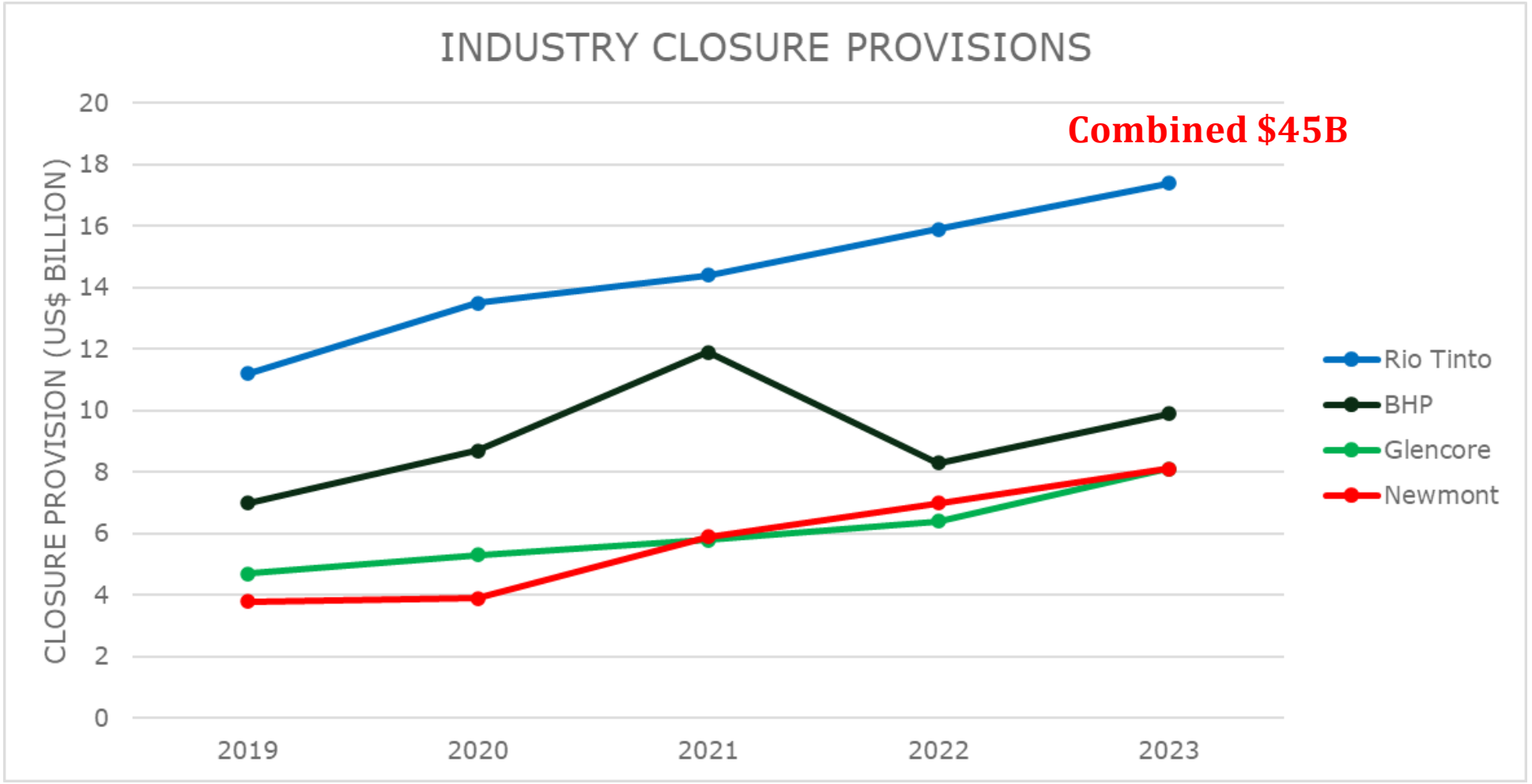
Mine closure liabilities – Understanding the true exposure

18TH JUNE 2025

Sustainability is our business

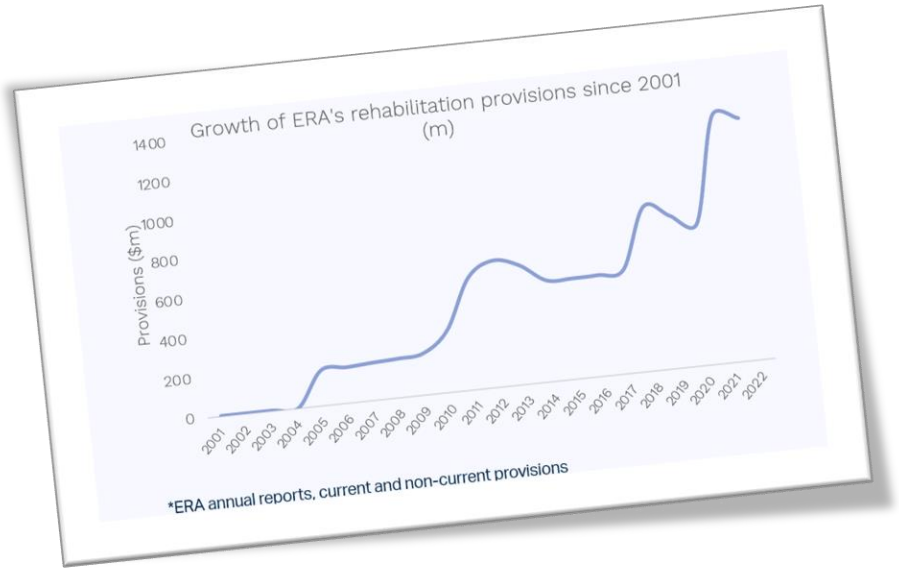


Combined $45B

Up $17B (+63%) over 4 years

Source: Harvey, P (2024) – ACG Mine Closure Conference

Ranger



2018

ABC NEWS Log in

Ranger Uranium Mine rehabilitation costs blow out by $296m amid fears over long-term monitoring

By Felicity James

Industry

Tue 11 Dec 2018

"…$808 million — $296 million more than ERA's initial $512-million estimate"

2022

ABC NEWS Log in

Ranger uranium mine rehabilitation costs could blow out to $2.2 billion, Energy Resources tells ASX

By Daniel Fitzgerald | ABC Rural | Mining and Metals Industry

Wed 2 Feb 2022

"…could cost up to $1.2 billion more than expected and take two years longer than initially planned"

2023

FINANCIAL REVIEW

Companies Mining

Ranger uranium mine rehab costs blow out

Elouise Fowler *Reporter*

Sep 26, 2023 – 4.40pm

"…rehabilitation would "materially exceed" $2.2 billion"

Victor Diamond Mine
Ontario Canada

CAD 74M (2017)

CAD 190M (2023)

↑ 256%

Equity Silver Mine
BC Canada

CAD 32M (1990)

CAD 87.2M (2018)

↑ 272%

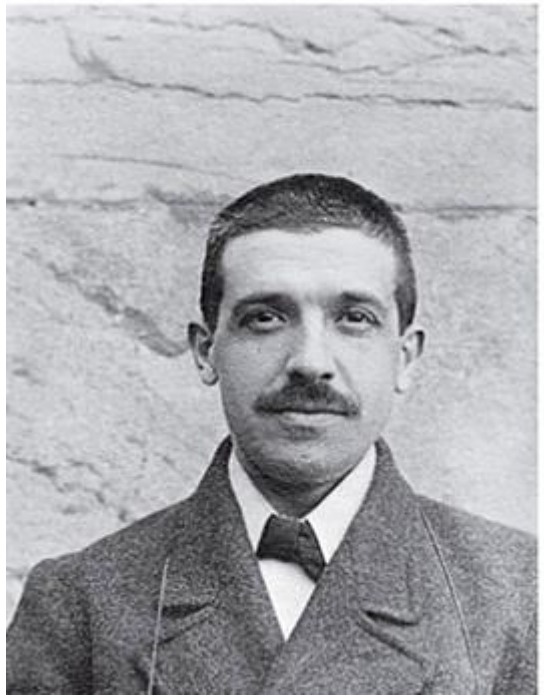
Giant Mine
NWT Canada

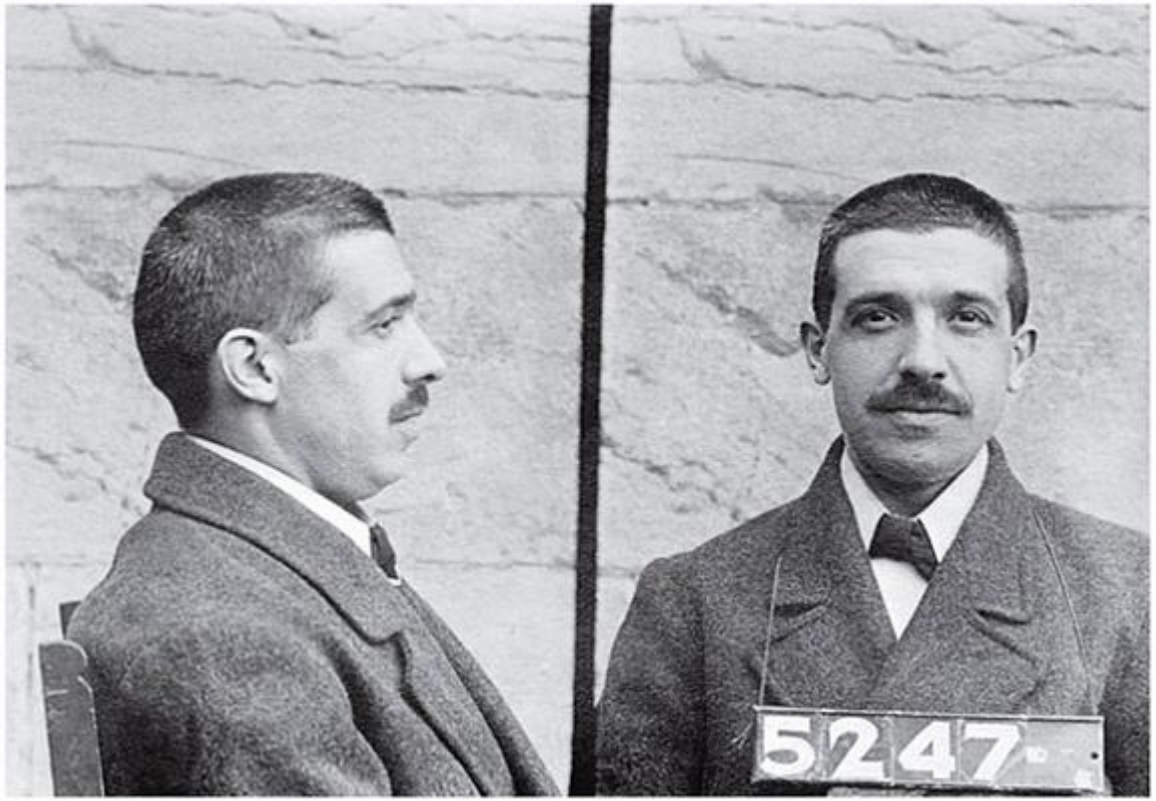
CAD 0.9B (2012)

