

DEVELOPING THE BUSINESS CASE FOR RESPONSIBLE MANAGEMENT OF AMD

CAROLYN OLDHAM | 5 AUGUST 2022



Acid and metalliferous drainage

International Network for Acid Prevention (INAP)

Acid and Metalliferous Drainage (AMD) is one of the most serious and potentially enduring environmental problems for the mining industry.

Left unchecked, it can result in such long-term water quality impacts that could well be this industry's most harmful legacy.

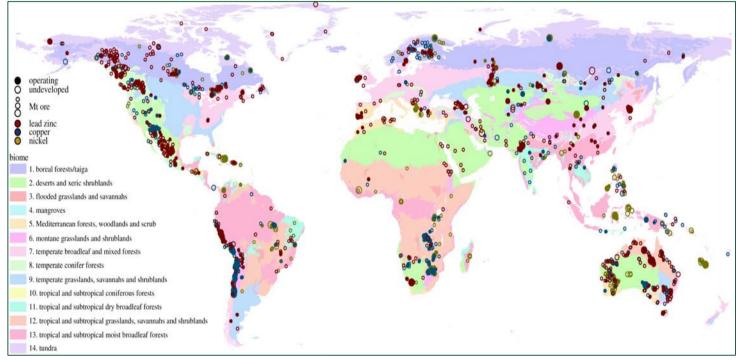
Effectively dealing with AMD is a formidable challenge as indicated by the high liability cost carried by many mining companies.





www.inap.com.au

Acid and metalliferous drainage (AMD)



Lead, copper and nickel mines (Sonter et al. 2018)

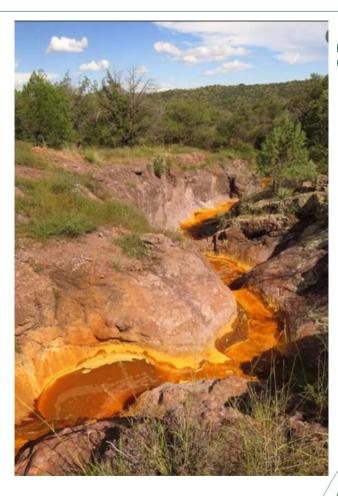
- Acid and metalliferous drainage (AMD) typically occurs due to mining and processing of base ores (e.g copper, zinc, nickel, gold) and coal
- Waters impacted by AMD can have pH 2 (~ lemon juice)

CR

Iron cycling and acidity



https://mining-report.de/english/predicting-acid-mine-drainage-past-present-future/

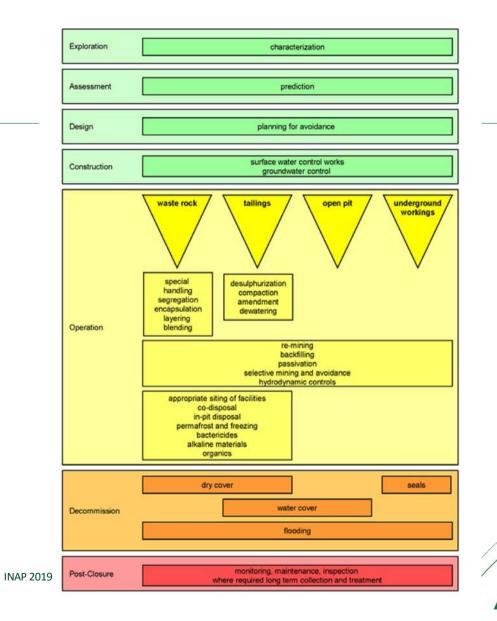


https://www.usgs.gov/mission-areas/waterresources/science/mine-drainage



Acidity and mining

- International Network for Acid Prevention (INAP)
- Started in 1998
- GARD Guide (2009) Best practice guide for prevention of AMD.





Why has acid and metalliferous drainage (AMD) been such an intractable issue?

What can be done about it?



- AMD impacts from operational and closed mines continue to grow.
- Strategies for AMD prevention or mitigation struggle to meet evolving stakeholder expectations.
- How can we help closure teams better make a case for responsible management of AMD across the mining life cycle?



