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Transition or transformation: shifting priorities and stakeholders in Australian mined land rehabilitation and closure

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ABSTRACT

This article is a retrospective study of the shifting priorities and stakeholders over the last four decades of Australia's mine rehabilitation and closure practices. We map the evolution of knowledge, stakeholder involvement, and community awareness of mining socio-environmental risks and impacts to show how mine rehabilitation and closure practices have evolved over time. We conclude that shifting priorities have transitioned through three phases as understandings of the priorities for successful closure evolved. An initial focus on biophysical rehabilitation within the boundaries of individual mines has extended to currently attend to management of risks that extend beyond the boundaries and include social dimensions. These practices are guided by a desire for improved engagement processes and agreement on outcomes for post-mining landscapes.

KEYWORDS

Mine rehabilitation; mine closure; legacy risks; liability; stakeholder engagement

Introduction

Australia has a mixed mining legacy. Mining has been an economic powerhouse for Australia for over 100 years. Nevertheless, mining is a 'temporary land use' generating wealth, jobs, and opportunities that do not last. The temporary land use also generates environmental consequences: degradation of productive, multi-functional land; generation of waste rock and tailings; and, changes to the quality, level, availability and flow of surface and ground water. Communities are increasingly aware and critical of these social and environmental consequences and mining legacies.

Mining standards and practices of companies and governments are subject to scrutiny across a range of issues. These include: proliferation of abandoned mines; unproductive mines either in 'care and maintenance' or in the control of perceived 'fly-by-night' companies; and large, long-life mines approaching depletion (Mudd 2010, 2013; Wright et al. 2011; Unger et al. 2012; Unger et al. 2015; Ashby, van Etten, and Lund 2016). These critical issues fuel a growing desire, by a wide range of stakeholders, to achieve effective rehabilitation, closure and relinquishment of Australia's mines. Greater attention to end of mine life applies to the range of mines in Australia including those of large multi-national

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corporations, those owned by wealthy individuals, and smaller second and third tier companies, both publicly listed and private.

We have organised the article into three sections to address the research question: *how have priorities and stakeholders in Australia's mine rehabilitation and closure (MR&C) practice shifted over the last four decades?* The first section defines the concepts and terms relating to 'rehabilitation' and 'closure'. The second section identifies the range of stakeholder groups engaged in MR&C. The third section reviews the changing priorities and identities of influential stakeholders while summarising key practices of MR&C associated with three phases. The article concludes with implications for current Australian MR&C policy and practice in alignment with current stakeholders and priorities.

Defining the terms of the study

In describing this study, it is important to be clear on terminology. In Australia, *mine closure planning* is defined as 'a process that extends over the mining life-cycle and that typically culminates in tenement relinquishment, includes decommissioning and rehabilitation' (Australian Government 2016a, 110). The term *mine closure,* in contrast, is used to 'indicate the point at which operations cease, infrastructure is removed and management of the site is largely limited to monitoring' (Australian Government 2016a, 110). *Rehabilitation* describes the biophysical repair of the landscape (Doley and Audet 2013; Australian Government 2016b). The International Council on Mining and Metals uses *closure* and *progressive closure* (ICMM 2019) rather than closure and progressive rehabilitation, because progressive tasks during operations that prepare for closure are not limited to rehabilitation.

Despite the definitions above, there is no consistent use of these terms either by stakeholders or across time within the Australian context. A persistent issue is that the terms *mine rehabilitation* and *mine closure* are conflated, creating ambiguity. Consequently, new terms have been introduced. The term *restoration* is used to describe processes assisting the recovery of ecosystems in preference to the more generic term *rehabilitation* (Society for Ecological Restoration Australasia 2017; Society for Ecological Restoration 2004; Cross et al. 2018). In addition, terms such as *regeneration* (Kuhn and Liebmann 2007, 123; Whitbread-Abrutat, Kendle, and Coppin 2013, 629) and *revitalisation* (Kaźmierczak, Lorenc, and Strzałkowski 2017, 697) are emerging to describe the process of counteracting socio-economic decline due to mine closure or abandonment. This links to belated attention to the social aspects of closure (Bainton and Holcombe 2018a, 2018b).