CAD 4.3B (2022)

↑ 478%

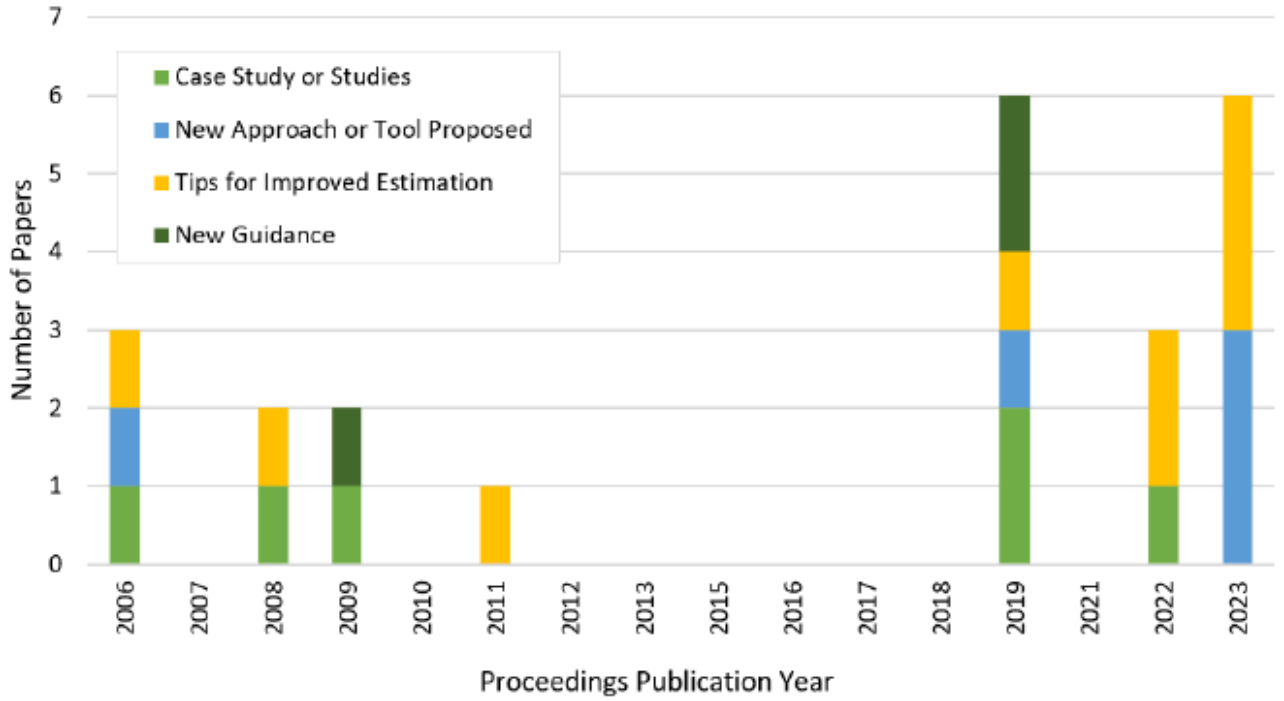
Source: Sanders, J. et al (2024) – ACG Mine Closure Conference

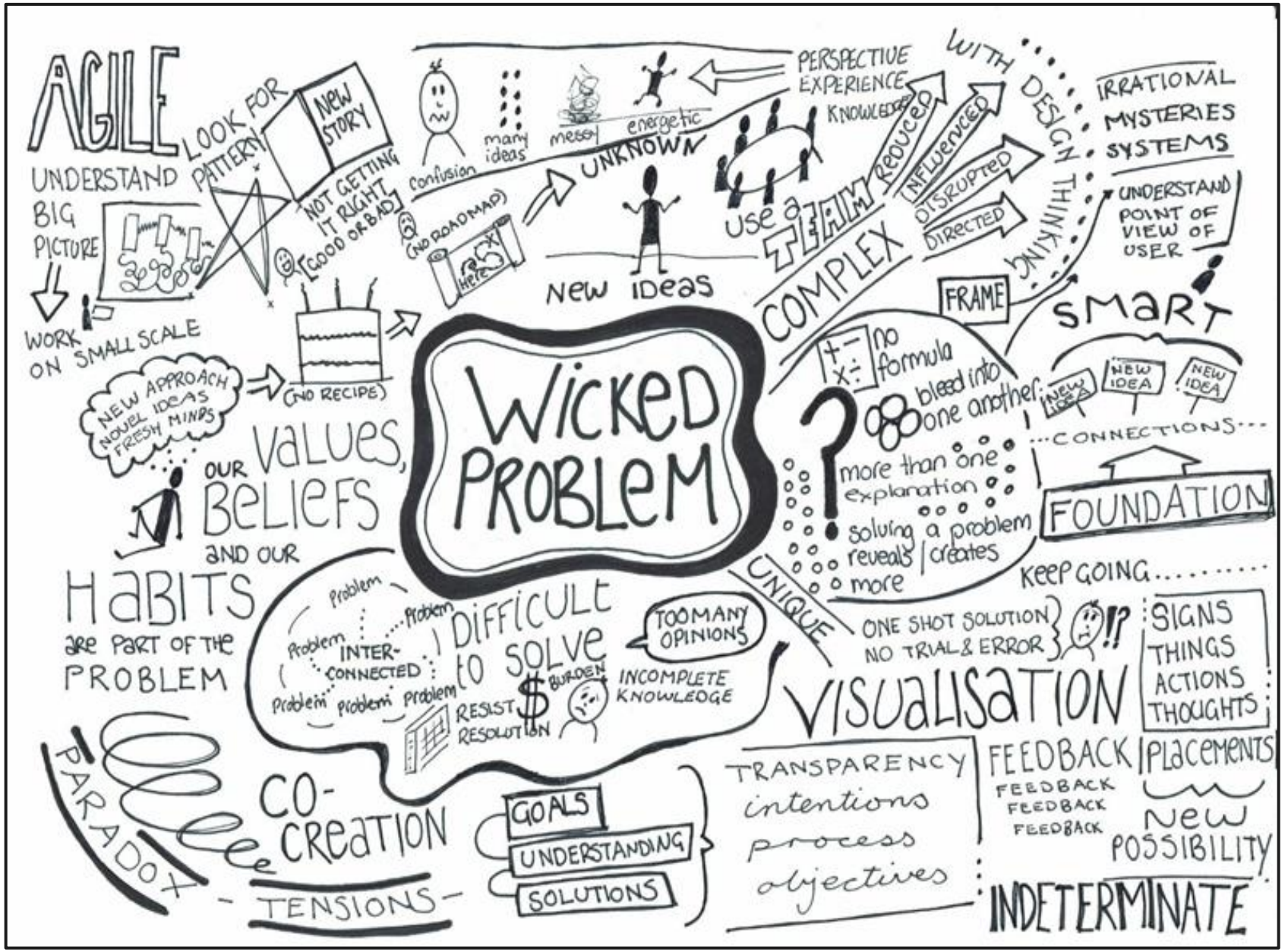




Charles Ponzi

Mine closure costing gaining increasing focus




AGILE
UNDERSTAND BIG PICTURE
LOOK FOR PATTERN
NEW STORY
NOT GETTING IT RIGHT (GOOD OR BAD)
WORK ON SMALL SCALE
NEW APPROACH NOVEL IDEAS FRESH MINDS
(NO RECIPE)
confusion
many ideas
messy
energetic
PERSPECTIVE EXPERIENCE KNOWLEDGE
UNKNOWN
(NO ROADMAP)
HERE
NEW IDEAS
Use a TEAM
COMPLEX
REDUCED
INFLUENCED
DISRUPTED
DIRECTED
WITH DESIGN THINKING
IRRATIONAL MYSTERIES SYSTEMS
UNDERSTAND POINT OF VIEW OF USER
FRAME
SMART
NEW IDEA
NEW IDEA
NEW IDEA
CONNECTIONS
FOUNDATION
Wicked PROBLEM
+ − × ÷
no formula
bleed into one another
more than one explanation
solving a problem reveals / creates more
UNIQUE
Keep GOING.....
ONE SHOT SOLUTION
NO TRIAL & ERROR
!?
SIGNS
THINGS
ACTIONS
THOUGHTS
VISUALISATION
OUR Values, BELIEFS AND OUR HABITS are part of the PROBLEM
Problem
INTER-CONNECTED
DIFFICULT to SOLVE
TOO MANY OPINIONS
INCOMPLETE KNOWLEDGE
$ BURDEN
RESIST RESOLUTION
PARADOX
CO-CREATION
TENSIONS
GOALS
UNDERSTANDING
SOLUTIONS
TRANSPARENCY
intentions
process
objectives
FEEDBACK
FEEDBACK
FEEDBACK
FEEDBACK
Placements
New POSSIBILITY
INDETERMINATE

Case Study: Coal, Queensland

1990

Pre-mining

Case Study: Coal, Queensland

2005

Active mining

Case Study: Coal, Queensland

2010

Active mining

Case Study: Coal, Queensland

2012

End of mining

Case Study: Coal, Queensland

Relevant factors:

- Proximity to Rosewood township and other neighbours - active community interest
- Company trying to get another mine approved – social licence
- Steep catchments (~100m fall from top of catchment to bottom, steep grades)
- Significant topsoil deficit (~30 ha of residual areas for which topsoil was not available)
- Dispersive topsoil/subsoil materials
- Underground workings in/near ML – potential issues with groundwater
- Water harvesting - licence
- Final landuse – grazing

Case Study: Coal, Queensland

Decision:

- Void backfilled to form free-draining landform
- Approximately 4 million m^3 was moved to backfill the ~80m deep void to the designed levels, taking ~2 years
- Site re-contoured to the final landform
- Topsoil imported
- Seed and gypsum applied
- Biosolids used – good results

Case Study: Coal, Queensland

2013

Commence backfilling

Case Study: Coal, Queensland

2014

Bulk earthworks complete

Case Study: Coal, Queensland

2015

Final grading, topsoiling and seeding

Case Study: Coal, Queensland

Case Study: Coal, Queensland

2017

2 years post rehabilitation

Case Study: Coal, Queensland

2025

10 years post rehabilitation

Case Study: Coal, Queensland

- **Stakeholder** landscape changed (political, social licence)
- **Closure scope** substantially changed
- **Closure cost** substantially increased

It’s a Burning Platform for Industry….

