Mining Legacies – Understanding Life-of-Mine Across Time and Space

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ABSTRACT

The Australian mining industries approach to life-of-mine planning has improved considerably in recent decades. It now needs to be matched by, and embedded in, mining governance systems that utilise a comprehensive whole-of-mine-life approach within a jurisdictional, industry and regional regime rather than just focusing on specific impacts in isolation. The need for a more comprehensive approach is supported by the many mining legacies, from historic, recent and some operating mine sites around Australia. There are sites that are leaving enduring environmental, community and public health impacts that are yet to be accurately assessed. While a number of these sites in Australia are estimated to be more than 50 000, this is probably an underestimation, with a lack of data and different state-based approaches complicating attempts to quantify mining legacies as a national issue. Qualitative assessments about the extent and nature of mining legacy impacts on nature and communities across Australia are also required if we are to understand and avoid ongoing and future mining legacies.

This paper commences with an exploration of mining legacies as an umbrella term for previously mined, abandoned, orphan, derelict or neglected sites. This is followed by a discussion of the current status of mining legacies as an Australia-wide issue, contrasting the Australian response with overseas examples. Common themes from past workshops are explored recognising that mining legacies are a growing public policy issue and identifying key ingredients for a successful response. Supporting this, and based on national data which re-enforces the need for action, is the changing scale and intensity of mining in Australia that, while lowering costs for mine operators, increases the liability that may eventually fall to the state if mine sites are not rehabilitated effectively. Though a national issue, mining is a state and territory responsibility, so the current approach to mining legacies is then examined state-by-state. Given the widespread application and recent changes to bonds and levies in Western Australia (WA) and the Northern Territory (NT) the merits of both are examined with reference to specific case studies. Despite the current division of responsibility and diversity of approaches, however, mining legacies remain a significant and growing problem with a recognised need and repeated call for cooperation and coordination at a national and international level. Future action is addressed in the final section with reference to liability, responsibility, industry reputation, regulation and leadership.

MINING LEGACIES – DEFINING TERMS AND UNDERSTANDING THE PROBLEM

With no coordinated or standardised policy on legacy mines nationally or even shared definitions for common terms, it is important to establish these clearly. Traditionally and confusingly, terms for mining legacies have been used interchangeably, as well as to delineate different aspects. This lack of clarity has been evident for some, with the 2003 *Management and Remediation of Abandoned*

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Mines workshop held in Brisbane (Bell, 2003) identifying the need to define abandoned mines and an international workshop held in Chile (UNEP and Cochilco, 2001) identifying the lack of a clear definition and the absence of criteria and standards of rehabilitation as a cause of inaction and any real progress on abandoned mines.

This paper uses mining legacies as an umbrella term encompassing abandoned, orphan and derelict mine sites, building on previous work by Worrall *et al* (2009) and Whitbread-Abrutat (2008). Both papers also define mining legacies as an umbrella term, referring to the negative legacies (impacts) of mining. Worrall *et al* (2009) defined legacy mined land as:

> *… land which has been mined and is now being used for another purpose, or is orphaned, abandoned or derelict and in need of remedial work …* (p 1429).

Following feedback from a survey as part of the Post-Mining Alliance's Eden Project in the United Kingdom, Whitbread-Abrutat (2008) modified his definition of a negative mining legacy to:

> *... the impacts of a closed mine that continue to negatively affect the environment or associated communities* (p 3).

He then further divided this into:

- *abandoned sites 'where the owner is known, but for some reason, is unable or unwilling to take the necessary remedial action'*
- *orphaned sites 'where the legal owner cannot be traced'* (p 3).

In Australia the term 'abandoned mines' dominates, though the often-cited definition of abandoned mines from the *Strategic Framework for Managing Abandoned Mines* (MCMPR and MCA, 2010) is more restrictive. It defines abandoned mines as:

> *… mines where mining leases or titles no-longer exist, and responsibility for rehabilitation cannot be allocated to any individual, company or organisation responsible for the original mining activities* (p 6).

Although containing some of the same components, the MCMPR-MCA definition of abandoned mines is clearly different to Worrall *et al* (2009) or Whitbread-Abrutat's (2008) and restricts the focus to where titles or leases no-longer exist. While it can be important to distinguish between abandoned and orphan mines in terms of responsibility, liability, solutions and management response; to focus only on abandoned mines is to ignore the problem that exists in existing leases and titles. In contrast, the Canadian 'National Orphan/Abandoned Mines Initiative' (NOAMI) addresses both areas.

Perhaps a change of emphasis is slowly occurring with the 2012 workshop (Unger, 2012a), despite often referring to abandoned mines, being called the *Managing Mining Legacies Forum*. Similarly, Unger, who has featured in much of the recent work on mining legacies in Australia, also refers to mining legacies (Unger, 2012a, 2012b). In their discussion paper for The AusIMM, Unger and Van Krieken (2011) utilised a definition for 'negative mining legacies' reflecting Whitbread-Abrutat (2008). Interestingly, The AusIMM's policy, released in June 2013 (The AusIMM, 2013), has used the more restrictive term of 'abandoned mines' although their policy does cover abandoned and orphan sites that:

> *... require rehabilitation and/or management but the owner of the site is either unable to be located or is unable or unwilling to undertake the required rehabilitation and/or management of the site* (p 1).

Alternatively, mining legacies could be understood in relation to completion criteria. That is, success is meeting specific criteria, where the failure to achieve effective closure results in a negative mining legacy. Whitbread-Abrutat, Kendle and Coppin (2013) offer a conceptual effective closure goal as meeting:

> *… the expectation that future public health and safety are not compromised, that the after-use of the site is beneficial and sustainable to the affected communities in the long term and that adverse socio-economic impacts are minimised and socio-economic benefits maximised* (p 638).

While it lacks an overt focus on environmental health, defining mining legacies by success provides a positive goal. Worrall *et al* (2009) provide a more detailed understanding of successful closure, or its absence, with their principles-criteria-indicators framework. This could be used as the basis for setting a clear direction for a successful response to mining legacies for Australian. To paraphrase UNEP and Cochilco (2001), mining closure and mining legacies can be considered two sides of the same coin.