Finally, the term 'stakeholders' also requires definition. In this article we use Freeman's (1984, 46) classic definition: 'any group or individual who can affect or is affected by the achievement of the organization's objectives'. Five stakeholder groups are identified in this article as relevant to the management of MR&C.

Stakeholders influencing MR&C in Australia

The first stakeholder group is industry peak bodies and industry practitioners, whether working within companies or as consultants. Industry peak bodies represent the views of member companies. Examples include: the Minerals Council of Australia (MCA), MCA-affiliated or independent state counterparts, and the International Council on

Mining and Metals (ICMM). Industry practitioners are those actually doing MR&C. They may also be members of professional bodies such as the Australasian Institute of Mining and Metallurgy (AusIMM), Environment Institute of Australia and New Zealand, and Engineers Australia.

The second stakeholder group includes state and territory governments responsible for the regulation of MR&C. There is considerable variation in the terminology and focus of legislation from one jurisdiction to another. In addition, there is variable attention to issues including: closure, legacy risks and financial provisioning, though there is a convergence of rehabilitation goals toward safe, stable, non-polluting and sustainable post-mining land uses.

The third stakeholder is the Australian, national government. Although states and territories in Australia have primary responsibility for mining oversight, the Australian government is involved to a limited extent in domestic and global rehabilitation and closure practice of mining operations and abandoned mines (Australian Government 2016d; Laurencont 2014). Within Australia, the Australian government has responsibility over: mines formerly owned by government (Northern Territory Department of Mines and Energy 2013), uranium mining policies (Energy Resources of Australia 2013; Australian Government 1980), Indigenous agreements (O'Faircheallaigh 2006), national environmental protection standards (Australian Government 2013) and regulation of radiological aspects by the Australian Radiation Protection and Nuclear Safety Agency (Australian Government 2018a). Globally, the Australian government participates in international forums and signs international treaties of relevance to MR&C, such as the Minimata Convention on mercury, a legacy impact from historic gold mining (Australian Government 2016c). The Australian Government also supports MR&C research, for example, through the Australian Nuclear Science and Technology Organisation (ANSTO) and, intermittently, through the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

The fourth stakeholder group is comprised of international organisations. These organisations have spurred a proliferation of voluntary, self-regulation activity that applies standardised sustainability indicators to encourage companies to report on their performance. The range of institutions developing such measureable indicators include the World Bank, the International Finance Corporation (IFC), and the Global Reporting Initiative (GRI) (Global Reporting Initiative 2016; Bond 2014; Evans and Kemp 2011). These initiatives create benchmarks for mining sector performance for MR&C financial assurance (to guarantee funds are available for rehabilitation and closure), impacts on biodiversity, water and livelihoods, pollution and environmental management (Equator Principles Association 2013; Lance 2013; Sassoon 2009).

The fifth stakeholder group is that of community stakeholders distinct from governments and commercial organisations that have exerted influence mainly though non-government organisations (NGO) and research institutions. Examples include: Environmental Defenders Office, Sunrise Project, the Australia Institute and Lock the Gate, as well as research groups specifically engaging in knowledge generation and sharing. Within this category are a more disparate group of local stakeholders. These local actors include local government, Indigenous landholders, local communities and neighbours. These local stakeholders have little formal role in MR&C, beyond the public consultations mandated at project approval stage; yet locals bear the consequences of mining legacies.

Having defined terms and distinguished between stakeholders, we now categorise three phases of priorities in practice in Australian MR&C. As we explore the phases below, we concentrate on practices of industry and organisational actors distinguishing international initiatives from Australian ones.