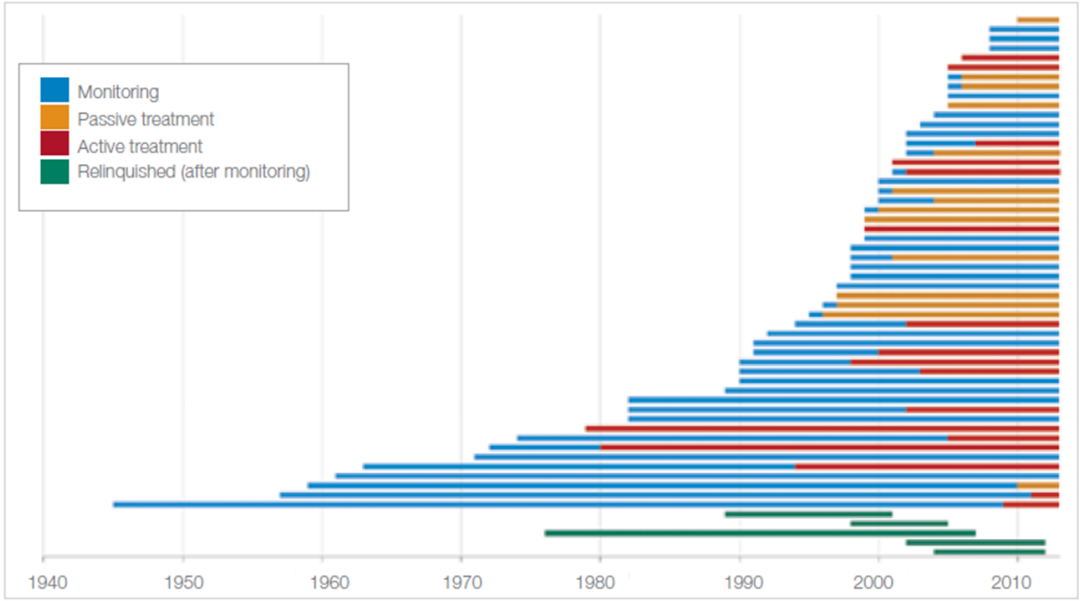
Closure is a **material risk** to mining companies.

The mining sector is beginning to better understand the potential total cost of closure:

- Often **multiple times higher** than originally estimated and/or carried on the books.
- Total cost of closure is **often unrealistic and optimistic** - based on overly optimistic estimates and timelines, design and operating decisions, and amplified by ambitious commitments for land rehabilitation made in pursuit of permits.
- Costs of execution commonly come in at levels that are can have a material impact on the bottom line.

There is tremendous **uncertainty** in the likelihood and timing that closed sites will be **able to be relinquished**. Relinquishment successes across the globe are rare.

There is little incentive for government to return financial securities and certify closure completion. This results in long term care and maintenance costs



There is need for a new approach….

ERM’s approach is centred on recognising that the problem is a “wicked problem” and we work to reimagine Closure, embracing the concepts of unconstrained thinking to solving complex problems.

It really is a “Wicked” Problem…

Mine closure is a classic example of a “wicked problem”

….. A wicked problem is at heart a social or cultural problem that is difficult to solve due to incomplete or contradictory knowledge, the number of people and opinions involved, the large economic burden, and the interconnected nature of these problems with other problems.

…it is an established fact that wicked problems cannot be engineered away…

….but great outcomes can be achieved by the right blend of expertise, an unconstrained approach to thinking, and an acknowledgment that **external stakeholders will ultimately judge the success of any solution and must play an intimate role in the establishment of a shared solution.**

Based upon Rittel and Webber (1973)

This is perhaps the main reason that so many closures achieve a poor outcome - while few achieve a brilliant outcome. Its all about acknowledging the problem fundamentals.

Costing challenges

Complexity

Tools and understanding

Knowledge base

Motivation to get projects going

Optimism bias

Avoidance of delivering bad news

Short term focus

Lack of oversight

Lack of clarity on end point

Tunnel vision

Stakeholder engagement

Project economics

Developing regulatory frameworks

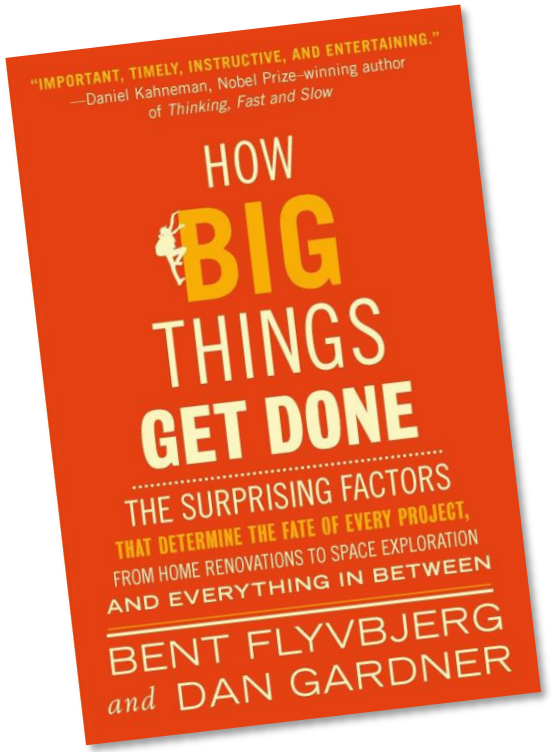
Rates

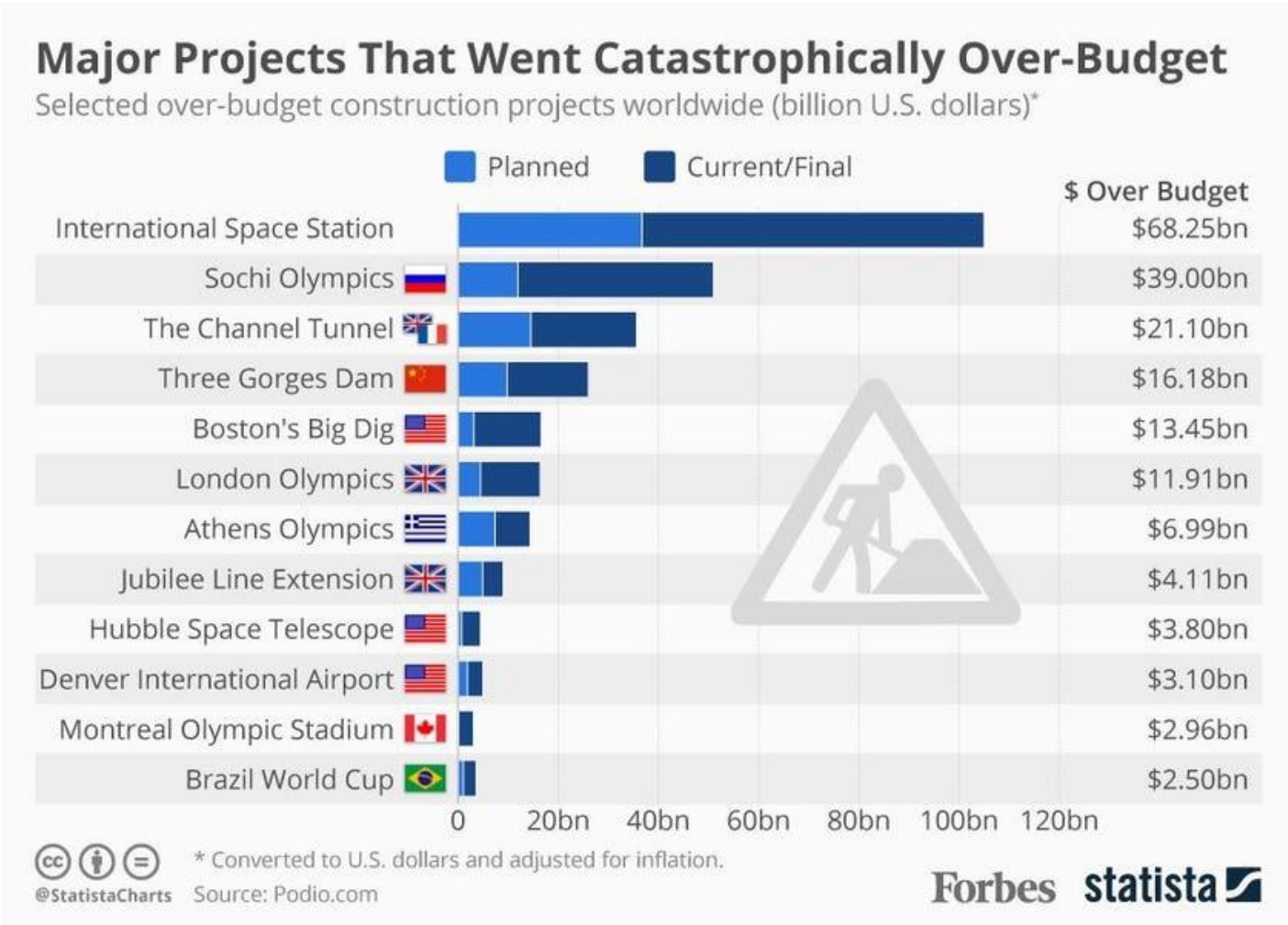
Getting projects going

Many mining projects/expansions start that should never (costs exceed income)

Desire to get projects off the ground

Optimism bias





Layered assumptions

Knowledge Base

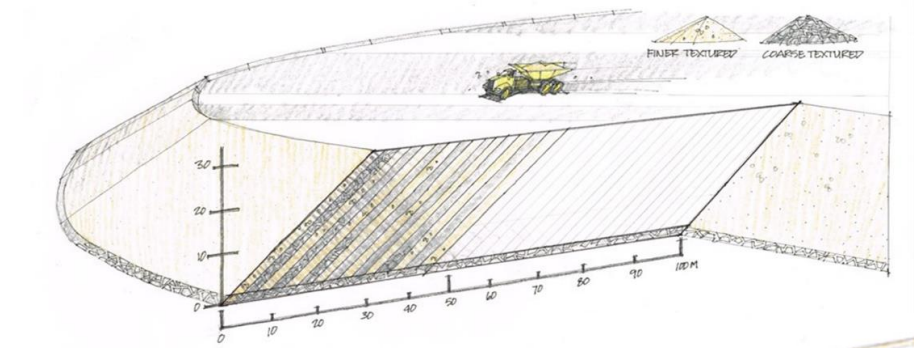
Propagating assumptions

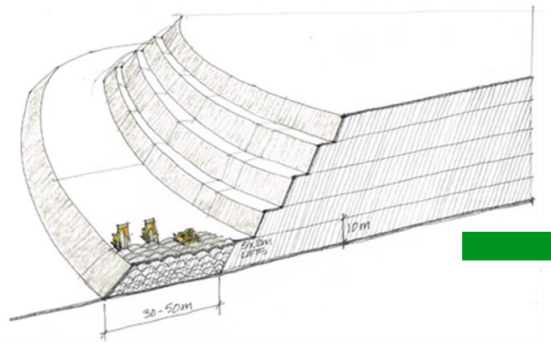
Tunnel vision

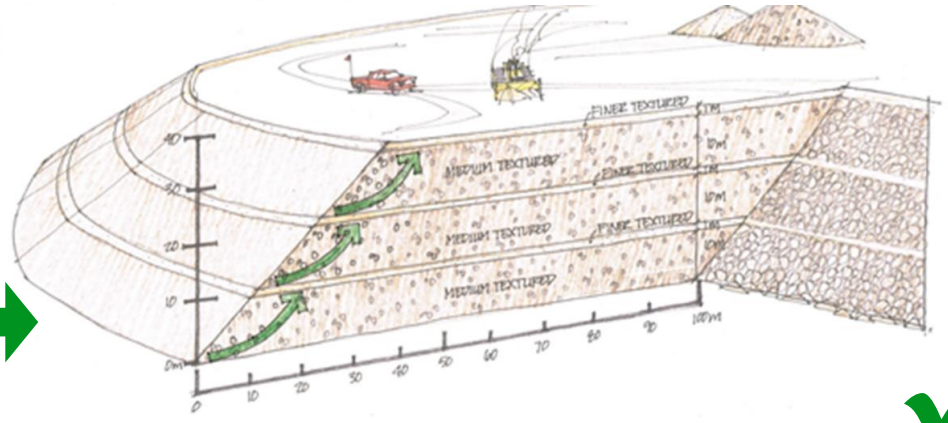
Short term thinking

Short haul versus long haul (LOM planning) - rehandle

Poor decisions can lead to long term implications (e.g. AMD)

