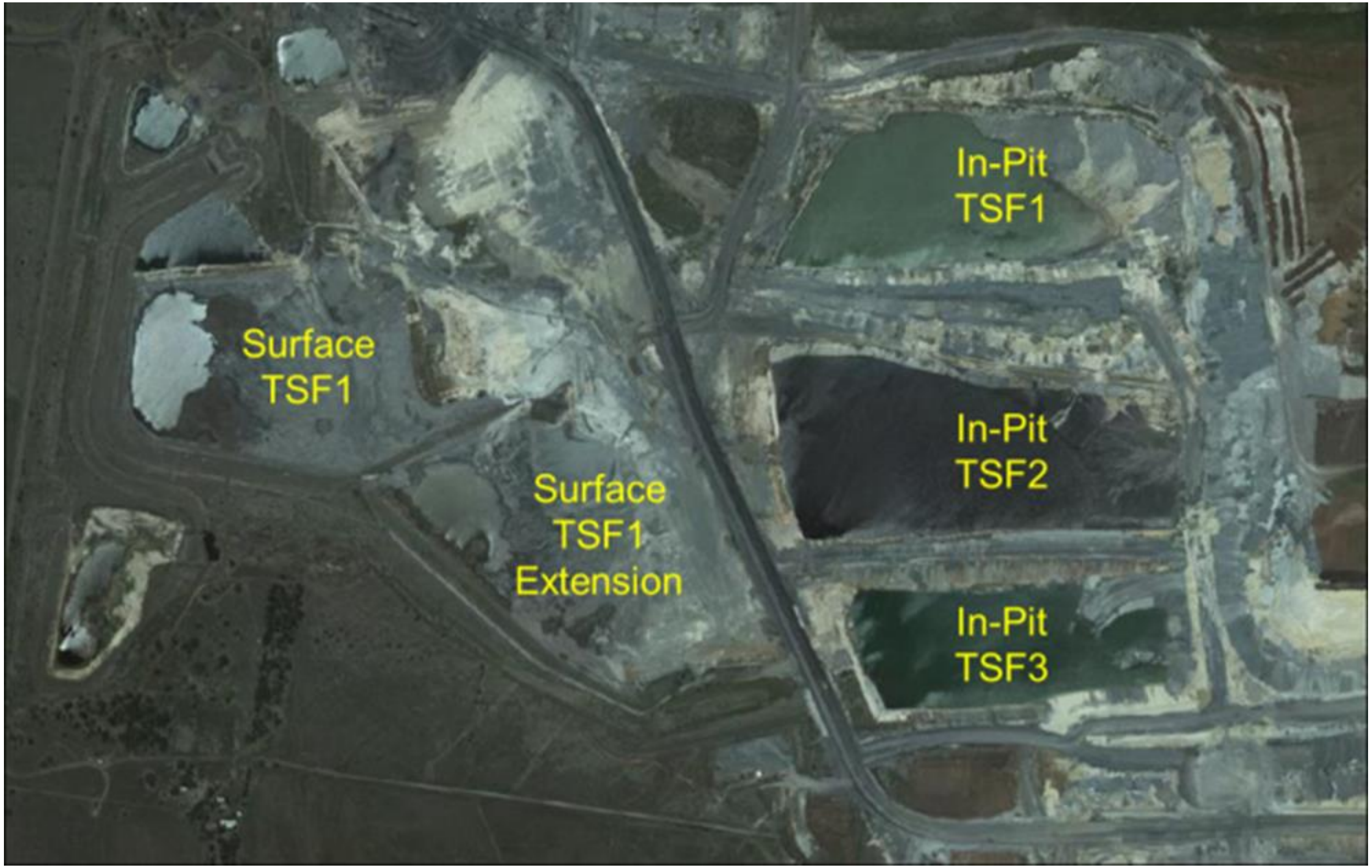
- Continuous 3:1 slope
- 0.3 m fine-grained alluvium over entire slope
- 230 mm of rip rap erosion protection over lower 2/3
- No drainage benches or downslope drains, and no reliance on reveg. of rip rap
- 0.3 m of coarse-grained alluvium over upper 1/3

Successful Rip Rap Rehab. of 100 m High, Benign TSF Slope

Rock Cover on Tailings – San Manuel, Arizona, USA

Capping Surface and In-Pit Tailings at New Acland Coal Mine, South-East Queensland

New Acland TSFs – March 2013



Overview of Surface Tailings Storage Facility

- A completed, conventional, surface slurried coal tailings storage facility required capping to facilitate rehabilitation for grazing purposes
- Pushing coarse reject (waste) by D6 Swamp Dozer was selected to facilitate initial capping