Phases within MR&C practice over 40 years

The centrepiece of this section is the 40-year timeline tracing prominent initiatives and developments by different stakeholders in MR&C primarily in Australia but also overseas (Figure 1). From an initial scientific focus on soils and vegetation, three phases of practice reveal the incorporation of additional dimensions of MR&C practice as the decades progressed. The timeline represents the activity of each primary stakeholder group with an interest in MR&C, using shaded shapes. The analysis contrasts *continuing* MR&C activities with those that are *discontinued*. Notably, some early examples of sophisticated MR&C practice remained isolated instances rather than part of overall trends, and as such are marked as outliers.

We characterise the three phases in colloquial terms: Kicking Dirt (1970s–1980s); Outside the Fence (1990s–2005); and Pass the Parcel (2005–present).

Phase 1: the 1970s and 1980s – 'Kicking dirt'

'Kicking dirt' is a term used to describe the practice of mine rehabilitation professionals getting together onsite to discuss rehabilitation challenges in the field. It describes an initial phase in Australian MR&C activity when the main initiatives came from mining professionals who formed regional groups and hosted workshops to build on sharing technical knowledge between professionals. At this stage, most mines were mid-scale, remotely located, and Australian-owned. With the exception of a few open cut mines, underground mining methods were more common until the 1950s. After that, open cut mining in Queensland, and elsewhere, created a larger disturbance footprint comprised of waste rock, tailings and final voids (Wilson 2018). During the 1970s practitioners, governments and Australia's national mining industry body responded to the increasing mine disturbance footprints. The four main developments during this phase are described below.

(1) Soil conservation and agricultural land uses

Primary production in the 1970s meant that Australia functioned largely as a farm and a quarry with agriculture and mining as the big industries (Harcourt 2007). Therefore, agricultural land uses and soil conservation were a focus of rehabilitation practice in response to the creation of large tracts of degraded and unproductive land caused in part by farmers' and miners' clearing of native vegetation and made worse by droughts, floods, dispersible subsoils, and invasive plant species (Mitchell 1991). These were the formative years of the science of mined land rehabilitation resulting in practical handbooks for professionals (Australian Mining Industry Council and RP Warren Environmental Consulting Services 1989; Hannan 1995, 1984). Therefore, this first phase focused initially on 'soil and vegetation cover'.