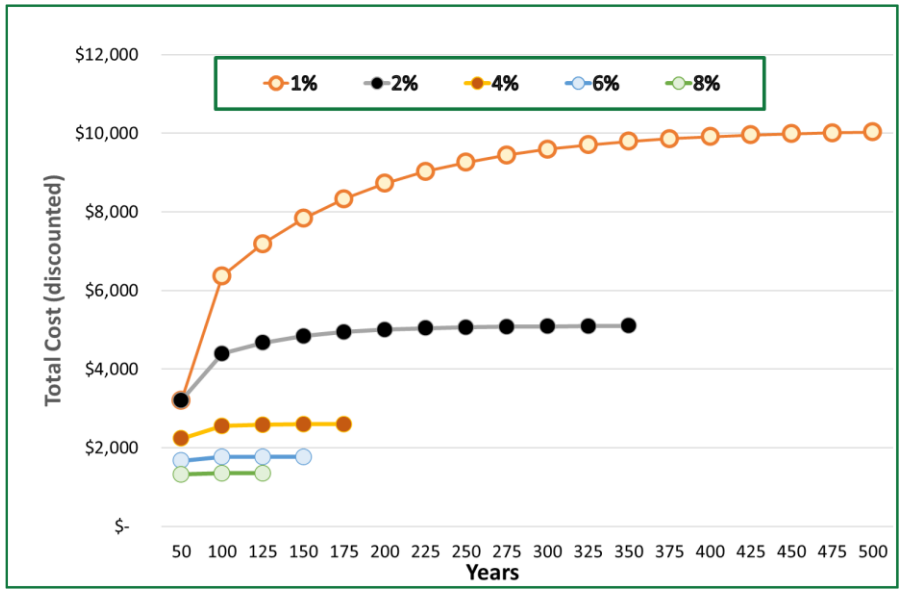


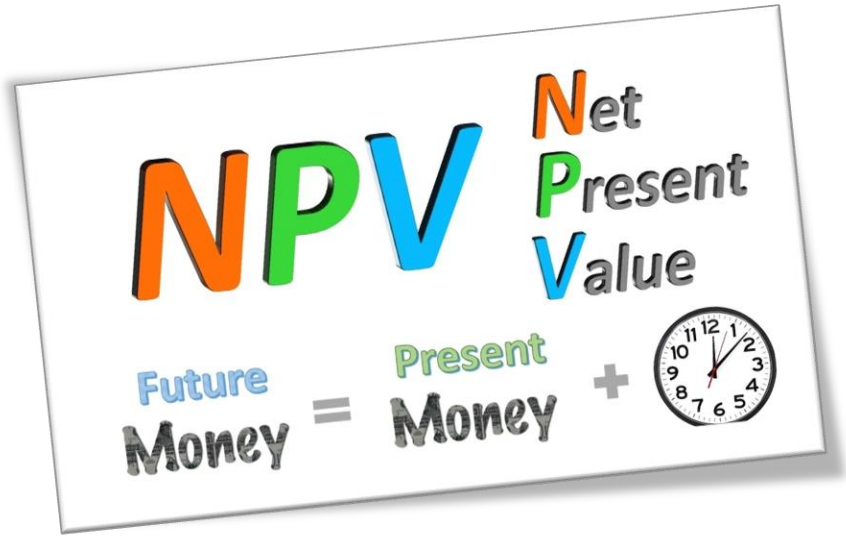




Financial analysis

Net Present Value (NPV) – has been used to delay of rehabilitation





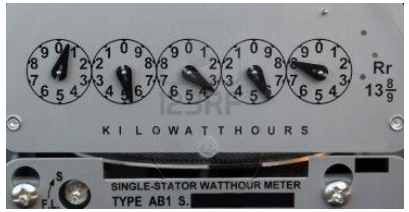
ICMM (2019b) states that:

> *"...An NPV (or present value) analysis of costs is likely to suggest that progressive closure is more expensive, as the present value of any expenditure will be lower the further in the future it is placed (assuming no change in scope). However, if progressive closure is looked upon as an investment, a more balanced analysis emerges..."*

Boundaries

Post closure overheads

Property tax



Power

Site Safety & Security

Water Management

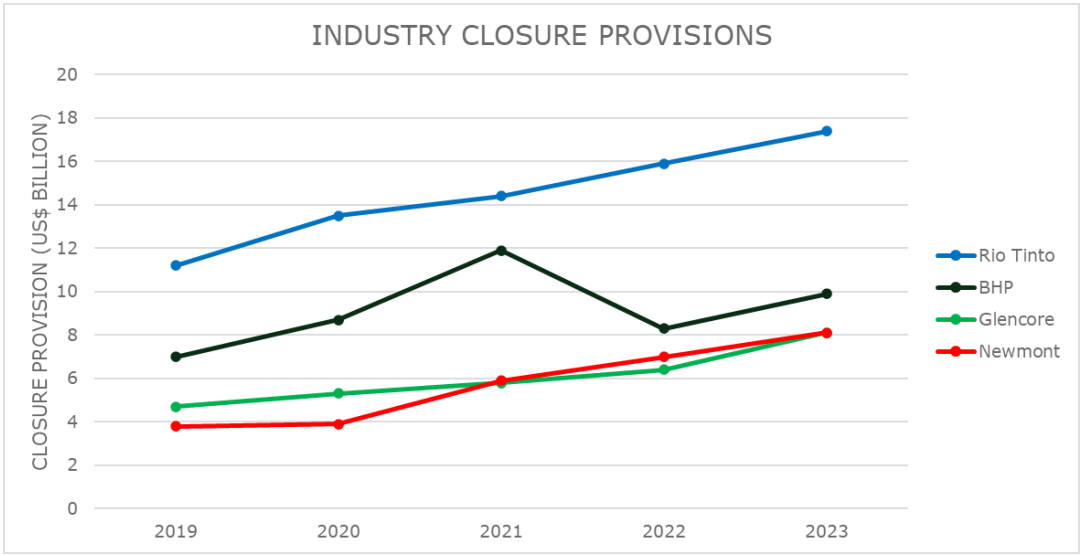
Severence - Rehab workers

Ongoing monitoring

Off lease obligations

Include assets not on the Mining Tenement where obligations may exist (e.g. working camps, dams, rail loops or contractual obligations for joint venture properties to remove / rehabilitate on closure. Contractual and license commitments need to be reviewed to determine rehabilitation responsibility.

Delivering bad news



Improved practice

Improved practice

Better closure planning leads to better outcomes and certainty – *and therefore better cost estimates*