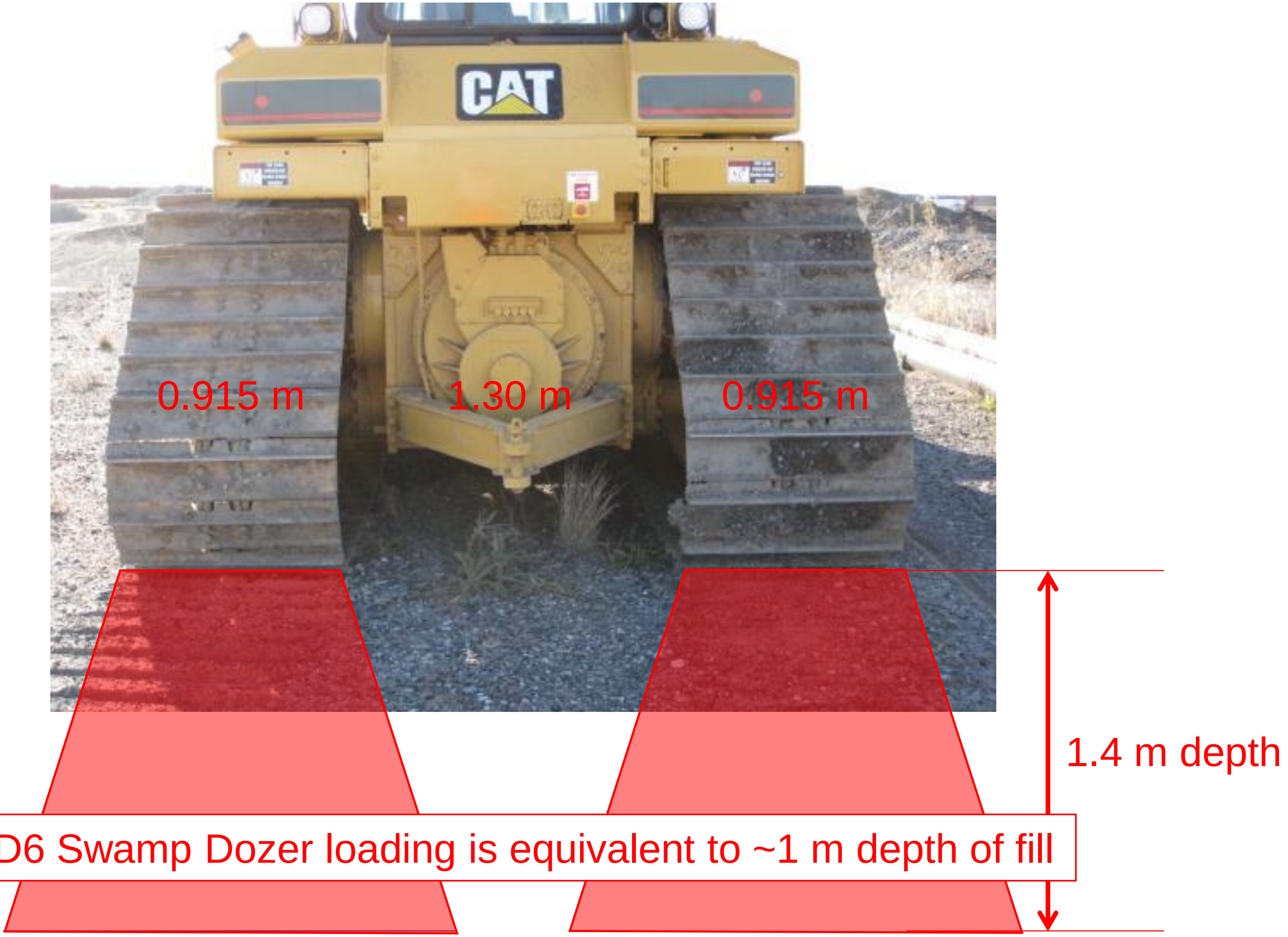
Imagine you're sitting on the dozer, with a bow wave forming ahead of you and a tension crack behind – What do you do?

Selection of Capping Method

- Coarse reject was proposed as capping material, being better-draining than spoil, which degrades rapidly
- Overall cover was to comprise an initial ~1 m capping layer of coarse reject, followed by a second 2 to 3 m thick layer of coarse reject and/or spoil, and finally a topsoil layer that was to be seeded and fertilised
- Possible capping methods:
  - Place coarse reject hydraulically, which was dismissed due to infrastructure required
  - Place coarse reject by a Rockslinger, which was trialled and found to have insufficient reach
  - Push coarse reject by D6 Swamp Dozer, which was adopted (D6 Swamp Dozer exerts an average track bearing pressure of 35 kPa, equivalent to ~1 m height of fill)