Defining the issue using mining legacies, encompassing all sites requiring management or rehabilitation, allows a more complete and comprehensive discussion of the problem, providing for appropriate solutions, rather than limiting the focus. This paper will follow Whitbread-Abrutat's (2008) definition, and that found in Unger and Van Kriekan (2011), of mining legacies and its subsets, recommending them as appropriate for the Australian context. It also is informed by the need for conceptual goals and stricter criteria in working towards a solution for mining legacies rather than being stalled by the extent and complexity of the problem.

MINING LEGACIES, AN INTERNATIONAL AND AUSTRALIAN PROBLEM

Australia has more than 50 000 mining legacy sites, as shown in Figure 1; though more accurate and probably higher figures has been restricted by unclear definitions, different classification systems and a lack of data (Unger *et al*, 2012). These sites can range from a shallow excavation, costean, adit or shaft to a major mining legacy site such as Mt Morgan in Queensland (Qld; Unger *et al*, 2003), Redbank in Northern Territory (NT; EcOz, 2009), Mt Lyell in Tasmania (Tas; Koehnken *et al*, 2003) or numerous other less well documented sites (eg Mt Todd, NT; Woodsreef, New South Wales (NSW); Mt Oxide, Qld; Mt Gunson, South Australia (SA); Teutonic Bore, Transvaal, Black Prince, Western Australia (WA); etc). While not all are 'legally' abandoned, the sites examined by Laurence (2006), provide various reasons for premature closure, which has and could lead to more mining legacy sites in Australia.

Australia is not alone in realising it has a problem with mining legacies. Since 2000 international attention on mining legacies has come from the World Bank, the International Finance Corporation, the United Nations Environment Programme, the World Conservation Union and the International Council on Mines and Metals. National leadership has also been shown most notably from NOAMI (Tremblay and Hogan, 2012) in Canada and the Post-Mining Alliance in the United Kingdom (eg Whitbread-Abrutat, 2008). These initiatives, reports and workshops are synthesized into a timeline in Table 1.

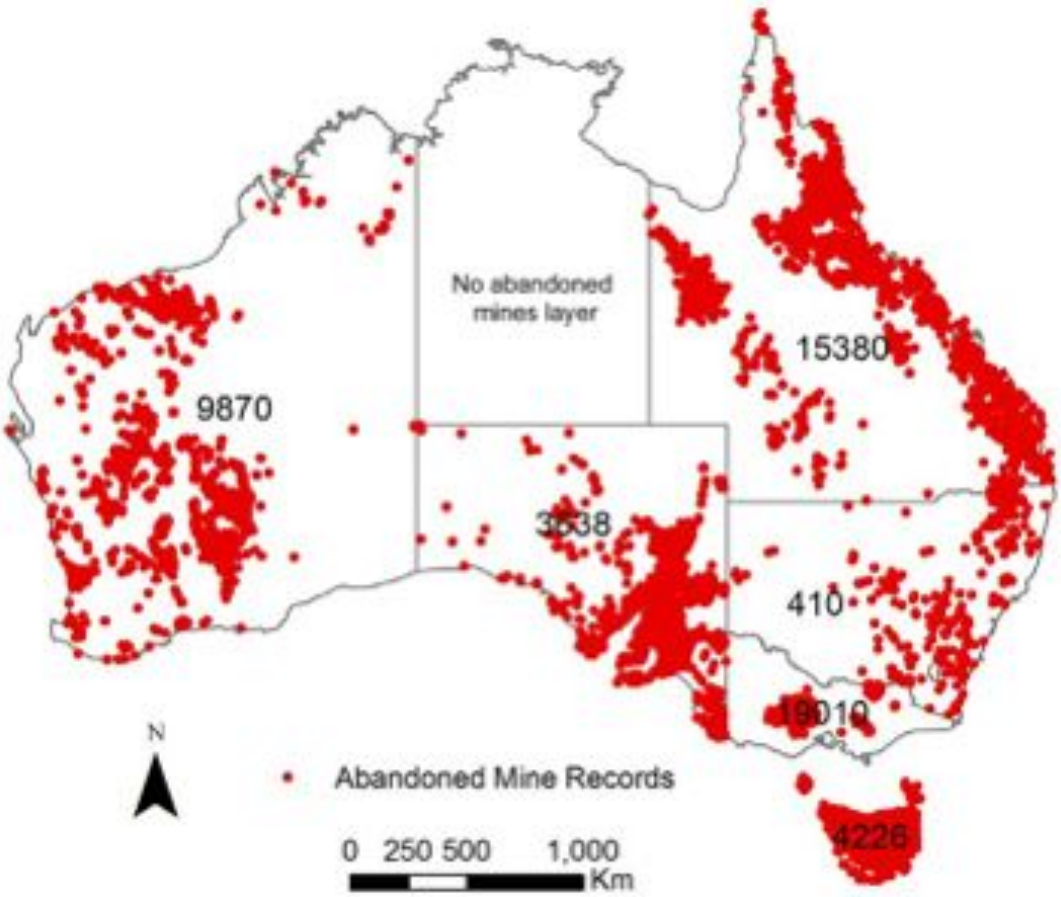

FIG 1 – Australia legacy mines, July 2011 (Unger *et al*, 2012).

TABLE 1
An international selection of mining legacy events and publications since 2000.