1. Regulatory reform
2. Value creation
3. Effective stakeholder involvement
4. Tools/approaches

Improving regulatory frameworks

Not just about financial assurance

Progressive rehabilitation

Clear end goals

Facilitating PMLU outcomes

Improving regulatory frameworks

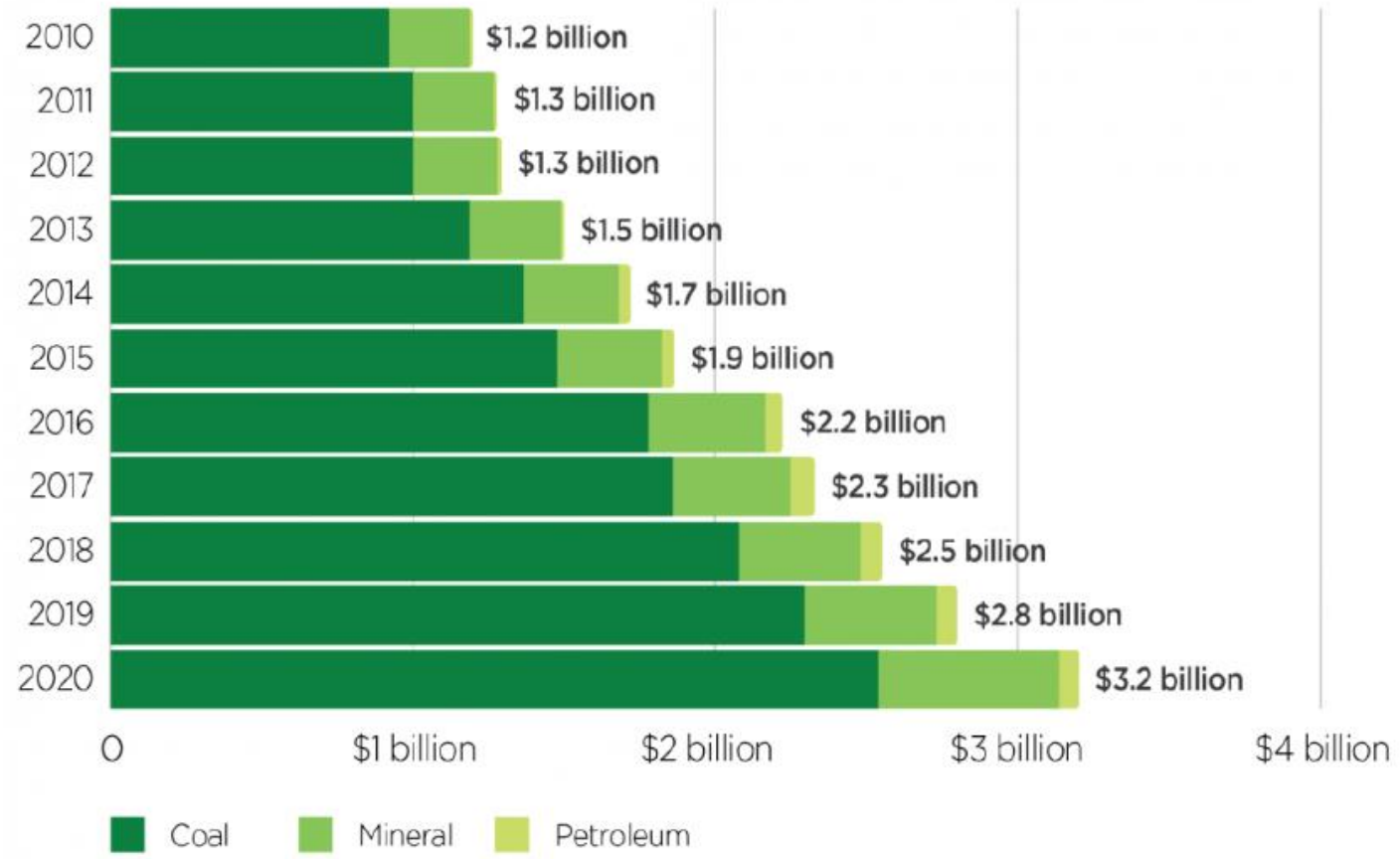
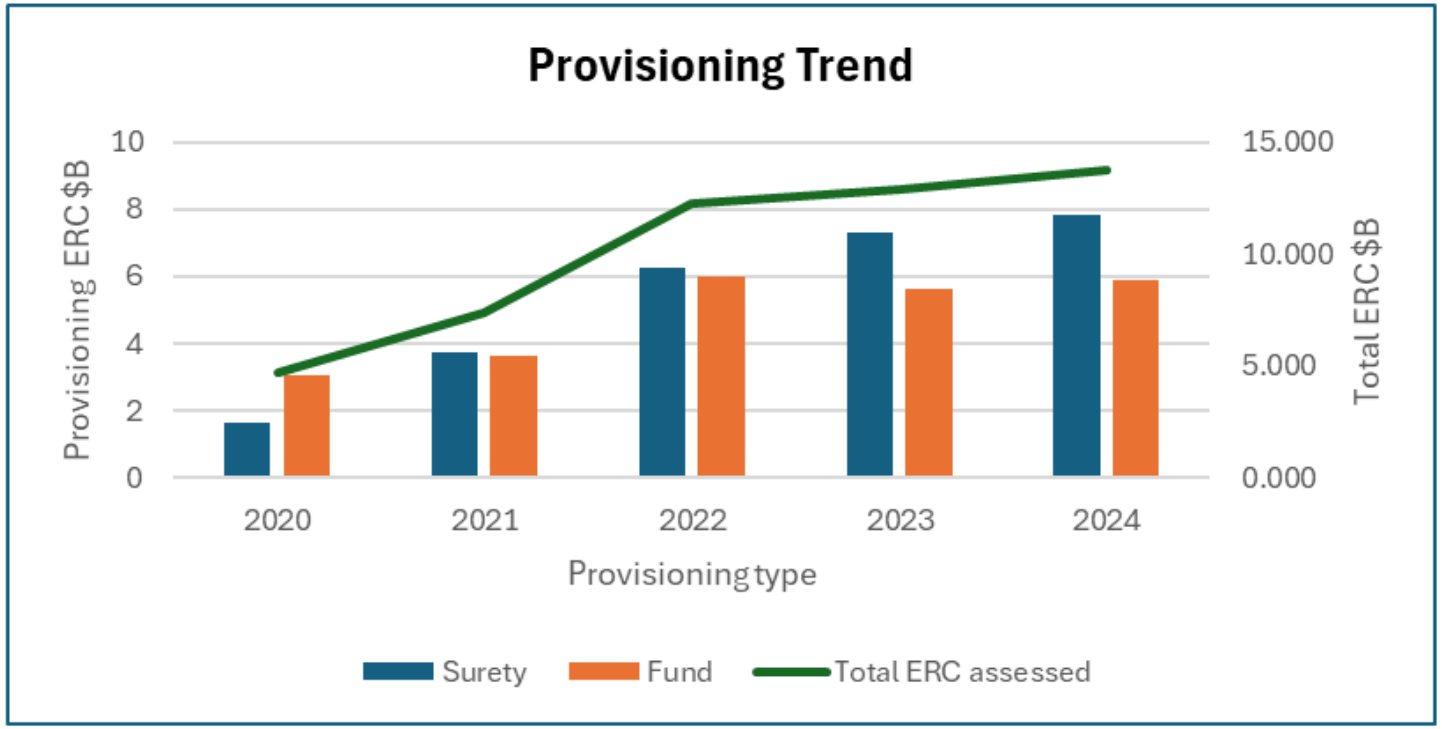


Figure 1 Rehabilitation and mine closure security deposits held by year by the NSW government

Improving regulatory frameworks



Value creation: Evolution of mine closure

LIABILITY MANAGEMENT

Compliance

Understand and mitigate risks

Manage costs

Stakeholder management

Relinquishment

Localised

Conservative

VALUE CREATION

Hitting ESG goals

Positive legacy

Social licence

Business resiliency

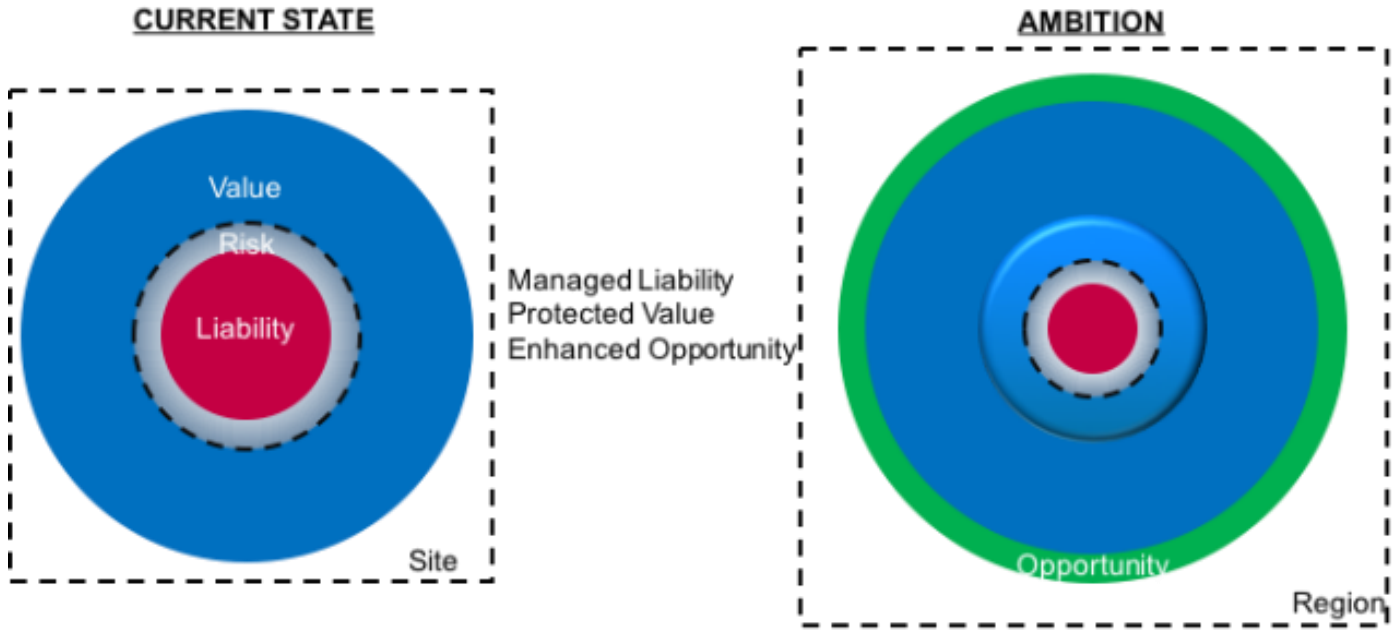
Regional and global scale

Innovative

Retaining assets

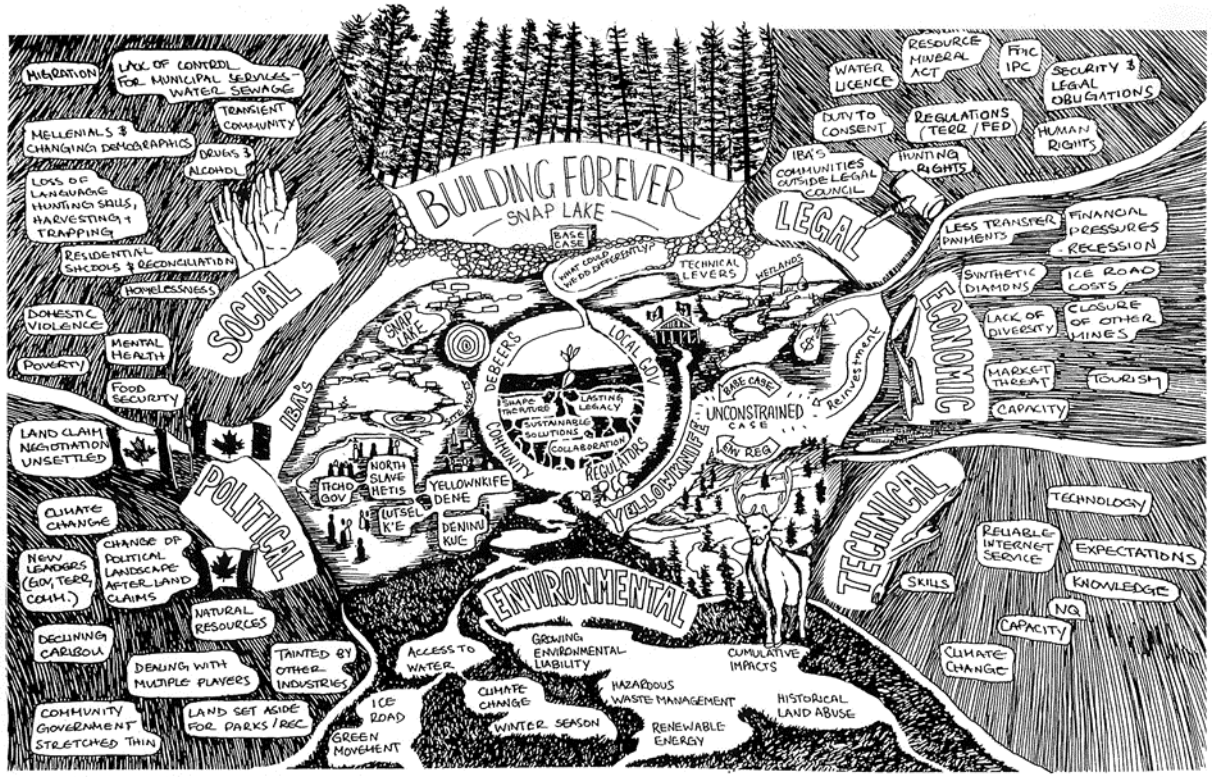
Enabling a Different Kind of Conversation: *The Shared Value Approach to Repurposing & Regeneration*

- To enable exploring a new closure paradigm, stakeholders need to be able to see this as an **Opportunity** as opposed to a scale back on environmental and social commitments.
- Need to move from a conversation about Mine Closure
- To a discussion on **Regional Opportunities** that can arise from different closure outcomes
- Mining Companies become an actor in the system instead of the single proponent, creating a ***shared value approach***



Shared Value Approach: *Collaborative Approach*

- Adoption of a new paradigm and strategic model to closure across the asset portfolio. ERM is working with De Beers at three (3) sites as active reimagining Case Studies.
- There are three concurrent elements:
  - Redefining the scope of closure activities to be undertaken on the mine site by <u>removing the constraints of past commitments:</u>
  - Working with local stakeholders and other interested parties to seek Collaborate Regional Development (reinvestment) options for the <u>region in which the mine is located.</u>
  - Working with local stakeholders and other interested parties to identify alternative post-mining uses for <u>site assets and the lands</u> themselves.