Rockslinger versus D6 Swamp Dozer Push

D6 Swamp Dozer – Dispersion of Bearing Pressure



D6 Swamp Dozer loading is equivalent to ~1 m depth of fill

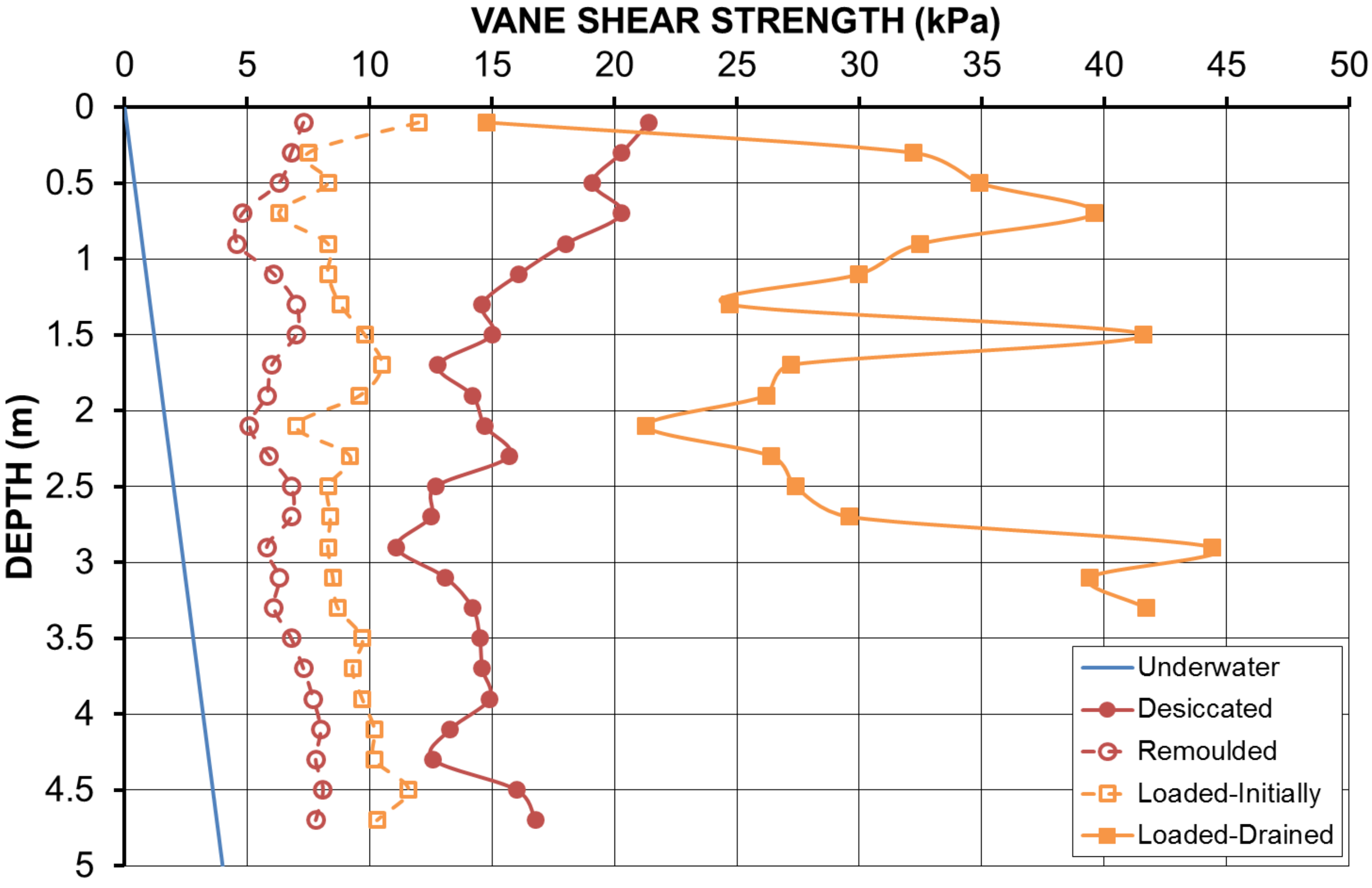
Surface TSF in August 2009 – Uncontrolled Capping

Adopted Methodology for Capping Surface TSF

- Status of TSF:
  - Facility had been closed for some years and upper tailings beach was well-desiccated, while residual ponds covered low areas with extent of ponding varying with rainfall
- Steps:
  - Tailings were tested using field shear vane, results of which were used to assess safe trafficking of dozer and placement of initial capping layer:
    - Peak representing small-strain loading
    - Remoulded representing ‘bow-waving’
  - An initial 1 m deep capping layer of coarse reject was placed by D6 Swamp Dozer, commencing from strongest, elevated tailings beach
  - Further vane shear testing was carried out to assess strength gain ahead of toe and beneath initial capping
  - Initial capping was advance to remnant ponds
  - Secondary capping was advanced using a D9 Dozer