Year	Author/organiser	Type	Description	Focus
2000	Mining Watch Canada	P	Mining's toxic orphans	Canada
2001	UNEP and Cochilco	P	Abandoned mines – problems, issues and policy challenges for decision makers	International
2001	Canadian Governments	W	Workshop on orphaned/abandoned mines in Canada	Canada
2002	WB/IFC	W	It's not over when its over: mine closure around the world	International
2002	NOAMI	I	NOAMI established	Canada
2003	ACMER	W/P	Management and remediation of abandoned mines	Australia
2005	MCMPR	I	Formation of the Abandoned Mines Working Group	Australia
2006	NOAMI	W	Orphaned and abandoned mines: a workshop to explore best practices	Canada
2008	IUCN-ICMM	W/P	Roundtable on restoration of legacy sites	International
2008	NOAMI	W	Workshop to explore perspectives on risk assessment of orphaned and abandoned mines	Canada
2010	MCMPR/MCA	P	Strategic framework for managing abandoned mines in Australia	Australia
2011	MCMPR	I	MCMPR replaced with SCER, AMWG no longer active	
2011–2012	AusIMM (Unger and Van Krieken, 2011)	P	Abandoned mines discussion paper, survey and report	Australia
2012	AusIMM/SMI-CMLR/ Corinne Unger	W/P	Mining legacies forum and report	Australia
2012	AusIMM/SMI-CMLR/ Corinne Unger	P	Value proposition for a national abandoned/ legacy mine hub at CMLR, SMI, UQ	Australia
2013	AusIMM	P	AusIMM Abandoned mine policy statement and annexure	Australia

P – publication/report; I – initiative; W – workshop; UNEP – United Nations Environment Programme; WB – World Bank; IFC – International Finance Corporation; NOAMI – National Orphan/Abandoned Mines Initiative; ACMER – Australian Centre for Mining Environmental Research; MCMPR – Ministerial Council on Mineral and Petroleum Resources; IUCN – International Union for the Conservation of Nature; ICMM – International Council on Mines and Metals; MCA – Minerals Council of Australia; SCER – Standing Committee on Energy & Resources; AMWG – Abandoned Mines Working Group; SMI – Sustainable Minerals Institute; CMLR – Centre for Mined Land Rehabilitation; UQ – University of Queensland.

Common elements in many of the mining legacy focused reports, initiatives and workshops is the identification of:

- mining legacies as a growing problem, in number, scale and complexity
- that mining legacies reflect poorly on the mining industry which is under increasing scrutiny and community expectations for successful mine closure
- the need for better data and data management
- understanding the problem/agreeing on definitions
- financial liability to state/community, different models to pay for clean-up
- consideration of legal liability
- the need for community involvement
- the need for a collaborative national and international plans and guiding bodies
- the slow rate of progress (see Table 1).

At a national level, research and advocacy for an effective response to mining legacies was lead initially by the workshop on the *Management and Remediation of Mines* (Bell, 2003) that identified a clear summary of issues. While more detailed than the outline of the international reports and proceedings above, most of the issues are nonetheless covered in the nine points. One difference was the focus on public safety in Australia, which seemed to be stronger than the environmental focus, perhaps influenced by current state approaches or by underestimating or misunderstanding the scope of the problem. There was also a strong emphasis on cooperation, leadership, seamless integration, information sharing and coordination. With a clear and prescient warning the 2003 workshop identified that 'high level agreement', leadership and coordination was required if action on mining legacies was to be successful at a national scale (Bell, 2003).

Almost ten years later, the Australian *Managing Mining Legacies Forum* was organised by and held at the Centre for Mined Land Rehabilitation (CMLR), part of the Sustainable Minerals Institute (SMI) at the University of Queensland (UQ). Many themes, similar to those above, were identified, including:

- the need for a national hub (aka NOAMI)
- full liability accounting to understand the scale of the issue
- knowledge sharing
- funding issues/opportunities
- the need for same high standards as for active mines
- data and knowledge sharing, cooperation (Unger, 2012b).

The lack of progress in Australia at that time contrasts with the Canadian experience. There, the catalyst for action was a civil society report in 2000 by Mining Watch Canada entitled *Mining's Toxic Orphans: A Plan for Action on Federal Contaminated and Unsafe Mine Sites* (MWC, 2000; Unger, 2012b). The report documented 10 000 mining legacy sites and over C$1 B in liabilities. This lead ultimately to NOAMI, a multistakeholder group and 'hub' formed to facilitate a planned and coordinated response to mining legacies. While NOAMI has achieved progress at some of the worst sites, including Giant Mine and Britannica, a lack of funds commensurate with the task means progress is slow. Despite NOAMI only having responsibility for 690 sites, it is estimated that it will take another 83 years to address these at its current pace, though this will still require an additional C$1.2 B in federal funds (Shields, 2014). Nevertheless, NOAMI is a good example, from a country with similar division of state/federal responsibilities, of the leadership and coordination that has been called for in Australia since 2003.

THE GROWING CHALLENGE OF MINING LEGACIES

Depending on size and seriousness of impact, mining legacies are a threat to human safety, the environment, socio-economic health and sustainability, culture and even aesthetics (Worall *et al*, 2009). Traditionally some jurisdictions may have focused more on human safety and had a narrower definition of potential impacts, the debate and community expectations have moved on from just boarding up shafts and fencing open cuts. As our understanding of on-site impacts grows, so too does our understanding of off-site, cumulative and perpetual impacts. The occurrence, extent and impacts of and acid and metalliferous drainage (AMD, also known as acid mine drainage) at many mining legacy sites is probably the best example of the importance of and need to address all of these impacts. For example, Koehnken *et al* (2003) predict Mt Lyell as having an AMD discharge that will last 'for many hundreds of years' (p 65) if left untreated. Examples of AMD impacts and other legacy mines are shown in Figure 2.

Intensity, spatial and temporal scale

The scale, intensity, risks and impacts of mining have changed significantly since mining first started at Australia's various mining regions. While not universal to all commodities or situations, this has been influenced by: declining ore grades; a transition/expansion from underground to open cut mining; increase in impurities; an increase in mine waste and extent of disturbed area; increasing waste rock to ore ratios; and often an associated increase in resource and energy intensity (such as GJ or m^3 water or t CO_2/t metal) (Mudd, 2010; Prior *et al*, 2012).

Western Australia provides relevant examples with gold, nickel, copper and zinc all showing declining ore grades; a four-fold expansion in mined tonnages since the late 1980s; an increasing arsenic risk associated with some Kambalda nickel ores; and increase in waste rock and disturbed areas mainly associated with iron ore (Roche and Mudd, 2014). As industry trends, these represent a major escalation in mining activity that could translate to an increase in impact and liability if future mining legacies are not avoided.