Who we are



UWA Project Team

Professor Carolyn Oldham



Ms Ana Singh



Dr Lisette Kanse



Dr Chantal Bourgault

Partners

University of Queensland CSIRO Flinders University MRIWA FMG Rio Tinto Golder BHP Sustainable Solutions South32 Dept Water and Environmental Regulation, WA Dept Natural Resources, Mines and Energy, QLD



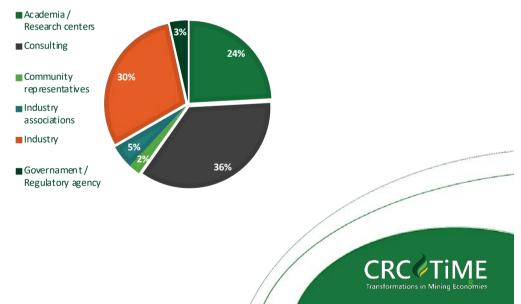
What we did

Global stakeholder workshops AMD Collaborative Dialogue Workshops - May 18 & May 5 Present 19/20 == * 🗆 🖬 🖬 206 Registered Canant Title Zone 0 0 0 0 0 0 7 Academia / Your Name Badge & Business Cant Overview of Gigo and Zoom - WATCH THES PLEASE? Consulting WELCOME 0 . 0 0 0 0 0 0 AMD Collaborative Dialogue Workshops Why has acid and metalliferous drainage (AMD) been such an intractable issue and what can be done about it? Industry 53 Satellite Map 1:00 pm 2:00 pm 8:00 pm 8:00 pm Industry *♦*TiME

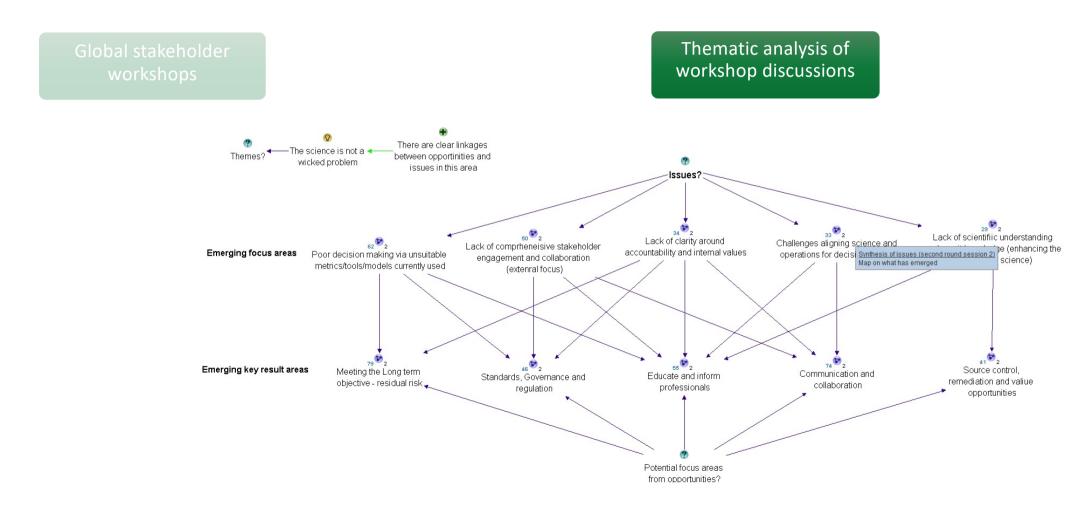
Google

Map data ©2021 Terms of Use

Thematic analysis of workshop discussions



What we did



Issue	Sub-aspects raised by participants
12. Challenges aligning science and operations for decision making (developing a business case)	How can we influence mine plans and op on source control and AMD prevention? the science / engineering behind AMD gen and treatment being well understood and c Science of AMD source terms is well establis occur. Mining engineers at the moment understand are too focussed on geotechnical stability. How and where to better educate all discipline: closure challenges. There continue to be challenges with material ch and scheduling.
	Those responsible for AMD issues are likely to be c in different organisations, and will likely change ove maintain momentum and coherence of approach.
	Approaches taken to implement solutions has been a continuity in testing of methods of control and treatn issues persisting that should have been solved.
	Need to bring these initiatives back to cost valuation ar value proposition is.

Issues are increasing with more reverse osmosis, waste a disposal.