Surface TSF in March 2014 – Controlled Capping

Assessing Shear Strength of Tailings Using a Vane



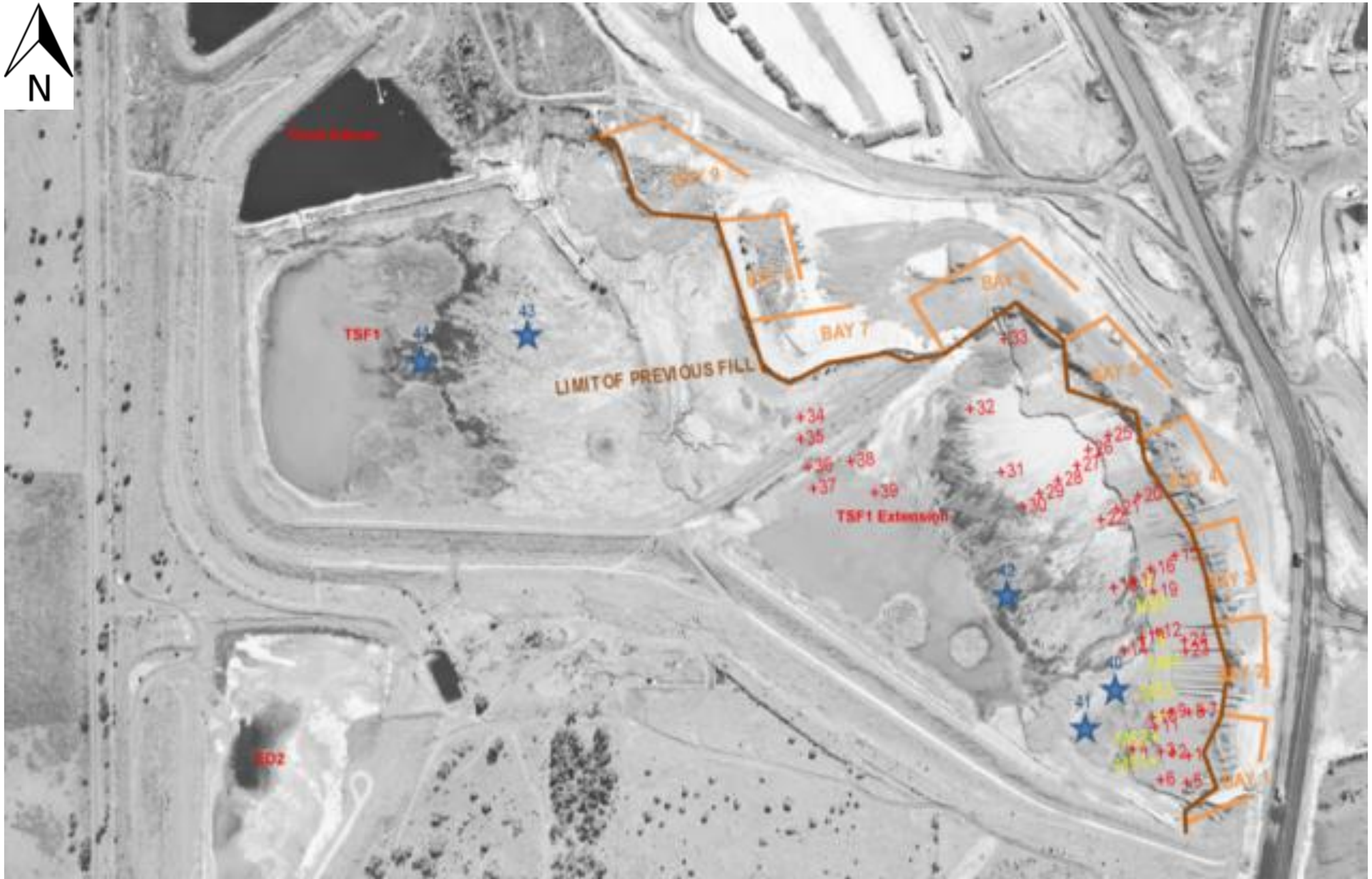
Vane Shear Testing of Crusted Tailings

Crest of old bow wave

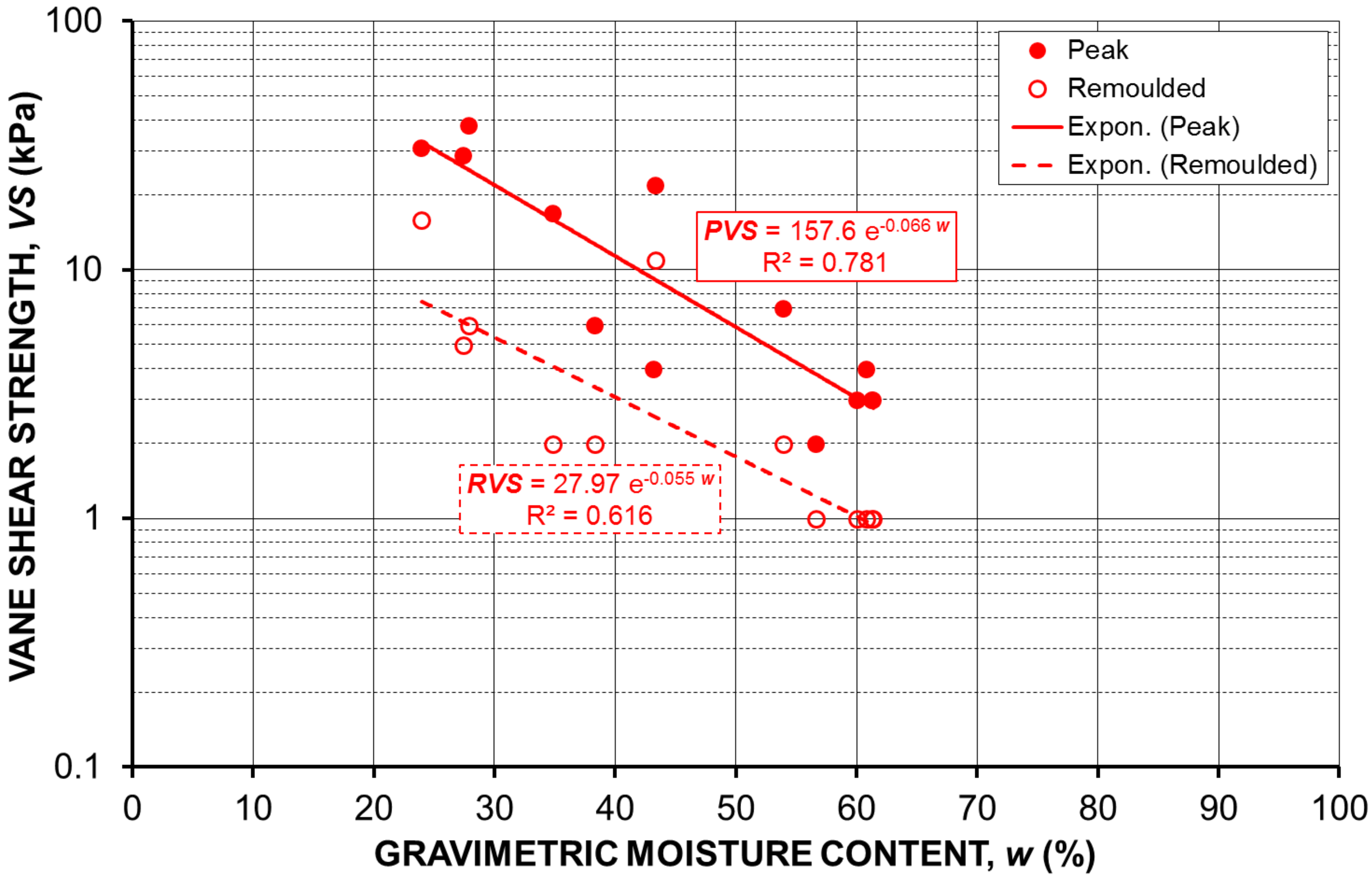
Southern reeds

Northern reeds

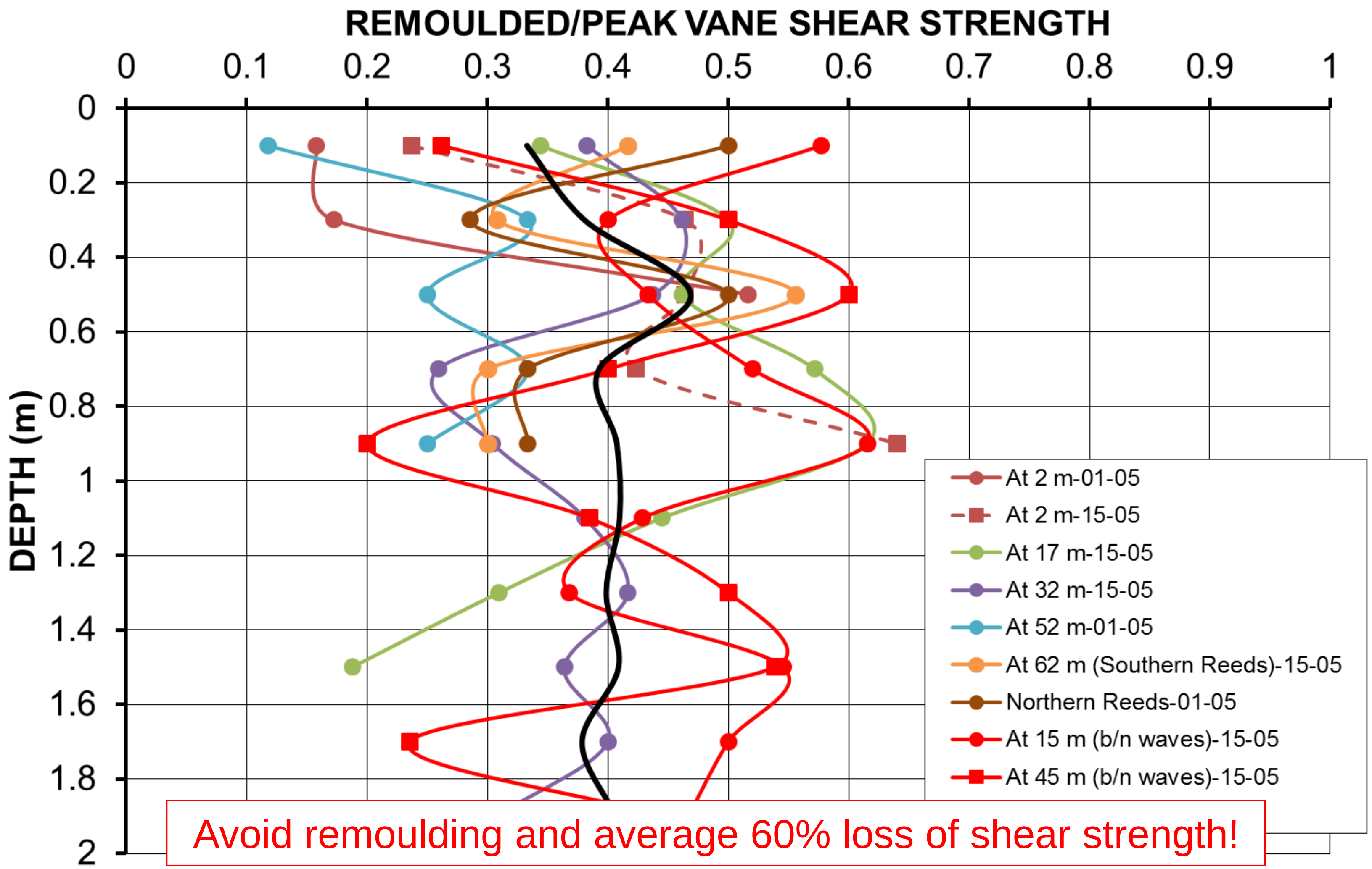
Vane Shear Test Locations



Vane Shear Strength vs Gravimetric Moisture Content

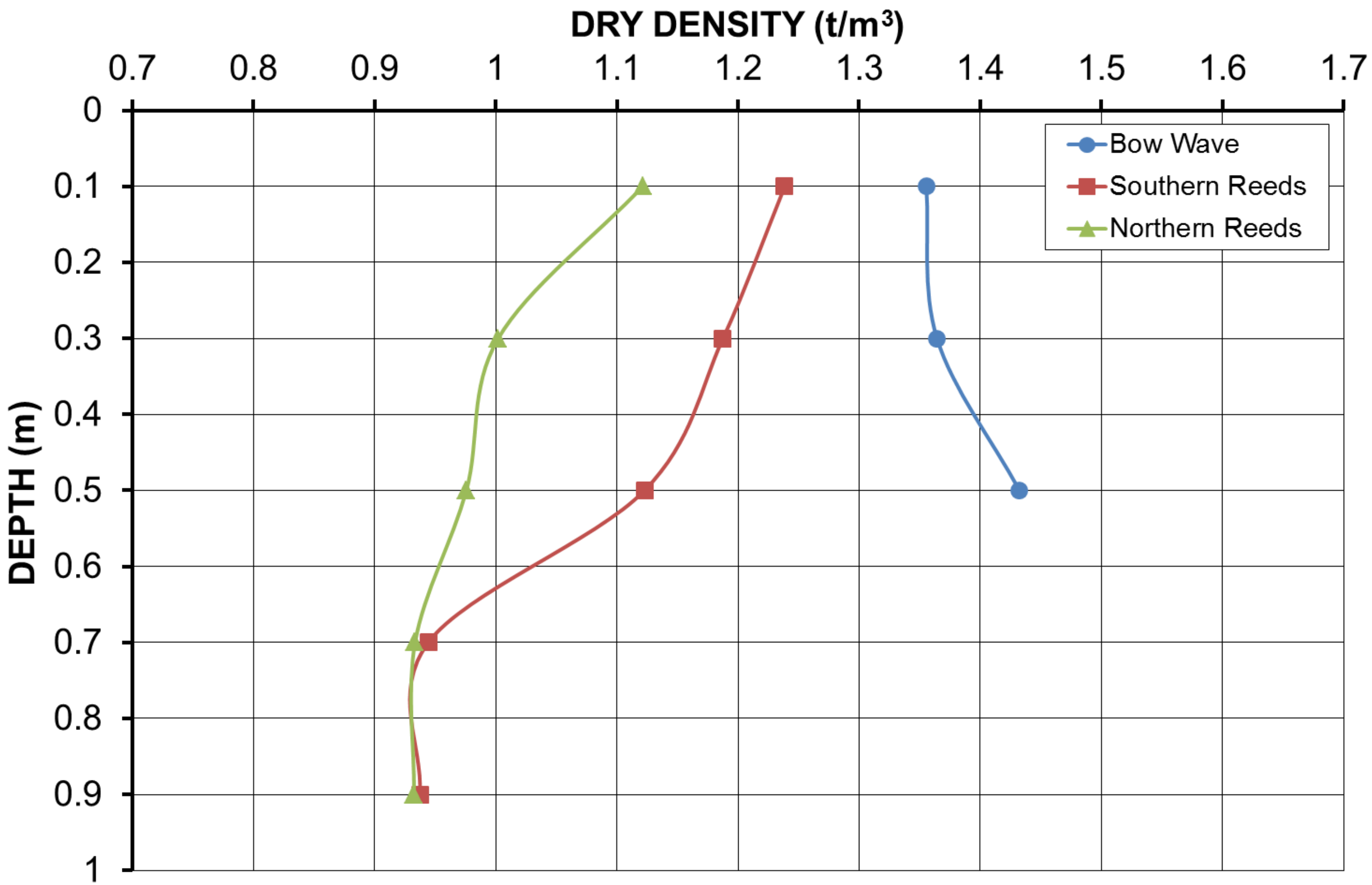


Remoulded/Peak Vane Shear Strength with Depth