While little work has been done on cumulative impacts of mining legacies, recent work on the cumulative impact of mining is relevant. Therivel and Ross (2007) make a strong case for cumulative effects assessment which should consider 'scale issues, spatial extent, level of detail and temporal issues' (p 365). This approach to mining would result in different mine waste solutions, better assessment and regulation leading to reduced mine legacy impacts and risks. Similarly, looking at project expansions as trajectories of change, both temporally and spatially, could provide the

King River, effectively biologically dead due to more than a century of acid and metalliferous drainage (AMD) and other mining impacts from Mt Lyell, in Queenstown, Tasmania (February 2014)

Acidic drainage (pH ~3.5) line from the closed Tabletop gold mine, Croydon goldfield, Queensland (July 2011; note solar panels for pumps and pipe/valve leak)

Visual evidence of acidic water in the Transvaal open cut, Southern Cross goldfield, Western Australia (July 2013)

Lack of rehabilitation, Black Prince mine, Forrestania region, Western Australia (July 2013)

Unrehabilitated asbestos tailings pile on exposed ridge, Woodsreef mine, New South Wales (July 2012)

FIG 2 – Examples of acid and metalliferous drainage and other aspects of selected legacy mines (all photos: Mineral Policy Institute).

opportunity to correctly identify and then address potential mining legacies before they can develop (Banks, 2013).

Mine closure and perpetual impacts

While there may be a perception that mining legacies are history, remnants of a less responsible mining industry prior to the introduction of modern environmental assessment and regulation, the truth is that mines continue to close and cause perpetual impacts (Dold, 2008; Kempton *et al*, 2010; Unger and Van Krieken, 2011). Indeed, one reason for adopting the wider term, mining legacies, is to include more recent mine sites. These could be closed or abandoned, on current and existing leases or where the owner is known but unwilling to assist, such as BHP's former Goldsworthy iron ore mine in Western Australia. In a study of approximately 1000 sites that closed between 1981 and 2005, Laurence (2011) found that at around 75 per cent of the sites, closure was premature or was unplanned. Associated impacts include:

- environmental – AMD, tailings, waste rock and voids
- socio-economic – employee, contractor and business problems, demise of indigenous opportunities and even death of a town
- health and safety – hazardous substances, steep open cut faces, vertical openings.

While the percentage of these sites that remained mining legacies is unknown, it would be irresponsible to assume that unplanned closures were just historical events or temporary situations, especially given the current constriction of the mining industry.

Laurence (2006) details a useful model for effective mine closure planning, which if implemented would address many of the impacts above. It would, however, require remarkable discipline by the industry and regulators, and more likely legislation and better resourcing, to ensure that up-to-date closure plans exist for unplanned closures, as well as the quarantined funds to complete them. Without substantial reform it seems unlikely, as Laurence notes, since reputations are rarely built by successfully closing a mine. Whereas new mines are greeted with corporate fanfare, excitement and political support, unplanned mine closures are orphans, marked by corporate demise or dysfunction, the absence of political enthusiasm, the departure of employees and the loss of opportunity for local business.

A pollution prevention and cleaner production is also required to reduce Australia's future mine legacies liability (eg Hilson, 2003). This requires improved planning, government leadership, regulation and financial incentives to ensure an even-playing field for companies willing to adequately prepare for unplanned closure and embrace cleaner production to achieve substantially reduced mining legacy risks.

Related, but perhaps harder to respond to, is the issue of perpetual environmental impacts, the need to assess and respond to them, as well as funding, where necessary, their ongoing management. The question is: at what point does a perpetual mining impact, such as AMD, become a public liability as a mining legacy? In the United States the potential impact and importance of AMD as a perpetual impact has been known for many years. In 1997 the US Environmental Protection Agency (US EPA, 1997) identified AMD as 'the most serious environmental threat of current hard rock mining' (p 3), noting that some mines 'may require water treatment in perpetuity' (p 4). A minimal list of Australian examples of AMD mining legacy sites include Mt Lyell, Tom's Gully, Mt Todd, Carrington, Rum Jungle, Mt Oxide, Mt Morgan, Kurri Kurri, Benambra, Sunny Corner, Teutonic Bore, Redbank, Zeehan, Brukunga, Captain's Flat, amongst numerous others.

To date, a thorough inventory of the rehabilitation status and ongoing risks, such as AMD, erosion, subsidence, biodiversity and ecosystem integrity, or public health and safety, from all former mines across Australia remains elusive. Furthermore, given the rapidly expanding scale of mining activities, this makes it ever more urgent to understand future risks based on better understanding of the scale of the mining legacy challenge we already face.

MINING: A STATE AND TERRITORY RESPONSIBILITY

Despite the early and ongoing recognition of the importance of a national strategy or policy and hub, as outlined earlier, mining legacies remain a state/territory responsibility with little national coordination or leadership. Every state and territory seems to have different views about mining legacies, different solutions, funding arrangements, prioritisation of the issues and even different government agencies that deal with mining legacy issues. While some states and territories have recently developed policies on legacy mines and different strategies to raise funds to begin the task of rehabilitating sites; a national hub and strategy seems no closer than in 2003.

The following section describes the different policy or regulatory frameworks in the states and territories, then examines these with reference to case studies. Significant differences between the states/territories are apparent when it comes to the number of sites, policy/program responses, age of initiatives and funding arrangements. All descriptions are based on informal telephone interviews with relevant departments and material readily available to the public, with some jurisdictions providing more detail and clarity than others. An overall summary is provided in Table 2 (it should be noted that the number of sites varies depending on whether a mine site is considered as a whole or tailings dams, shafts, open cuts, waste rock dumps, etc, are considered separately – again reinforcing the need for standard definitions and terms).

TABLE 2

Approximate number of mines or mining-related features and current approaches to mining legacies in states and territories.