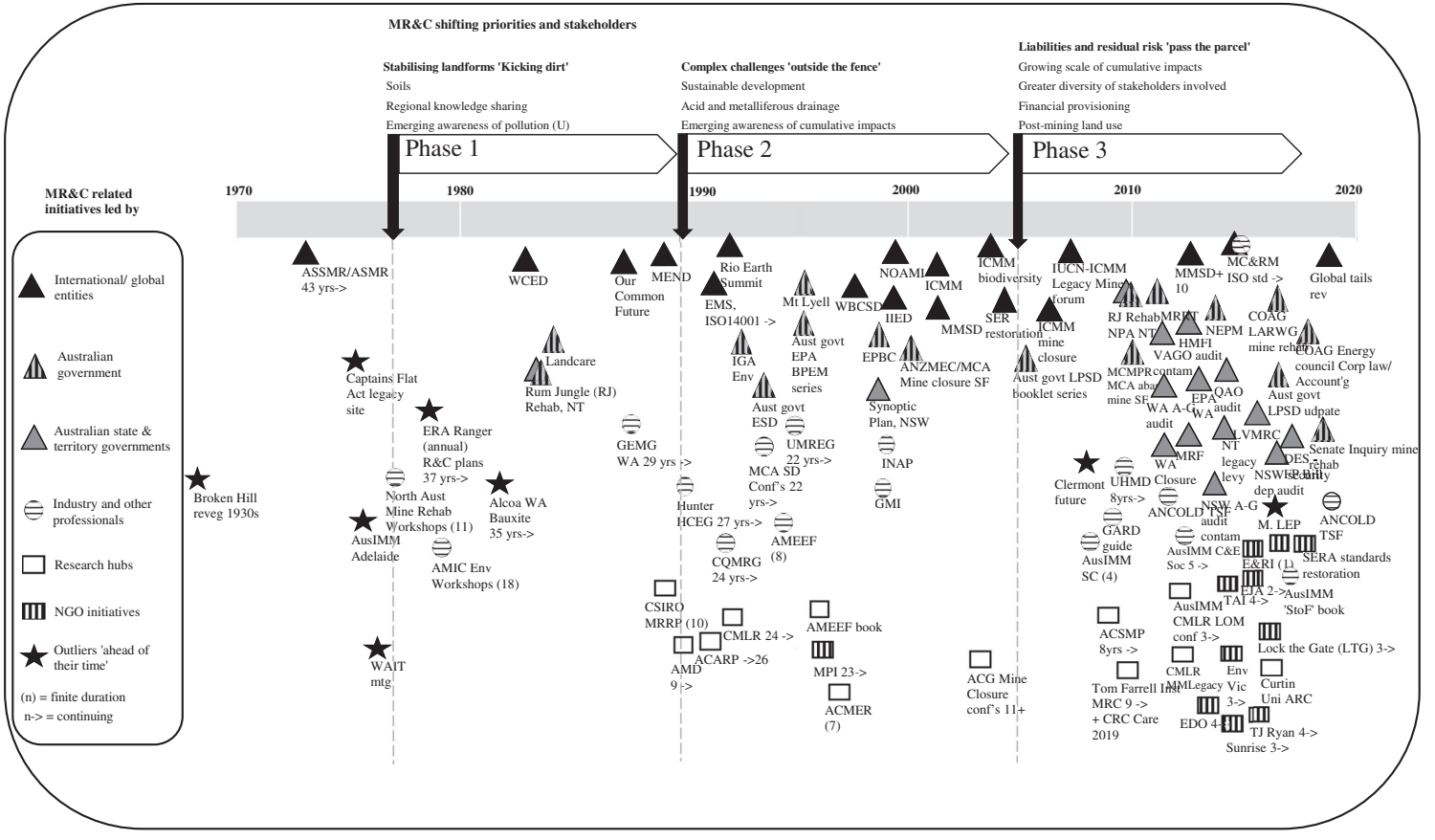

Figure 1. Significant mine rehabilitation and closure influencing initiatives: ~1977–2019 (see Table 1 for explanation of abbreviations and sources).

Table 1. Abbreviations and sources used in Figure 1.