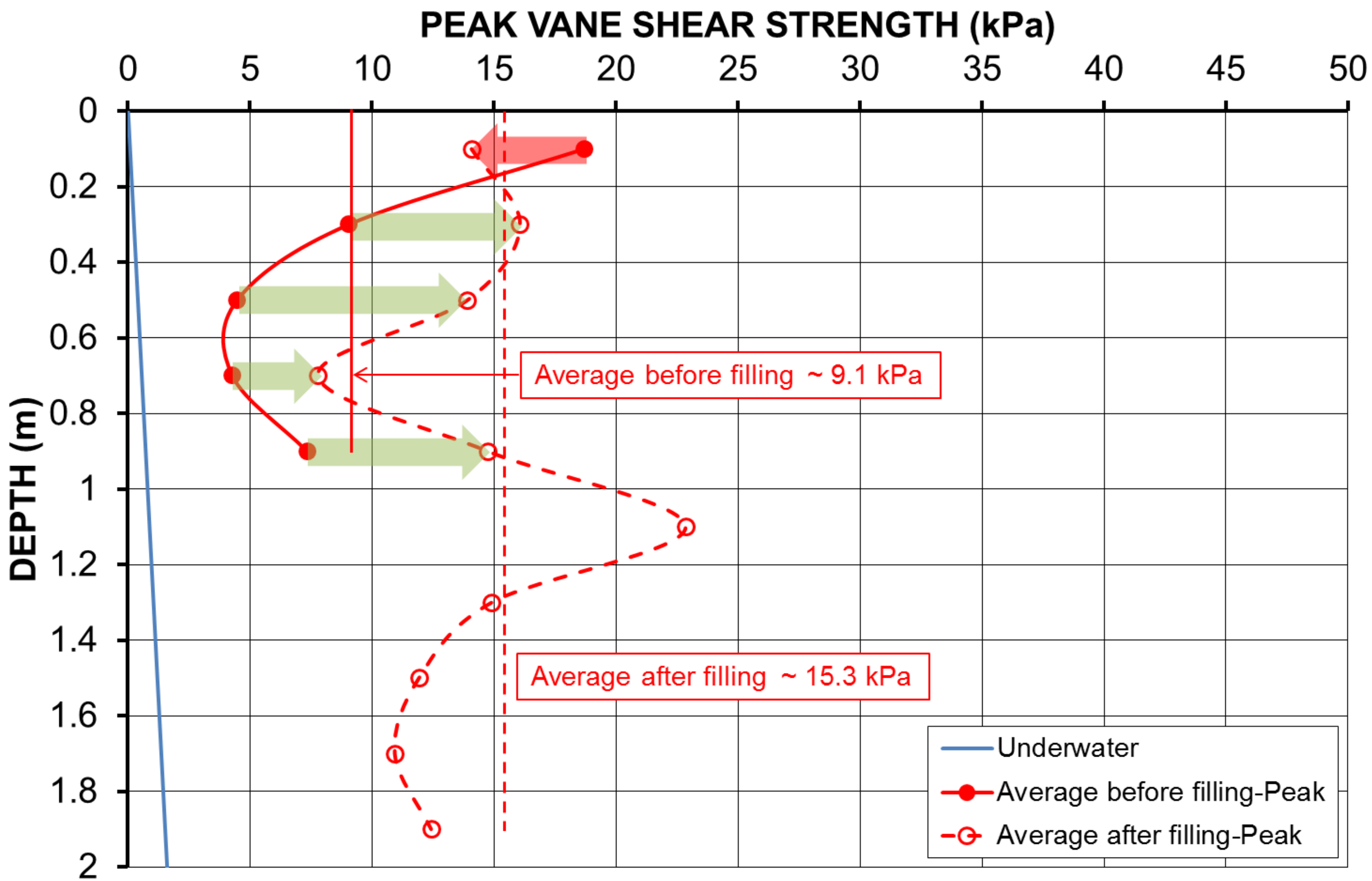


Avoid remoulding and average 60% loss of shear strength!

(Saturated) Dry Density versus Depth



Increase in Peak Strength with Dissipation of Excess PWP



Identified Capping Zones

Development and Implications of Initial Capping



Pushing initial 1 m coarse reject capping by D6 Swamp Dozer over old bow wave

Impacts of initial capping beyond bow-wave

Progress of Capping by June 2015

Up to 0.5 m High Scarps in Initial Capping over Soft Tailings