	Number of sites (approximate)	Mining legacies policy/program	Year established	Bonds	Fund for legacy rehabilitation
NT	Unknown	Under development	2013	Yes, 100% of mine closure costs	Yes, Mining Remediation Fund – 1% levy on new mines – invested
WA	88 705 (Ormsby, Howard and Eaton, 2003)[a]	Under development	2013	Bonds can be applied by the Minister for special cases. Government plan to move away from bonds	Yes, Mining Rehabilitation Fund – 1% levy on new mines – invested
Tas	4036 (Gurung, 2001)	No	1995	Yes	Mining Lands Trust Fund – but there is no clear income
NSW	573 (NAGO, 2012)[b]	Derelict Mines Program	1974	100% of mine closure costs	*Ad hoc* – through acquisition of mining machinery that is put in a fund and invested
Qld	15 000 (Unger *et al*, 2012)	Abandoned Mine Lands Program	2001	Yes	No
SA	3000 (Unger *et al*, 2012)	No	2009	Yes	Not entirely. There is an Extractive Areas Rehabilitation Fund (coal, oil, sand, gravel) – no fund for minerals, ie CU, Ag, Ur
Vic	19 000 (Unger *et al*, 2012)	No	NA	Yes, 100% of mine closure costs	No

[a] – For Western Australia this is the number, as of 2002, of mining-related features (eg tailings dams, waste rock dumps, shafts, open cuts, infrastructure, etc). [b] – Based on the extent of the mining industry across New South Wales (NSW) (eg gold, copper, tin, coal), this number is likely to be an extreme under-estimate (especially in comparing say all other states/territories to NSW).

Tasmania

Tasmania has no official policy on mining legacies. It does, however, have a bond system and a trust fund, though it could not be considered an adequate funding arrangement for addressing Tasmania's mining legacy liabilities – in particular where there is no liable company and no ongoing commercial interest. On average $160 000 a year is spent on rehabilitation works generated by the appropriation and sale of machinery or buildings left on abandoned sites and forfeited security deposits. Rehabilitation activities sites have simply included capping shafts, revegetation, soil and water sampling, baseline surveys, improving drainage, works on tailings, weed control and seed collection.

Of the 681 metal-related abandoned mines in Tasmania, 215 pose a threat to the environment with acid producing rock – the root cause of AMD (Gurung, 2001). Unfortunately, there seems to be no clear time frame, ambition or source of finance to address the 215 AMD sites, despite the significant environment risks from AMD. In 2013 the Tasmanian Environmental Protection Agency (EPA) acknowledged that the clean-up of the 215 sites will not be funded through the Trust (TMC, 2013). This has been accompanied by increased expectations that new mine proposals in Tasmania could shift the responsibility of rehabilitating the abandoned mines within new mine leases on to new companies.

Victoria

Victoria has approximately 19 000 legacy sites (Unger *et al*, 2012) but there is no official policy on mining legacies or a funding mechanism for rehabilitation. Until early 2014, Victoria had a system of 100 per cent closure bonds but this has now been relaxed. The responsible agency, Earth and Energy Resources (EER) of the (now former) Department of Primary Industry, has no policy, program or fund in place to rehabilitate legacy mine sites in Victoria.

Curiously, given the historic importance of the gold rush era, many legacy mines are now protected under the *Heritage Act 1995*. There are a few small abandoned open cut mines, some abandoned quarries spoil dumps and the odd dredge with heritage listing. Mining infrastructure, however, has largely disappeared over time through scavenging and/or decay.

While there are some issues with As in tailings around the goldfields (EPAV, 2009; Pearce, Dowling and Sim, 2012), EER's priority is in community education and awareness programs on As in sands

and tailings rather than rehabilitation. The EER has no position on either identifying shafts or filling them in. Although there have been instances where the EER have remediated abandoned sites, it has been done in an *ad hoc* way based on the situation (such as media attention) rather than any legislated responsibilities. While the EER has recently undergone some regulatory change, the focus is expected to remain on compliance rather than implementing a policy of rehabilitation.

New South Wales

The NSW Department of Trade and Investment, Resources and Energy (now former DTIRE) began the Derelict Mines Program in 1974 (DTIRIS, 2014), although there is no guiding policy or statutory responsibility to rehabilitate abandoned mines. Despite this program being the first program in Australia to address the issues of mining legacies there are still an estimated 573 sites in NSW (NAGO, 2012). In 2011–2012 there were 27 sites with rehabilitation works done costing $2.1 M, including the Belmont mineral sands, Ardlethan tin and Home Rule gold mines. It remains unclear how much future rehabilitation, if any, work needs to be done on these and all other sites.

Funds for the Derelict Mines Program have been generated through the acquisition and sale of abandoned mine processing plants, from investing the money within the fund, money from security deposits, and through appropriation of money from the Minerals and Petroleum Administrative Fund by Parliament or approved by the Minister. The NSW Auditor General's Office (NAGO, 2012) argues that 'derelict mines may represent the State's largest category of contamination liability' (p 16), raising serious concerns about the capacity to fund ongoing rehabilitation needs. This has led to new calls for an audit into the total liability of NSW legacy sites and calls for a 2020 deadline to rehabilitate.

Queensland

The Department of National Resources and Mines (and predecessors) established an Abandoned Mine Lands Program (AMLP) in 2001 (NRM, 2013a). Although they claim that 'Queensland spends more on the management of abandoned mine sites than the rest of Australia combined' (NRM, 2013a) – they have no policy or guidelines available on their website, no consistent accounting nor reporting of rehabilitation works and costs. Despite this lack of transparency and accountability, they have managed to repair thousands of abandoned shafts where other states and territories have not (eg the Gympie goldfield has seen >2100 shafts capped by concrete or other means; NRM, 2013b).

Recently there have been examples of sites where the AMLP have conducted work, but have not eliminated the pollution risks of As or acid mine drainage (McCarthy, 2013). In 2009 severe flooding in Queensland exposed the very serious environmental risks posed by legacy sites, with the overflow of AMD waters from the Mt Morgan open cut in early 2013 being another major example.