Abbreviation	Explanation and link to relevant source if available
ACARP	Australian Coal Association Research Program https://www.acarp.com.au/
ACG	Australian Centre for Geomechanics, UWA Mine closure conferences http://acg.uwa.edu.au/mine-closure/
ACMER	Australian Centre for Mining Environmental Research
ACSMP	Australian Centre for Sustainable Mining Practices http://www.acsmp.unsw.edu.au/
AMD	Acid and metalliferous Drainage – Australian AMD conferences held every three years since 1990 https://smi.uq.edu.au/event/104/9th-australian-acid-and-metalliferous-drainage-workshop
ANCOLD TSF	Australian National Committee on Large Dams: Guidelines on tailings dams – planning, design, construction, operation and closure. The 2012 guideline has recently been updated in 2019 (Revision 1) https://www.ancold.org.au/?product=guidelines-on-tailings-dams-planning-design-construction-operation-and-closure-may-2012
AusIMM	The Minerals Institute – professional body http://www.ausimm.com.au/ https://www.ausimm.com.au/content/docs/abandoned_mine_management_in_australia.pdf
AusIMM Adelaide	Workshop on landscaping and land use – planning as related to mining operations March–April (AusIMM 1976) Adelaide Branch
AusIMM StoF	Start to Finish: Life of Mine Perspective Spectrum 24, 2018 (McCullough et al. 2018) https://www.ausimm.com.au/publications/publication.aspx?ID=17564
AMEEF	Australian Minerals and Energy Environment Foundation book on Environmental management in the Australian minerals and energy industries: principles and practices (Mulligan 1996)
AMIC	Australian Mining Industry Council (later became MCA)
ANZMEC /MCA	Australian and New Zealand Minerals and Energy Council, Minerals Council of Australia, Strategic Framework for Mine Closure http://www.sernageomin.cl/pdf/mineria/cierrefaena/DocumentosRelacionados/Strategic-Framework-Mine-Closure.pdf
ANZECC/ARMCANZ	Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000) Australian and New Zealand guidelines for fresh and marine water quality http://www.agriculture.gov.au/water/quality/nwqms
ASSMR/ ASMR	American Society for Surface Mine Reclamation (ASSMR), later, American society of mining and reclamation (ASMR) rehabilitation focus on coal mined lands initially, later, all forms of reclamation. http://www.asmr.us/
BPEM	Best practice Environmental Management – series of booklets published in 1990s by Australian government EPA
Broken Hill revegetation	Broken Hill NSW includes in its heritage listing (Australian Heritage Council 2015) its 1930s pioneering revegetation 'green belts' for dust control (McIlveen and McNally 1996) and chronology of plantings by Albert and Margaret Morris http://www.aabr.org.au/aabr/wp-content/uploads/2017/04/ShortSummary-BrokenHillRegenScheme.pdf
C&E Society	Community and Environment Society of the AusIMM from 2013 (followed Sustainability Committee 2009 to 2013) https://www.ausimm.com.au/content/default.aspx?ID=344
Clermont	Clermont township in Central Queensland initiated a preferred futures strategy in 2008 to build resilience to mine closure http://www.mdpi.com/2079-9276/2/4/528/htm (Richard, Aleta, and Kieren 2013)
CMLR	Centre for Mined Land Rehabilitation, Sustainable Minerals Institute The University of Queensland https://www.cmlr.uq.edu.au/
COAG	Council of Australian Governments
COAG Energy Council	Energy Council agrees to examine mine clean-up rules http://www.miningreview.com.au/news/coag-energy-council-agrees-examine-mine-clean-rules/
CRC CARE	Cooperative Research Centre for Contamination Assessment and Remediation of the Environment, based at the University of Newcastle, now involved in annual rehabilitation conferences in the Hunter Valley with the team of the former TFI https://www.minedlandrehab.com.au/
CSIRO MRRP	Commonwealth Scientific and Industrial Research Organisation – Minesite Rehabilitation Research Program, under the Division of Soils Adelaide.
Curtin Uni ARC	Australian Research Council Industrial Transformation Training Centre for Mine Site Restoration (CMSR) http://arc-cmsr.org/index.php/en/
DES FP Bill	Queensland Department of Environment and Science, Financial Provisioning Bill https://www.legislation.qld.gov.au/view/html/bill.first/bill-2018-017
EDO	Environmental Defenders Office (Qld) from 2014 https://www.edoqld.org.au/edo_qld_s_submission_on_discount_criteria_for_mining_rehabilitation_obligations
E&RI	Energy & Resources Insights report: The hole truth: the mess coal companies plan to leave in NSW, 2016 (Energy & Resource Insights 2016) http://downloads.erinsights.com/reports/the_whole_truth_LR.pdf
EJA	Environmental Justice Australia, 2016 https://envirojustice.org.au/sites/default/files/files/EJA_Dodging_clean_up_costs.pdf

(*Continued*)

Table 1. Continued.