A Collaborative Design Approach to Multi-Stakeholder Engagement for Reimagining Asset Retirement

Effective stakeholder engagement

Linked to clear end goals

Changing expectation

Multi-stakeholder approaches

Adapted from: ICMM and the Partnering Initiative. 2021. *Partnering For Our Common Future: Optimising mining's partnering capability to contribute to community resilience and thriving societies.*

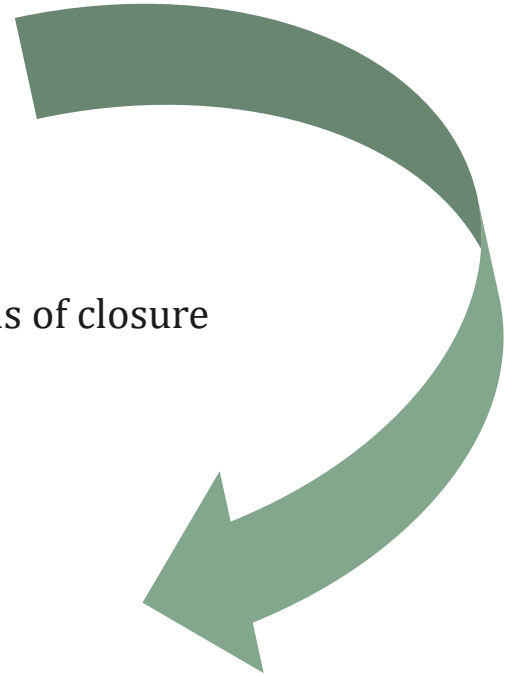
Linear…To Dynamic and Iterative

Traditional Stage Gate Approach

- Programmatic delivery
- Stage Gate approach at fixed time intervals
- Internally focused
- Engineering driven solutions
- Not proactive to emerging opportunities
- Internally Focussed – and perhaps doesn't understand sufficiently the wider implications of closure
- Leads to higher costs/provisions

Embedded Closure and Regeneration Approach

- Dynamic and iterative process not a single end point
- Allows interrogation of any opportunities
- Embeds external stakeholders in the co-creation of solutions
- Focuses on positive outcomes, including both corporate and community
- Designs and operates assets with future economy of the area in mind
- Manages liability exposures and creates successful exit strategies
- Leads to optimised costs - Driving down provisions



Evolution not Revolution

Better closure planning

Operate with a view to closure

- Manage operations so that they don't hinder closure process
- Circular Economy for Materials
- Tips & tailings operated for safety
- Progressive restoration & habitat creation
- Remediation where necessary

Envision an end to operations

- Preparation towards an end to mining
- Divestment or repurposing?
- Local needs and post-closure readiness – are the right skills available?
- How does closure affect local communities and the environment?
- Understand value of place
- Use Sustainable Development Goals to frame this

Engage with stakeholders and identify opportunities

- Who influences and shapes?
- What do communities want in place of a mine / refinery? How does this affect SDG Framework
- Data Gathering
- Regulatory Impact of closure - obligations
- What opportunities exist and who can carry these through to fruition?
- Review process / widen stakeholder base
- Develop Regeneration Options Appraisal

Have a post closure vision & determine success factors

- Assist in master planning / defining a post-closure vision for the site
- Define what a sustainable outcome is for company, the site and community
- Consider metrics for success / develop targets

Evolve Preferred Option - Exit framework / Asset Transfer

- Who to? Can they deliver the vision in the required timeframe?
- Guarantees
- Surety / long term nature of any transfer
- Need for dowry – arrangements for release / capping of payments
- Legal agreements
- Up-side agreements

Summarising the Principles Underpinning the “Reimagination” of Closure

- The mining phase is a **temporary land-use** activity within a broader regional socio-economic context;
- The boundaries of **mine closure extends beyond the “fence line”** to include the region in which the mine is located;
- Environmental **end points must be set** in balance with broad social and financial considerations;
- There is a need to **challenge base assumptions (constraints)**
- **Lands and infrastructure used for mining may provide future value** for the Company or other land users / investors;
- Need to consider regional and national governmental and/or private investment as **enablers of future shared value**;
- **Residual site liabilities are managed** through a combination of physical/management/legal conditions;
- **Relinquishment** of asset lands is not a prerequisite;
- Regulatory mechanisms exist externally to **make changes to the existing closure plans**;
- There **needs to be community perception of a Shared Value approach** to defining closure.

This unconstrained thinking is used for Legacy sites, Sites near Closure and helping to achieve Closure by Design – Wicked Problem solving provides a framework for success.

Tools and approaches

Financial tools

Life of Mine cost estimate

Cost of closure at end of operations
Discounting used
Audience – internal

1

2

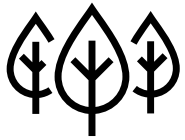
Financial liability/provision/ARO

Estimate of rehabilitation of current disturbed footprint
Discounting used
Audience – market, financial auditors

3

Sudden closure

Cost to closure the mine tomorrow
Used to evaluate internal business risk
No discounting
Audience – internal



Regulator (financial assurance)

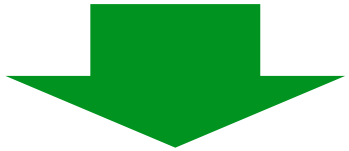
Basis for cash security, bonding
Adopts external rates for closure
Discounting rules vary
Audience – regulator

4

Types of closure cost estimates

Traditional (Deterministic) Costing Approach

- Quantitative risk analysis is performed
- Uses single-point estimate
- Components of a project: Assigned values + discrete scenarios = outcome might be for each
- Values are based on existing information, commercial experience and/or guestimates
- No attempt to assess the likelihood of each outcome
- Treatment of contingency – often arbitrary based on little understanding of risk

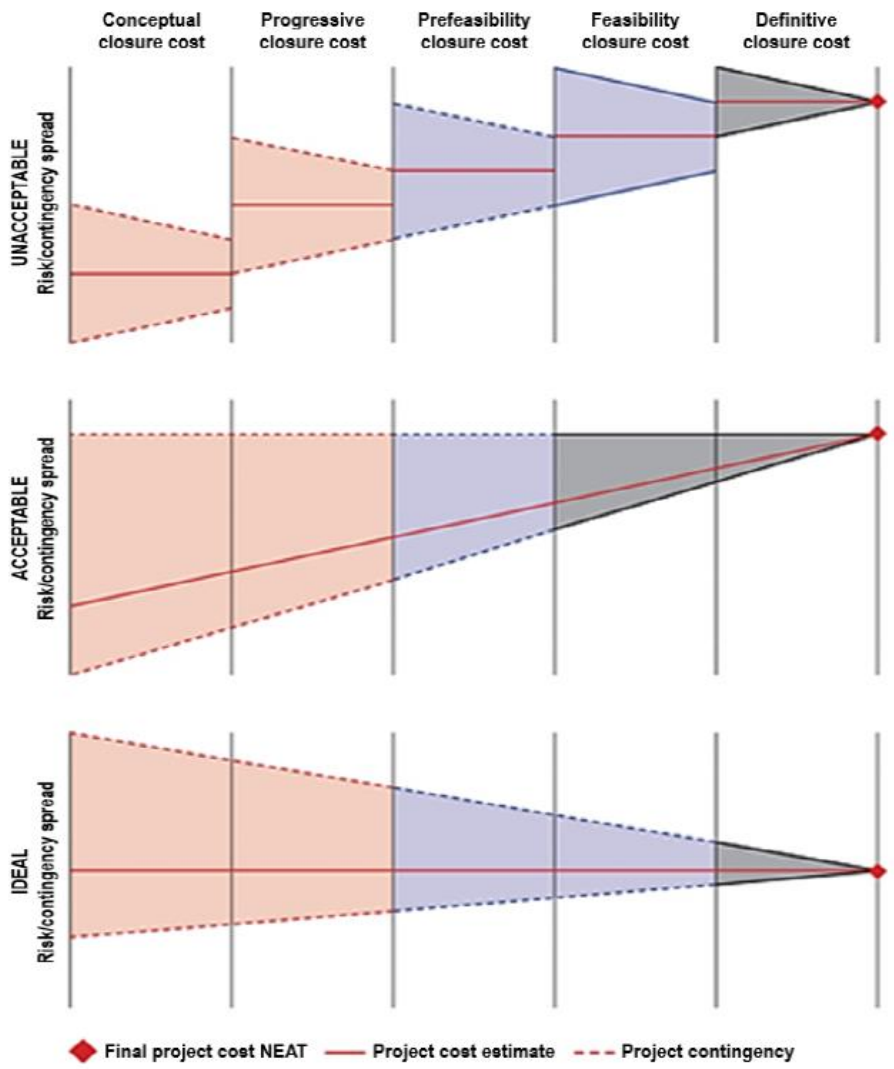


- Approach excludes potential interactions between scenarios
- Complex finance implications for companies and investors approaching closure
- Lack of reliable information to support project and investment and cashflow
- Lack of understanding where the focus of should be

In this example a simple addition of the worst-case, most likely and best-case values for each line item creates a wide variance between best and worst-case totals

Description	-50%	Most likely	+50%
Line Item 1	$160,000	$320,000	$480,000
Line Item 2	$260,000	$520,000	$780,000
Line Item 3	$76,000	$152,000	$228,000
TOTAL	$496,000	$992,000	$1,488,000

Closure cost maturity



Project phase (design accuracy)	Phase name	Example target date (years prior to end of mining)	Typical mine closure planning inputs (studies/ assessments)
Detailed design (+/–10%)	Class 1/ execution	< 2	Refine the closure engineering with inputs from FS forward works programs As-built designs
Feasibility study (–10 to +15%)	Class 2/front-end loading (FEL) 3	2 to 8	Refine the closure engineering with inputs from pre-feasibility study forward works programs Construction trials
Pre-feasibility study (–15 to +25%)	Class 3/FEL 2	8 to 15	Refined closure engineering with inputs from PFS forward works programs Agreed post-mining land and infrastructure use(s) Social transition engagement and integration, including infrastructure repurposing Agreed closure objectives and success criteria Clear closure obligations and legal requirements Consolidated knowledge base and spatial data management Closure design basis including climate change considerations Closure risk and opportunities assessment Closure scenario options assessment for each closure domain (guided by post-mining land use/s and closure objectives) Life of mine plan opportunities (mine rock handling, growth medium stockpiling, tailings deposition, water management, etc.)
Concept (–35 to +100 %)	Class 4 or 5/FEL 1	> 15+ years	Identified post-mining land use, depending on time to the end of operations Infrastructure decommissioning plan Closure social programs Closure vision, objectives and success criteria Closure risk and opportunities assessment Closure scenario options assessment for each closure domain (guided by post-mining land use/s and closure objectives)