Northern Territory

The NT Department of Mines and Energy (NT DME) is addressing mining legacies through the establishment of a Mining Remediation Fund (MRF) introduced through parliament as part of the Mining Management Amendment Bill 2013 (MMA) (NT DME, 2013). The MRF requires a one per cent levy from all operating mines, the fund will be invested and interest raised from the investments will be used for the rehabilitation of legacy sites. The NT DME estimate the liability of all NT legacy sites to be in excess of $1 B, and expect to raise $6 M in the MRF's first year.

The NT will still be required to have a 100 per cent bond for mine closure as well as the non-refundable levy (NT DME, 2013). The first major job will be to identify and assess the NT's legacy sites, meaning they are still a long way off initiating rehabilitation work. Whilst the MRF is a good start to addressing the NT's serious legacy sites, as part of the new arrangements under the MMA the NT DME has removed the requirement for annual environment reporting at operating mines – decreasing transparency at a time when more is needed.

South Australia

SA's policy on mining rehabilitation differs from other jurisdictions. Firstly they categorise mining into two sections, extractives and non-extractives. Extractives are defined in the *Mining Act 1971* as sand, gravel, stone, shell, shale or clay, whereas non-extractives or minerals include metals (eg Au-Ag-Cu-U-Zn). Secondly, the responsibility of rehabilitation of extractive or non-extractive

mines was a responsibility of the State Government from 1972 until 2004 when the responsibility of rehabilitation of non-extractives shifted back to the mining companies. Non-extractives are required to have a bond and there is an expectation these companies will do their own rehabilitation. Future orphaned sites or legacy mines will rely on retrieving the bond – but where the bond falls short there is no guarantee of government funding for rehabilitation.

The SA Government have taken on the responsibility of addressing the rehabilitation of just three sites: Radium Hill U mine, Port Pirie U processing facility and Brukunga iron sulfide mine (DMITRE, 2014) (although it should be noted these were all SA government projects in any case).

Extractives miners are required to pay a levy (50 per cent of the royalty they pay to the State or 10 c/t) which makes up the Extractive Areas Rehabilitation Fund (EARF). The EARF will be used to rehabilitate sites if the company has not rehabilitated the site or if the site has been abandoned (PIRSA, 2009). There is $17 M in the EARF for extractives only – sand, gravel, stone, shell, coal, oil. This fund grows by $2 M every year. For non-extractives or minerals there is no such fund.

Western Australia

In 2003 the Department of Industry and Resources (now Department of Mines and Petroleum, DMP) completed a field inventory of legacy mines in WA, noting some 88 705 mining-related legacy features such as tailings, waste rock dumps, open cuts, shafts or other infrastructure (Ormsby, Howard and Eaton, 2003). Although the inventory has been updated in digital form to 2011 (GSWA, 2012), very little action to address the challenges of the enormous number legacy mine features appears to have been undertaken.

In 2013 the DMP established the Mining Rehabilitation Fund (also 'MRF') to raise funds for the rehabilitation of legacy mine sites that already exist as well as future sites. The MRF will raise money through a non-refundable mining levy on new mines, calculated on disturbance area, risk and level of impact. The fund will be used as an investment fund, with the profits generated from investments to be used to fund rehabilitation of existing legacy mines. The MRF began operating in July 2013 for a one-year voluntary period and becomes compulsory from July 2014. Within the first two months of the voluntary MRF scheme the Government paid back $84 M in bonds and recouped $2.2 M in non-refundable levies. Within six months the DMP has relinquished $221 M in bonds and recouped $5.1 M into the MRF. The WA MRF has removed requirements for bonds, however, there will be some retention of bonds of existing mines entering the MRF and the Minister will retain powers to require bonds for new mines.

FINANCIAL MECHANISM TO PREVENT AND ADDRESS MINING LEGACIES

Mechanisms for addressing legacy mines have been diverse and with varying degrees of success. NSW, Tasmania and Queensland have a longer history of proactively working on rehabilitation but with poor funding arrangements and without significant progress. Efforts have been hampered by insufficient or absence of bonds to cover the costs of rehabilitation, with the sale of infrastructure at sites not generating sufficient funds. The NT and WA are developing new mechanisms and plans to address this problem of inadequate funding arrangements. This section will discuss levies and bonds, including specific dis/advantages, supported by examples from around Australia.

The mining levy

Both the NT and WA governments have developed a one per cent levy on new mines (and WA retrospectively in exchange for bonds) to address current legacy sites. In WA the fund has been designed to fund any future legacy mine sites this has been part of the justification for removing requirements of bonds. Profits from investments will be used for existing legacies but the fund itself will be made available in the future for new legacy sites. In WA the fund contribution rate is proposed to be one per cent of the rehabilitation liability estimate, whereas in the NT an annual levy of one per cent on the total calculated rehabilitation cost will be applied.

Advantages of mining levies

- Places the burden of financing rehabilitation work on the mining industry.
- Could potentially fund the rehabilitation of current legacy sites and provide a safety net for the future.

Disadvantages of mining levies

- Where there is no bond or punitive measures made available to regulators (for example the WA MRF), the levy provides no incentive for meeting mine closure objectives and a lack of consequences for not meeting them.
- Levies implicitly endorse new mining to generate the funds. The need for or priority of raising funds could exacerbate or deepen a perceived dependence on the mining industry.
- It is unclear how quickly the funds can be generated. There is no clear time frame on investments, returns and the allocation of funds for works. Like other mechanisms for rehabilitating legacy sites, it could simply fail to move into action.

The bonds system

Most states and territories have developed a bonds system for mines. Bonds systems can be categorised as the 'upfront or gradual set-aside or guaranteeing of expected clean-up cost' (Peck and Sinding, 2009). Bonds systems have commonly been criticised for falling short of meeting the actual mine closure costs. The only way to ensure a bond does not fall short is to develop a system that can accurately calculate the cost of mine closure and for this to be annually reviewed and adjusted reflecting performance milestones or non-compliance with any incremental mine closure requirements and to legislate that all mines need a bond equivalent to 100 per cent of actual closure costs, rather than an optimistic or best case scenario.