Abbreviation	Explanation and link to relevant source if available
EnvVic	Environment Victoria 2014, Preventing the preventable, policy options for accelerating coal mine rehabilitation and creating jobs in the Latrobe Valley http://environmentvictoria.org.au/wp-content/uploads/2016/07/Preventing-the-Preventable.pdf
EMOS	Environmental Management Overview Strategy (EMOS) introduced to the Queensland Mineral Resources Act early 1990s
EMS	Environmental Management Systems (ISO 14001 Environmental Management Systems) http://www.iso14001.com.au/iso-14001-standard.html
EPA WA	Environmental Protection Authority of Western Australia – Cumulative impacts of mining in the Pilbara (Vogel 2014) http://www.epa.wa.gov.au/sites/default/files/Publications/Pilbara%20s16e%20advice%20%20270814.pdf
EPBC	Environmental protection and biodiversity Conservation Act 1999 (EPBC Act) Australian government's central environmental legislation http://www.environment.gov.au/epbc
ERA	Energy Resource of Australia, Ranger Mine http://www.riotinto.com/energyandminerals/energy-resources-of-australia-ltd-4711.aspx
ESD	Ecologically Sustainable Development, National Strategy, Australian government, Department of the Environment and Energy http://www.environment.gov.au/about-us/esd/publications/national-esd-strategy
GARD (guide)	Global Acid Rock Drainage Guide http://www.gardguide.com/index.php?title=Main_Page
GEMG	Goldfield Environmental Management Group http://www.gemg.org.au/
Global Tails Rev	Global Tailings Review, collaboration between ICMM, UN Environment and PRI, in response to the catastrophic failure of a tailings storage facility in Brumadinho, Brazil on 25 January 2019. https://globaltailingsreview.org/
GMI	Global Mining Initiative, 2000 https://www.icmm.com/website/publications/pdfs/governance/global-mining-initiative/106.pdf
HCEG	Hunter Coal Environment Group Inc http://www.hceg.com.au/
HMFI	Hazelwood Mine Fire Inquiry 2014 – initial inquiry http://report.hazelwoodinquiry.vic.gov.au/ and 2016 Mine rehabilitation inquiry http://hazelwoodinquiry.vic.gov.au/wp-content/uploads/2015/09/Hazelwood-Mine-Fire-Inquiry-Report-2015-2016-Volume-IV-%E2%80%93-Mine-Rehabilitation-web.pdf
IUCN-ICMM	International Union for the conservation of nature & ICMM legacy mine roundtable forum (2008) (Post-Mining Alliance, IUCN, and ICMM 2008) https://www.iucn.org/theme/business-and-biodiversity/our-work/business-partnerships/international-council-mining-and-metals http://www.icmm.com/website/publications/pdfs/511.pdf
ICMM	Planning for integrated mine closure (2008) https://www.icmm.com/en-gb/environment/mine-closure/planning-for-integrated-mining-closure Good practice biodiversity https://www.icmm.com/website/publications/pdfs/biodiversity/good-practice-mining-and-biodiversity
IIED	International Institute for Environment and Development https://www.iied.org/mining-minerals-sustainable-development-mmsd https://www.iied.org/about
IGA on Env.	Intergovernmental Agreement on the Environment, 1 May 1992 http://www.environment.gov.au/about-us/esd/publications/intergovernmental-agreement
INAP	International Network for Acid Prevention, http://www.inap.com.au/
ISO	International Organisation for Standardisation https://www.iso.org/standards.html e.g. Environmental Management systems ISO14001
Landcare	The name 'Landcare' evolved in Victoria through an initiative of Joan Kirner, (then Minister for Conservation, Forests and Lands) and Heather Mitchell, (then President of the Victorian Farmers Federation). https://landcareaustralia.org.au/about/the-landcare-story/
LTG	Lock the Gate mine rehabilitation campaign http://www.lockthegate.org.au/minerehab
LOM	Life of Mine conferences, commenced in 2012 and are hosted by AusIMM and CMLR, every 2 years. LOM2016 link – http://www.lifeofmine.ausimm.com.au/
LVMRC	Latrobe Valley Mine Rehabilitation Commissioner – statutory office to monitor and audit mine rehabilitation and consult local communities under the Mineral Resources (Sustainable Development) Amendment (Latrobe Valley Rehabilitation Commissioner) Bill 2017 https://www.lvmrc.vic.gov.au/
MAC	Mining Association of Canada
MCA	Minerals Council of Australia
MC&RM	Mine Closure and Reclamation Management ISO standard in progress ISO/TC 82/SC 7 https://www.iso.org/committee/5052041.html
MCMPR	Ministerial council on Minerals and Petroleum Resources (now part of COAG energy council) http://www.coagenergycouncil.gov.au/
MEND	Mine Environment Neutral Drainage http://mend-nedem.org/default/

(*Continued*)

Table 1. Continued.