Source: Sanders, J. et al (2024) – ACG Mine Closure Conference

Revisiting the Costing Approach

Traditional Method

Deterministic Approach

Limits or excludes uncertainties

There is not 100% confidence in each line item that supports a cost estimate

The cost estimate increasingly suffers from compound error

Revised Method

Probabilistic Approach

Embraces the uncertainties related

Combines the variables and analyze multiple scenarios

Generates outcomes based on probability

Supports prioritization

Supports robust business decisions

Example: Embracing uncertainty

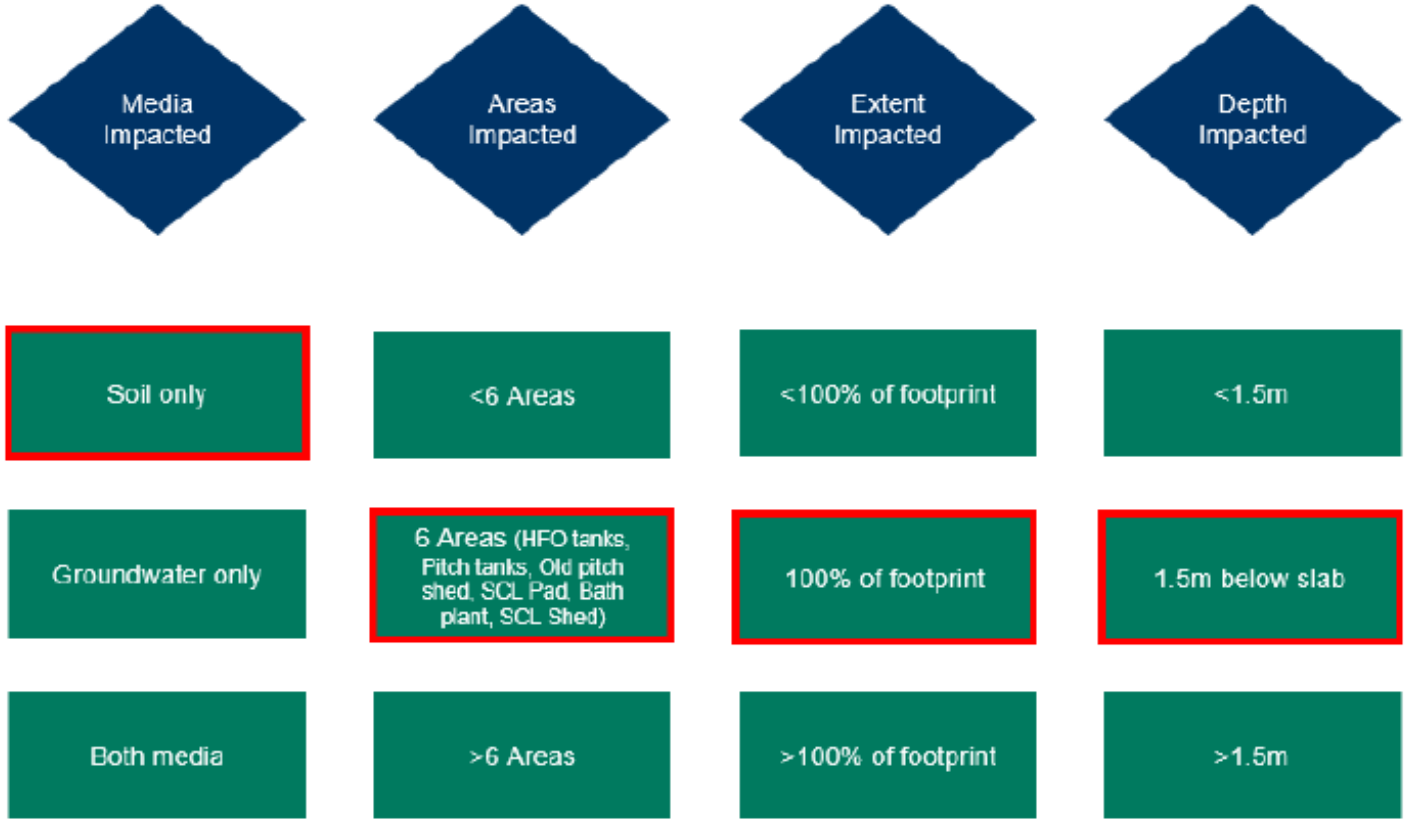
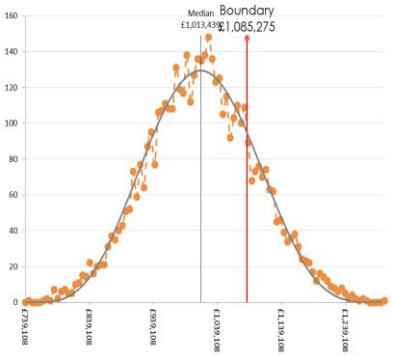


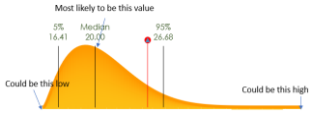
Figure 1 Illustration of options relating to soil & groundwater contamination

Cost Risk Analysis (CRA)

- Uses Monte Carlo simulation
- Analysis of the site aspects, closure criteria, objectives
- Uncertain inputs in a model are represented using ranges of possible values known as probability distributions
- More realistic way of describing uncertainty in variables of a risk analysis
- In cost modelling, probability distributions often fall towards the higher end of the curve being more likely

For each iteration, the simulation produces an estimate for an individual line item based on a predetermined probability distribution with values around the median/most likely value produced more often than those on the 'tails' of the distribution. In this case with 5000 iterations being run for each line item the distribution of results (right) shows the most likely (median) result as £1,013,439 with an 80% confidence it will be at or below £1,085,275.



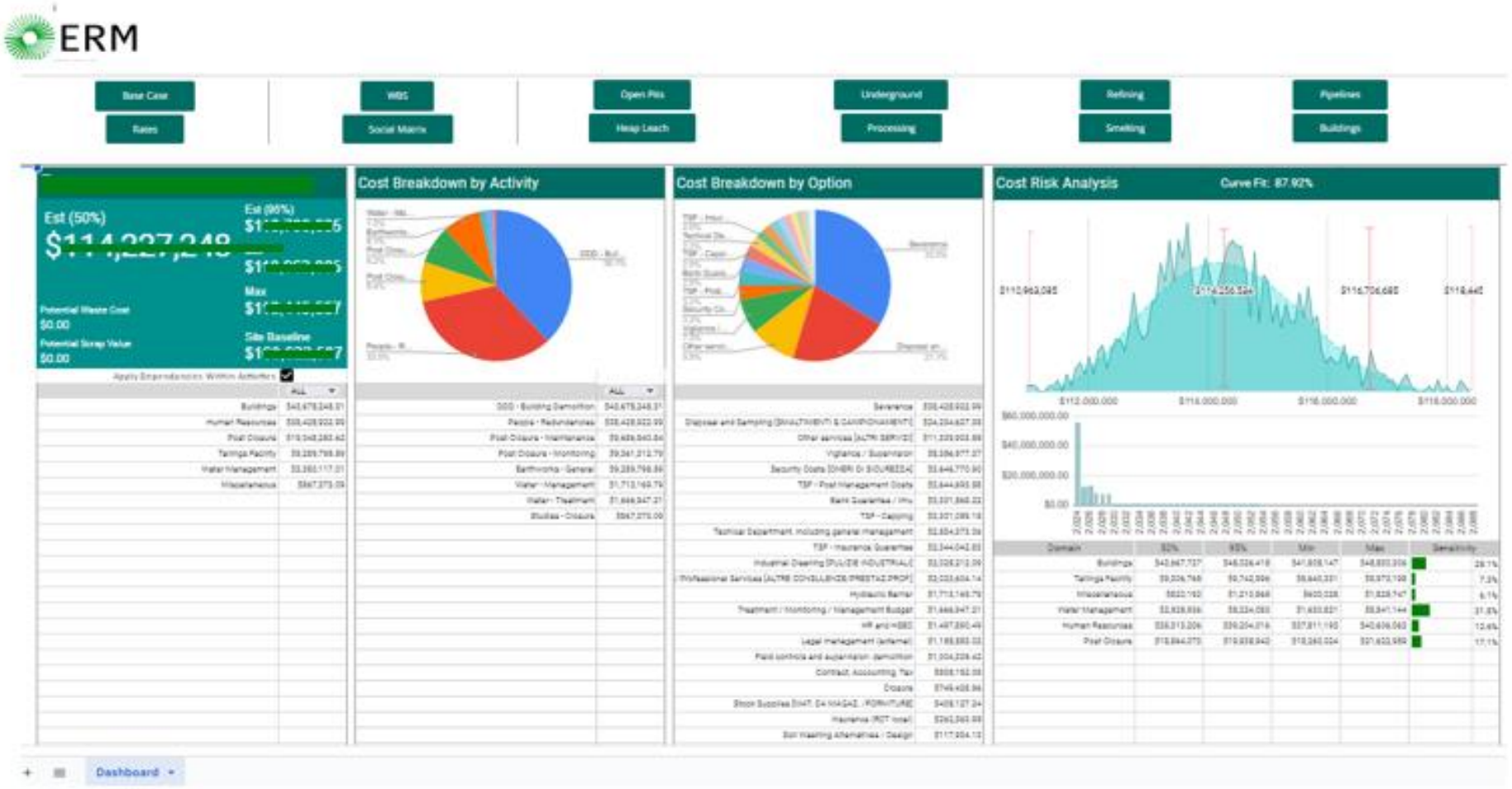


Description	Iteration 1	Iteration 2	Iteration 3	Iteration 4	Iteration n
Line Item 1	398,103.62	302,603.33	307,837.19	341,125.21	281,464.38
Line Item 2	311,585.12	264,997.67	300,591.44	246,425.79	303,546.31
Line Item 3	422,601.17	423,653.22	295,313.21	341,064.03	271,523.80
TOTAL	1,132,289.91	991,254.22	903,741.84	928,615.03	856,534.49