Between the States and Territories there are a diversity of bonds arrangements and exemptions, with a growing trend towards increasing bonds to 100 per cent of estimated closure costs. With WA's MRF, however, they are planning to remove requirements for bonds while retaining Ministerial powers to require bonds. In WA the bonds system currently in place is estimated to only cover 25–30 per cent of the actual cost of rehabilitation (van Merwyk, 2013). The idea of maintaining a strict bond system to represent the true cost of rehabilitation has been discounted by the DMP because of tying up money that the industry could be investing in new mines and because of industry backlash (WA DMP, 2013):

> *The bonds system does not cover the true cost of rehabilitating abandoned mine sites, and increasing bonds to cover the full rehabilitation costs would impose a significant financial impact on the Western Australian mining industry... Bonds discourage investment by tying up significant funds that could be used for developing a mining project.*

Advantages of bonds

- A full mine closure cost in bonds could provide a good incentive to rehabilitate. Especially if supported by strong regulation and enforcement with criminal liability and punitive financial instruments.
- A 100 per cent bond can ensure that the company responsible for mining is responsible for paying for the rehabilitation. Avoids costing the taxpayer money and improves community confidence in mining.

Disadvantages of bonds

- Many bonds systems have been insufficient in meeting the actual cost of closure (see case studies below).
- Where bonds are insufficient – ie the actual costs of closure are greater than the loss of bonds – there is not a sufficient incentive to rehabilitate (see case studies).
- Ties up funds that could be invested.

Inadequate bonds and government inaction

Redbank, Redbank Copper Ltd (current owner), Northern Territory

The Redbank copper mine operated from 1994 until 1996 when the Cu price dropped making the mine uneconomic (EcOz, 2009). The mine was placed under care and maintenance and remains a prime example of Government not securing any bonds for unplanned rehabilitation and subsequent Government inaction. The site is a source of intense AMD which leaks freely through the water table and via overflow channels to Hanrahans Creek – which is biologically dead due to the severity of

the AMD (see data in EcOz, 2009). Some site photographs of the AMD and its impacts are shown in Figure 3.

The site remains unrehabilitated, nor have there been attempts to remediate the source of AMD and ongoing pollution. In August 2005 Burdekin Pacific Ltd took over as owner and operator, and changed name to Redbank Mines Ltd (now just Redbank Copper Ltd; RC), and sought to develop the site into a commercial mine. RC is a junior exploration company and are not in a financial position to remediate the site and appear to be struggling to secure the required capital to develop the mine given recent market conditions. Future mining at the site has been heralded as way to remediate the site but five years after releasing an EIS the company says they are still 'exploring'. The NT Government is now committed to using the MRF to assist in the clean-up of Redbank and the Mines Minister has commented that this site is a priority. The extent of the impacts and the marginal economics of the project may prevent any attempt to restart the mine with liability then transferring the NT Government.

Mt Lyell, Mt Lyell Mining and Railway Company, Tasmania

The Mt Lyell mine in Tasmania has been a classic example of inaction and extensive mine-derived pollution. In 1997, after several years of field work and research, which included Tasmanian agencies and the Commonwealth's Office of the Supervising Scientist, the final report on remediation scenarios for the Mt Lyell field (Koehnken, 1997) outlined four options – and yet effectively nothing has ever been done to substantially reduce the extensive AMD or mine remove mine wastes along the Queen and King Rivers and along the shores of Macquarie Harbour. Numerous subsequent studies have followed – but rather than move towards remediation, recently the Tasmanian Government has issued a tender for the commercial mining of the source of the AMD at Mt Lyell, a move that is likely to result in more delays. The current estimated liability to clean up the site is $16 M, which will undoubtedly prove to be a significant underestimate if rehabilitation ever begins. Some site photographs are shown in Figure 4.

FIG 3 – Severe acid and metalliferous drainage (AMD) problems at the former Redbank copper mine, Wollogorang region, NT: AMD seeping out from waste rock (A); small high density polyethylene (HDPE)-lined pad for the trial heap leach in 2006 (B); AMD flowing through the water table and into the Sandy Flat open cut (C); biologically dead Hanrahan's Creek, adjacent to Redbank (D) (all photos: Mineral Policy Institute; July 2011).

FIG 4 – Extensive environmental impacts from more than a century of Cu mining in the Mt Lyell field, western Tasmania: bare hills surrounding Queenstown, largely due to emissions from historic smelting (left); train over the Queen River, severely polluted by ongoing acid and metalliferous drainage (AMD) and historic riverine disposal of mine waste (right) (all photos: Mineral Policy Institute; February 2014).

Failure of bonds to meet closure costs

Benambra, Denehurst Ltd, Victoria

The Benambra Cu-Zn mine in eastern Victoria was abandoned in the 1990s after four years of operations, and there was only a very small bond (some $300 000). EER effectively became site owner and had to rehabilitate the site. The EER sold off assets at the site and were granted further funds from the Department of Treasury and Finance. Altogether $6 M was used to rehabilitate the tailings, to remove acid-producing materials from spoils that had been left on the surface and put them in the dump. After Benambra, the Victorian Government required 100 per cent rehabilitation bonds upfront – although this requirement has recently been removed despite the obvious lesson. The project is now named the Stockman project and is being investigated for new development.

Continued corporate responsibility

Goldsworthy, BHP Billiton Ltd, Western Australia

Waste rock containing black shale continues to be stored at 'Billy Goat Hill' and 'Rosemary' within the waste rock there is a high content of pyrite which has led to AMD. The potential for AMD was identified in 1999/2000 (Burrell, 2013) during a routine inspection of the site. A study in 2009, nine years after the initial discovery of AMD, confirmed that there is AMD present but was not irreparable given it had not spread too far (Roga, 2009). It is estimated the clean-up of the AMD at this point will cost $100 M (Santhebennur, 2013), involving the burying of the acid producing rock below the water table – although there is still no formal rehabilitation plan for acid producing rock at the site.

BHP had been trying to sell the site and to be relinquished from any further environmental obligations. The sale has been halted and the WA Government has not relinquished the site, with the ongoing cost and rehabilitation at Mt Goldsworthy remaining the responsibility of BHP. It is possible that maintaining ongoing responsibility for this site occurred because of the size and profile of the company, the establishment of the WA Contaminated Sites Regulations 2006 and the committee that decides whether or not to relinquish responsibility of rehabilitating contaminated lands.