Abbreviation	Explanation and link to relevant source if available
M. LEP	Muswellbrook Shire Council, NSW LEP (Local Environmental Plan) discussion paper (Muswellbrook Shire Council 2017) https://muswellbrook.nsw.gov.au/index.php/component/edocman/?task=document.viewdoc&id=1457&Itemid=0
MML	Managing Mining Legacies forum hosted by CMLR 2012 at University of Queensland following LOM 2012
MPI	Mineral Policy Institute http://www.mpi.org.au/ Mining legacies initiative
Mt Lyell	The Mount Lyell Remediation Research and Demonstration Program in 1995 – Tasmanian and Australian government funded strategy for remediating environment effects of past mining at Mount Lyell in Tasmania
NEPA	National Environmental Protection Authority (Australia)
NEPM	National Environmental Protection Measures, 2013 http://www.nepc.gov.au/nepms/assessment-site-contamination
NOAMI	National Orphaned/Abandoned Mine Initiative (Canada) http://www.abandoned-mines.org/en/
Our Common Future	Brundtland Report 'Our Common Future' 1987, following the 1983 World Commission on Environment and Development (WCED) http://www.sustainabledevelopment2015.org/AdvocacyToolkit/index.php/earth-summit-history/historical-documents/92-our-common-future
LARWG	Land Access for Resources Working Group, under COAG
LPSD	Leading Practice Sustainable Development series of booklets https://industry.gov.au/resource/programs/lpsd/pages/lpsdhandbooks.aspx
LTG	Lock the Gate Alliance http://www.lockthegate.org.au/
MIRECO	Mine Reclamation Corp of South Korea http://www.mireco.or.kr/html/english/01_sub/sub01_01.jsp
MML	CMLR Managing Mining Legacies 2-day forum in 2012, following AusIMM/CMLR Life-of-Mine-Conference in Brisbane
MMSD	Mining Minerals and Sustainable Development Project by IIED https://www.iied.org/mining-minerals-sustainable-development-mmsd
MMSD + 10	Mining Minerals and Sustainable Development Project review after 10 years by IIED http://pubs.iied.org/16041IIED/
MRF	Mine Rehabilitation Fund, Western Australian government http://www.dmp.wa.gov.au/Environment/What-is-the-MRF-19522.aspx
MRRT	Minerals resource rent tax (MRRT) is a 'tax on certain profits generated from iron ore, coal, anything produced by in situ consumption of coal or iron ore, coal seam gas extracted as a necessary incident of coal mining or from a proposed coal mine' https://www.ato.gov.au/Business/Minerals-resource-rent-tax/ The MRRT replaced the Resource Super Profits Tax (RSPT) 2010 which was applicable to all companies at a higher headline tax rate.
NAMRW	North Australian Mine Rehabilitation Workshops – eleven held in total (#11, Jabiru, NT)
NSW AO	New South Wales Audit Office Volume six 2012 Environment, water and regional infrastructure http://www.audit.nsw.gov.au/ArticleDocuments/255/01_Volume_Six_2012_Full_Reportv3.pdf.aspx?Embed=Y Managing contaminated sites (2014) http://www.audit.nsw.gov.au/news/managing-contaminated-sites Mining rehabilitation security deposits (2017) http://www.audit.nsw.gov.au/publications/latest-reports/mining-rehabilitation-security-deposits
NT Legacy levy	Northern Territory government Legacy Levy, 2013, under the Mining Management Act https://dpir.nt.gov.au/mining-and-energy/mine-rehabilitation-projects/about-legacy-mines/levy-and-security
QAO	Queensland Audit Office, 2014 Environmental regulation of the resources and waste industries (report 15:2013-14) https://www.qao.qld.gov.au/reports-parliament/environmental-regulation-resources-and-waste-industries
Rio Earth Summit	United Nations conference on Environment and Development (1992) http://www.un.org/geninfo/bp/enviro.html
RJ	Rum Jungle copper and uranium mine remediation – first undertaken in the mid-1980s with further work initiated around 2011 under an NPA (National Partnership Agreement) between Australian government and the NT government
SER	Society for Ecological Restoration, Primer (2004) defining ecological restoration https://cdn.ymaws.com/www.ser.org/resource/resmgr/custompages/publications/ser_publications/ser_primer.pdf
SERA	Society for Ecological Restoration Australasia http://www.seraustralasia.com/, National Standards for the practice of ecological restoration in Australia (2016) http://seraustralasia.com/standards/National%20Restoration%20Standards%202nd%20Edition.pdf, National Standards for the practice of ecological restoration in Australia 2nd edition (2017) http://seraustralasia.com/standards/National%20Restoration%20Standards%202nd%20Edition.pdf
SC AusIMM	Sustainability Committee of the AusIMM (preceded the C&E Society)