Significant Bow-Waving of Soft Tailings

Capping Surface TSF – New Acland (~$70,000/ha)

Before capping – August 2009

During capping – April 2013

During capping – March 2014

Completed capping – January 2019

Capping In-Pit TSF

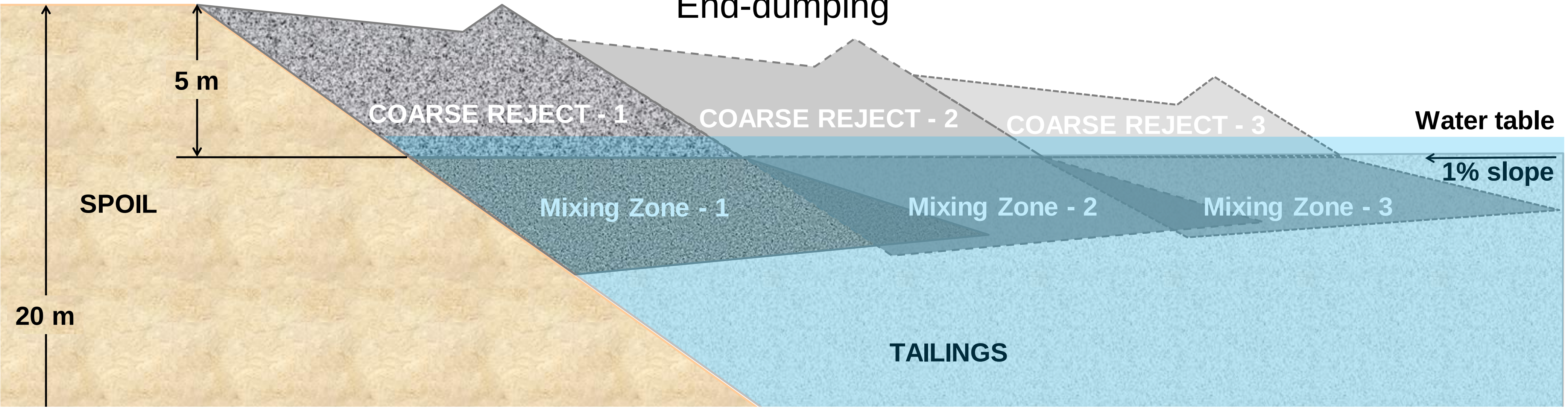
Selection of Capping Method for Soft, Wet Tailings?

- Dewater, and cap by dozing coarse reject from elevated beach:
  - Soft, wet tailings will be difficult to traffic
- Place coarse reject cap hydraulically:
  - Requires infrastructure
- End-dump coarse reject (waste) into wet tailings/water, displacing water and tailings to form a well-mixed layer, consolidating tailings sufficiently to support a D6 Swamp Dozer and additional capping

Hydraulic Placement vs End-Dumping of Coarse Reject

Hydraulic placement

End-dumping



Capping In-Pit Coal Tailings – New Acland (~$75,000/ha)


Before capping – March 2014


During capping – February 2016


During capping – September 2016


Completed capping – December 2017

Some Upcoming Meetings and Conferences

10th Australian Workshop on Acid and Metalliferous Drainage (AMD) 2020 – 23-26 March 2020, Dubbo – https://amdworkshop.com.au/home

Mine Waste and Tailings (MWT) 2020 – 28-30 July 2020 in Brisbane – https://tailings.ausimm.com/ – Call for Abstracts open till end October 2019

International Conference on Acid Rock Drainage (ICARD) 2021 – 30 August to 3 September 2021, Brisbane – https://www.inap.com.au/icard/