ised

Bactericide technology is not yet accepted in mainstream

Table 3 Sub-aspects raised in relation to Issue Theme: Poor decision-making due to unsuitable iaue э эцо-аэресы raiseu in reiauon to issue metrics / tools / models currently being used. At the start of an operation, companies rarely have sufficient clarity on Sub-aspects raised by participants future consequences and risk of AMD. Predictive modelling is never done over the next few hundred years lifew Predictive modelling is never done over the next rew nunared years (rew models are capable). But this is exactly what is needed for prediction of ANU impacts. Current company cultures are often reactive instead of proactive. AMD Management suffers because of this. Had a preventative approach been taken right from the beginning, people current company canares are orden real management suffers because of this, would teel responsible for AMD prevention. Important time horizons differ between different stakeholders. Residual risk is often not considered until closure is imminent and by then Residual risk is often not considered until closure is imminent and by the many options have closed. Those closed options may have been more The focus on short-term vs long term risks is determined by current val and norms. But those norms aren't the same across all stakeholders. effective and cheaper. effective and cheaper. The focus on short-term vs long term risks is used. and norms. But those norms aren't the same across all stakeholders. and norms. But those norms aren't the same across all stakeholders. and norms. But those norms aren't the same across all stakeholders. and norms. But those norms aren't the same across all stakeholders. and norms. But those norms aren't the same across all stakeholders. and norms. But those norms aren't the same across all stakeholders. and norms. But those norms aren't the same across all stakeholders. and norms. But those norms aren't the same across all stakeholders. and norms. But those norms aren't the same across all stakeholders. and norms. But those norms aren't the same across all stakeholders. and norms. But those norms aren't the same across all stakeholders. and norms. But those norms aren't the same across all stakeholders. and norms. But those norms aren't the same across all stakeholders. and norms. But those norms aren't the same across all stakeholders. and norms. But those norms aren't the same across all stakeholders. and norms. But those norms aren't the same across all stakeholders. and norms. But those norms aren't the same across all stakeholders. and norms. But those the those the those the the those the th and norms. But mose normal approaches to AMD issues are not stander the formational culture and approaches to AMD issues are not stander to formation of the fo and the second s economics. To stage-gate (approval stages - proof of concept>pr to stage-gate (approval stages - proof of concepts) a project must consider economic levers and oper-15. Poor decision a project must consider economic revers and ope stage, using this approach would ensure that A making due to considered across each stage of the life of mi unsuitable considered across each stake of the office of the office of a speed to assess viability of all options and metrics / tools / including after closure. How do we accurately include AMD costs into discounted cash flow analysis in models currently Using net present value (NPV) often dr estimates of net present value (NPV). USING HEL PRESENT VOIDE (11 Y) UTEN Making, Typically, supervisors sugge estimates of net present value (NPV) Chanse manager KPIS to include long-term berspective. Improve divestment due diligence and better apportion change manager KPIs to include long-tem perspective. management are deferred. Economics is a major problem around i too short-term (decisions are inappropriat. Change manager KPIs to include long term perspective. NPV is used as a KPI but AMD risk increases ia NEV IS USED AS A NET DUL ANNU TISK INCLEASES TA Breater costs in the long term. NPV is not a useful decision-making. NPV is useful for capturing known cost at a specific poh. Not measure non-financial costs . Costs of tailings reprocessing are high, so trials get stopped w. bad. Currently most focus is on reprocessing of the tailings for economic not measure non-financial costs .

recovery. Guidelines are being used as standards.

CRC¢Ti

Opportunity Sub-aspects raised by participants

vork with communities for relinguishment.

Develop case studies on reiniquisment. Make better use of post-closure management for elocure needs to hange ment funds.

Management for closure needs to happen at beginning of life Use residual risk frameworks in planning for closure at the beginning of life closure to deter

Scenarios Use economic models with low and high uncertainty bounds for risk

assessment Require all investment decisions to quantify social and environmental risk

reinquishment. Develop case studies on relinquishment.

OS. Meeting

the long term

Opportunity to quantify the impact of mine vegetation actability for a communities of the impact of mine wegetation actability means in communities

Nora - Unis is it key interest to communities Baallus maaast aa imaamaasa aastaabiishment is crucial

Engage community on which part of environment they walk outset to set realistic expected not so much, and adapt according to community preferences Work with communities from the outset to set realistic expectations and

responsibilities for relinquishment Frame conversation in terms of ongoing management rather than

Make better use of post-closure management funds essential to clarify the vision for closure ~ at the beginning of life of mine. It is

essential to clarify the vision for closure at the beginning. scenarios.

Straspects also a participation Bora - this is if key interest to communities.

Long-term, vegetation establishment is crucial. Engage community on which part of environment they value mosit which part of environment they value most which part Really need to improve monitoring programs (start monitoring even earlier) to tso much, and adapt according to community preferences

Issues – core themes

Need for improved scientific understanding of deposit knowledge Challenges aligning science and operations decision making

Need for greater alignment of accountabilities Need for better stakeholder engagement and collaboration Poor decision making due to unsuitable metrics / tools / models



Opportunities – core themes

Improve knowledge of source control, remediation and value opportunities Develop a common language across professional teams

Enhance standards, governance and regulation

Enhance communication and collaboration with communities

Quantify residual risk to improve the business case



Table 1 Links across issue and opportunity themes.

lssues	11. Need for improved scientific understanding or deposit knowledge (enhancing the biophysical science)	I2. Challenges aligning science and operations for decision making (internal focus)	13. Need for greater clarity around accountability and internal values	I4. Need for comprehensive stakeholder engagement / collaboration (external focus)	IS. Poor decision making via unsuitable metrics / tools / models currently used
Opportunities					
01. Improve knowledge of source control, remediation and value opportunities	~	~			
O2. Educate and inform professionals (internal focus)	~	~	1	~	~
O3. Enhance standards, governance and regulation			~	~	~
O4. Enhance communication and collaboration (external focus)			~	~	
O5. Meeting the Long-term objective – quantify residual risk for improving the business case		~	~	~	~