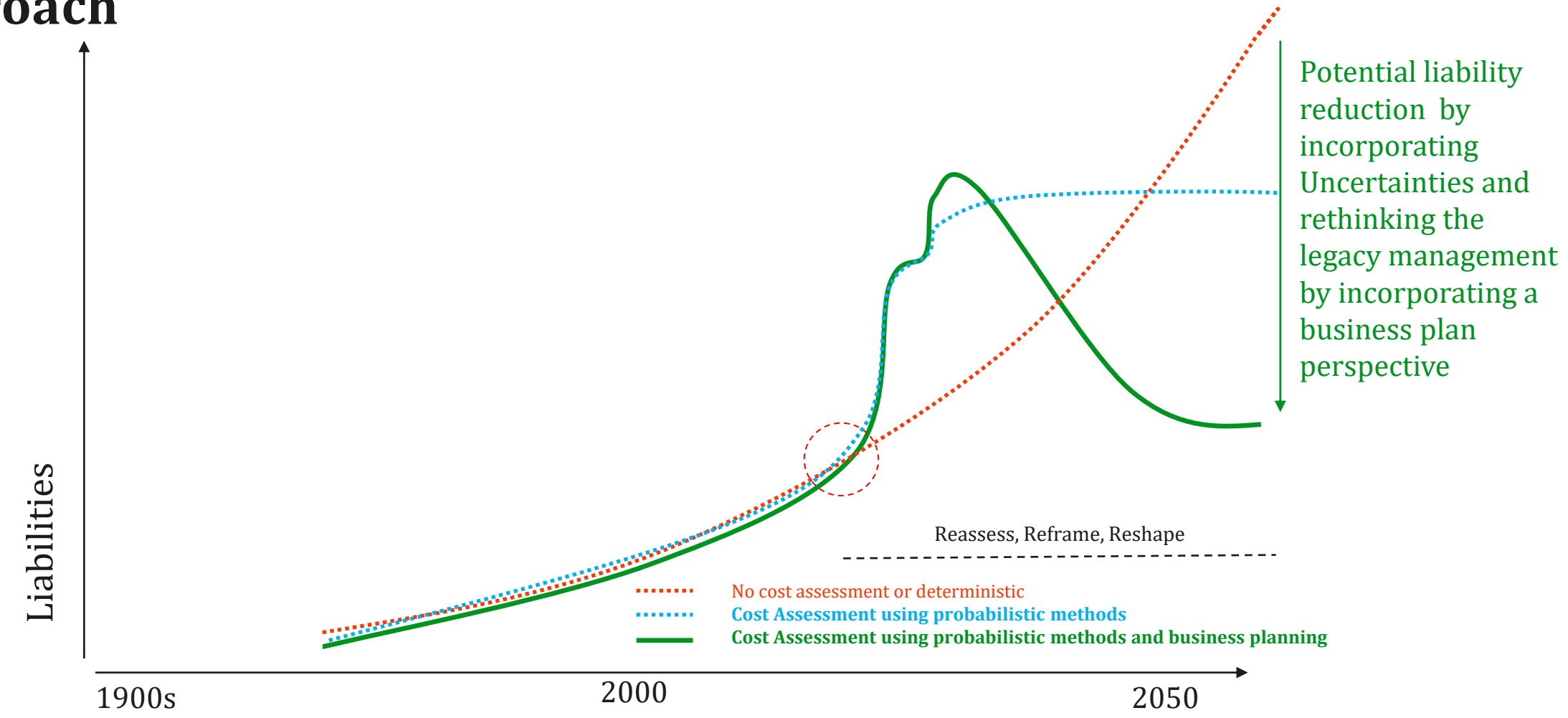
Example of interactions

Cost Risk Analysis

Example of cost Risk Analysis Dashboard

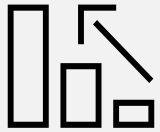
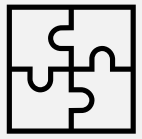
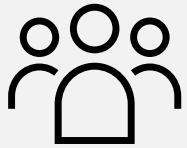


Experience throughout the Mine Closure: Transition to a process that incorporates uncertainty and rethinks the legacy management approach



Other improvement strategies

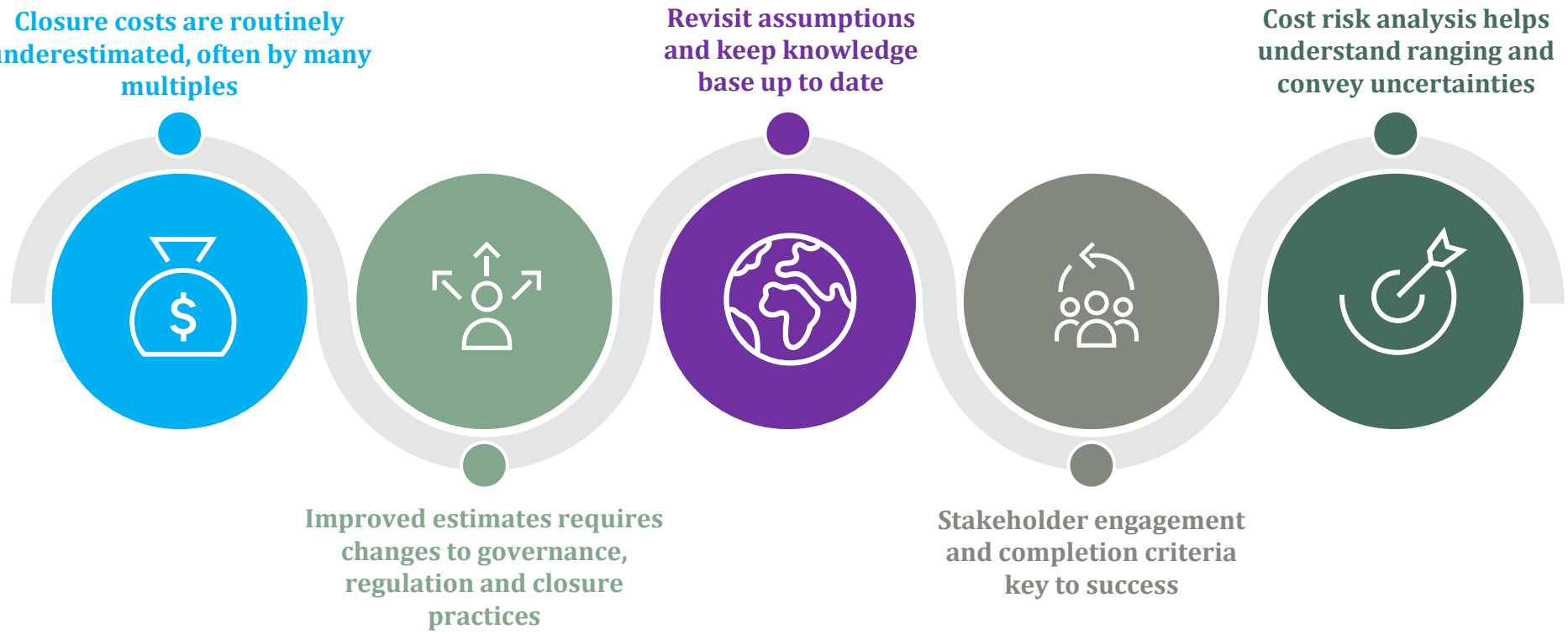
Integrating best practice closure planning into governance and operating models:

 Basis of estimate	 Front end load closure studies	 Corporate governance	 Risk & opportunity in LOA planning	 Closure vision endorsed by management	 Integrate closure designs into LOM
 Progressively improve knowledge base	 Track obligations (incl social)	 Right expertise	 Independent reviews	 Effective stakeholder engagement	 Feedback loop from progressive rehabilitation

Adapted from Sanders, J. et al (2024) – ACG Mine Closure Conference

Conclusions

Conclusions



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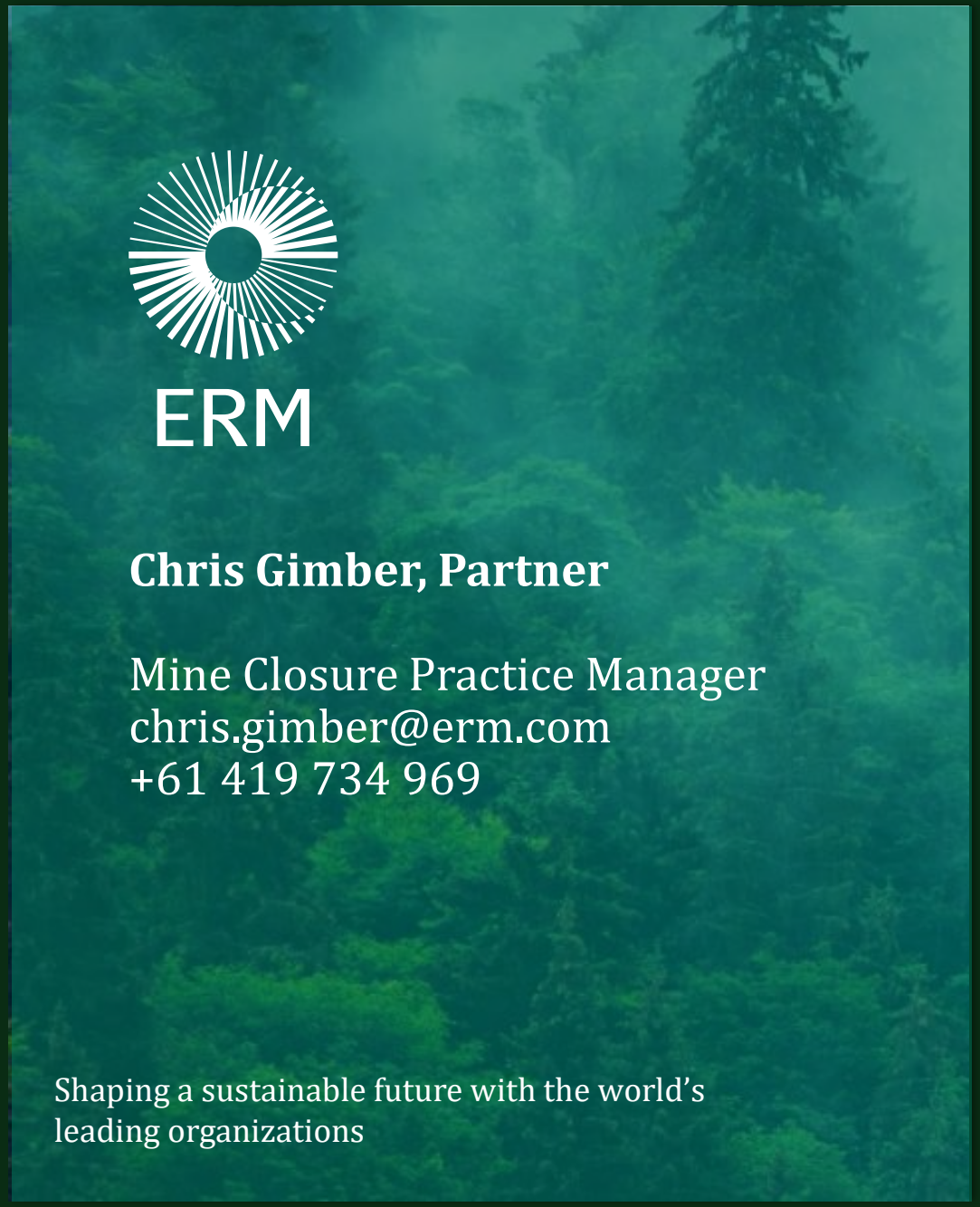
Thank you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