Problem of levies without bonds

Meekatharra, GMK Exploration, Western Australia

Reed Resources Ltd entered into the voluntary period of the WA MRF in 2013 and had their bonds released. Shortly after this transaction their subsidiary company GMK Exploration Pty Ltd, who own and operate the Meekatharra Au mine, went into voluntary administration (Reed Resources Ltd, 2013). The project had become unviable because of lower than expected ore grades. Reed Resources remains solvent and in their ASX statement following the decision, stated they would work with the Administrators to retrieve value from the project. It is unclear what that means for the activity on the site towards rehabilitation, or whether it could be sold to another company. This example,

though still unfolding, highlights the major concern with the MRF: with no bonds in place and with no punitive measures for non-compliance of mine closure obligations in the Mining Act there is no incentive for the company or its administrators to rehabilitate a mine site.

Rehabilitation through new mine developments/partnerships

Multiple sites, Tasmania

There are some examples of partnerships between government and mining companies for new mines to take on responsibilities for rehabilitating legacy sites within new or proposed mine leases. Particularly in Tasmania this arrangement is promoted by Government and industry. There are examples where this approach is working and examples where it has not been implemented. For example, the Savage River Rehabilitation Program (EPAT, 2013) is a partnership between the Tasmanian Government and Grange Resources; they now have a total project budget of $12 M to rehabilitate the legacy issues of the operating Savage River magnetite mine – although given the substantive size of the Savage River project footprint, there remains a considerable scope of issues to address (including AMD issues, amongst others).

New mine developments under the same jurisdiction are receiving approvals without such partnerships or agreements to rehabilitate despite legacy mines on those tenements, such as Venture Minerals Ltd proposal for a tin mine at Mt Lindsay and Shree Minerals Ltd proposal for an iron ore mine at Nelson Bay.

It remains to be seen how successful these partnerships will be in cleaning up the pollution and other risks from mining legacies, how often these partnerships will be formed, how they will be enforced, monitored and regulated, and most importantly, how successful they are in reducing mining legacy impacts.

Supporting financial instruments through regulation and enforcement

While attractive to industry and political leaders, overly relying on financial instruments is unlikely to deliver the reform needed in a high-risk industry, which has a history of underperformance alongside better performance from more progressive companies. In addition to financial instruments, positive incentives should be investigated, that reward effective mine operations that limit environmental impact. For example, companies with a good environmental and social record and high levels of transparency could be rewarded with increased flexibility, preferred access to sites or streamlined (but not weakened) assessment. Alternatively, companies and directors of sites that result in mining legacies, especially those with perpetual impacts that require ongoing management, could be liable to severe punitive sanctions, including custodial sentences. The combination of effective regulation and enforcement, the carrot and the stick, and appropriate financial instruments would ensure a greater focus and priority on avoiding mine legacies throughout planning, construction, operations and rehabilitation, thereby avoiding new mining legacies.

THE NEXT TEN YEARS

As has been identified by various authors, workshops and organisations (see Table 1), addressing mining legacies clearly requires a coordinated response. In Australia this could be achieved by either federal government leadership or multilateral leadership from the states and territories, though preferably both. Given the current focus on government financial restraint, perhaps federal, state and territory government's will recognise that to limit significant and future financial liabilities from legacy sites, cumulative and perpetual impacts will require an effective response now. Alternatively, governments may be encouraged or forced to take action by more progressive mining companies seeking to harmonise responsible life-of-mine planning and operations with effective and supporting governance frameworks.

Leadership, and/or the incentive for government/industry response, could also come from the community. While difficult to quantify or qualify, increasing community expectations and growing resistance to mining is generating conflict that then imposes significant costs on industry, both in direct costs and in lost opportunity (Franks *et al*, 2014). In the experience of the authors, well recognised negative mining legacies (eg see case studies) are a key factor in the increasing concerns about potential and actual mining impacts from existing and potential projects. While addressing

historic mining legacies alone will not overcome poor mining governance or validate new mining proposals, it could help improve community confidence in what is increasingly seen as untrustworthy industry (see Arena Magazine, 2013; Davis and Franks, 2011; Franks *et al*, 2014).

While we await strong leadership towards national or joint state/territory action from all sectors, there is already strong agreement on the first steps. Firstly an Australian inventory of mining legacies, preferably through a national hub, is needed to identify the hazards, risks, future land uses and prioritisation of the most dangerous sites. This needs to be combined with discussions leading to committed plans to harmonise state responses to avoid future mining legacies and to secure the funds to pay for the rehabilitation of the 50 000+ plus sites around Australia.

CONCLUSION

Mining legacies can have a significant human and environmental impact at a local, state, national and even international level. Unfortunately an effective response to the problem has been held back by a lack of understanding about the nature and extent of the issues and a lack of leadership necessary to address it. Adopting the more comprehensive umbrella term and concept of mining legacies across Australian jurisdictions would be a good first step in finding common ground and solutions to what is a national legacy.

Furthermore, the changing scale and intensity of mining in Australia in combination with cumulative and perpetual impacts demands a rapid and effective response to mining legacies. Failure to do so will result in ongoing environmental and social impacts and a growing financial liability for damages and rehabilitation when the issue is finally addressed.

While different states and territories will need to customise policy responses to local conditions, it would be significantly advantageous to industry, government and community if there were a combined response. Problems with inadequate financial instruments and a lack of effective regulation continue to restrict efforts to prevent future and rehabilitate existing mining legacies. Both industry and government should accept some responsibility for existing sites and work together with community to progressively rehabilitate existing sites.

Australian and international work on mining legacies has already established a need for action and outlined the essential components needed to address the challenges of rehabilitating mining legacy sites. These actions and systems should be pursued as soon as possible to mitigate ongoing pollution, to address community and public health concerns and to repair the environment. To paraphrase Laurence (2006), mining legacies should not be orphans; rather the responsibility for them should be accepted today by industry, government and community instead on leaving the challenge to future generations.

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