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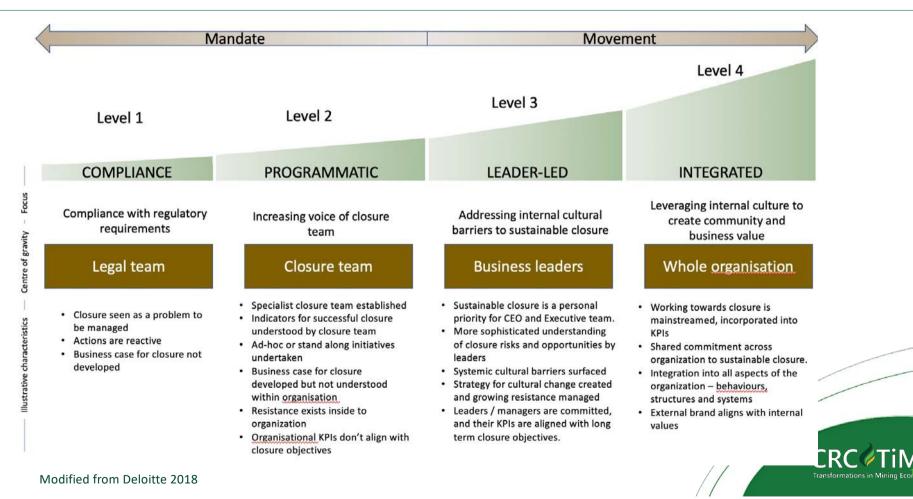


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O3. Enhance standards, governance and regulation			~	~	~
O4. Enhance communication and collaboration (external focus)			~	~	
O5. Meeting the Long-term objective – quantify residual risk for improving the business case		1	~	~	~

- A. Enhancing the business case for AMD management
- B. Engagement, communication and education.
- C. Standards and governance.
- D. Understanding the science of AMD.





Short Term (0-3 years)	Medium Term (3-6 years)
Enhancing the business case for	improved AMD management
Develop methodologies to support the required transitions in organization maturity relating to mine closure generally, and AMD management specifically.	Improve frameworks to adequately quantify risks and opportunities throughout mine-of-life, particularly for mine closure planning and associated residual risks.
Undertake a case study audit of KPIs and their timeframes, across the whole of business, identifying where conflicts arise for AMD management.	



Short Term (0-3 years)	Medium Term (3-6 years)			
Educate and inform cross-disciplinary professional teams				
Identify skills needs and education required to capture closure challenges in the business case for improved AMD management.	Deliver educational resources for cross- disciplinary teams, to facilitate a shared understanding of AMD risks.			



Short Term (0-3 years)	Medium Term (3-6 years)	
Understand community aspirations for AMD-affected lands		
explore how to improve traditional owner and community awareness of AMD.	Develop effective AMD communication resources with adequate language and messages for different stakeholder groups, based on their	
Explore opportunities for two-way science with raditional owners of AMD-affected lands.	concerns.	
Use traditional owner and community aspirations for the future use of AMD-affected lands, to drive AMD and closure research.	Develop platforms to share (anonymised) operational data for benchmarking and to improve community and investor engagement.	
	Select demonstration sites and develop case studies of both failures and success in AMD management and the relinquishment of AMD- affected land.	

Short Term (0-3 years)	Medium Term (3-6 years)		
Enhance standards, governance and regulation			
Develop approaches for governance of regional- scale AMD management, with consideration for cumulative impacts on regional economies.	Review and evaluate the decision-making processes that underlie the existing permitting conditions with respect to AMD (water pollution).		
Assess operational and regulatory barriers that may limit social and environmental monitoring and reporting, and the associated liabilities.	Develop new regulatory approaches that can be used to improve outcomes, based on specific site-level environmental constraints.		



Short Term (0-3 years)	Medium Term (3-6 years)			
Improve knowledge of source control, remediation and value opportunities				
Improve our understanding of source control and materials handling through accurate forecasting of AMD.	Develop predictive models of current and future AMD risk, to support long-term AMD governance.			



Implications



- Insight into socio economic political barriers to implementing acidity reduction approaches throughout life of mine
- Clarified where CRC TiME can contribute to the issue
- Our findings are being embedded within CRC projects e.g. pit lakes project
- Work on organisational cultural change will require strong engagement with partners.
- Understanding aspirations of mining communities will require strong engagement with communities
- Demonstrated of the usefulness of open space technology approaches on contested issues.





Lake Kepwari, relinquished coal pit lake, Collie WA

THANK YOU

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