(*Continued*)

Table 1. Continued.

Abbreviation	Explanation and link to relevant source if available
Sunrise	Sunrise Project-engaged with abandoned mine issues from 2015 and mine rehabilitation of coal mines from 2016, https://sunriseproject.org.au/wp-content/uploads/2018/05/2015-Sunrise-Project-Annual-Report.pdf https://sunriseproject.org.au/wp-content/uploads/2018/05/2016-Sunrise-Project-Annual-Report.pdf
Synoptic Plan	Synoptic plan: integrated landscapes for coal mine rehabilitation in the Hunter Valley of NSW prepared by Andrews.Neil for Department of Mineral Resources, 1999
TAI	The Australia Institute – MR&C begins to be included from 2014 http://www.tai.org.au/sites/default/files/TAI%202014%20Warkworth%20Continuation%20PAC%20submission.pdf
TFI	Tom Farrell Institute, University of Newcastle mine rehabilitation conferences – 8 hosted to 2018 http://www.tomfarrellinstitute.org/2017-mine-rehab-conference.html http://www.tomfarrellinstitute.org/
T J Ryan	T J Ryan Foundation began engaging with mine rehabilitation and legacy issues in 2016, co-hosting a mine rehabilitation forum in 2017 with Royal Society of Qld http://www.tjryanfoundation.org.au/cms/page.asp?ID=1488
UHMD	Upper Hunter Mining Dialogue – multi-stakeholder forum to minimise cumulative impacts of mining – MR is one of 10 environmental aspects included. http://www.nswmining.com.au/dialogue/home
UMREG	Uranium Mine Remediation Exchange Group http://umreg.net/ https://www.iaea.org/publications/8404/the-uranium-mining-remediation-exchange-group-umreg
VAGO	Victorian Auditor General's Office (2011) Managing contaminated sites, audit report; https://www.parliament.vic.gov.au/papers/govpub/VPARL2010-14No90.pdf
WA AG	Western Australian Auditor General's Report, Report 8, September 2011 Ensuring compliance with conditions on mining https://audit.wa.gov.au/wp-content/uploads/2013/05/report2011_08.pdf
WAIT	Western Australia Institute of Technology later merged with WA school of Mines, Agricultural college and others to eventually transition to Curtin University http://about.curtin.edu.au/who/history/wa-institute-technology/
WBCSD	World Business Council for Sustainable Development http://www.wbcsd.org/
WCED	World Commission on Environment and Development https://sustainabledevelopment.un.org/milestones/wced

(2) Networking and knowledge sharing

By the late 1970s, mine rehabilitation professionals in Australia recognised the value of sharing mine rehabilitation knowledge to achieve rehabilitation goals. They convened multi-lateral groups of stakeholders including the following. The North Australian Mine Rehabilitation Workshop, organised by volunteers from industry and government, continued for eleven years. The Australian Mining Industry Council initiated an annual environmental workshop that continued until the 1990s when it transitioned into the MCA's Sustainable Development conference. During the 1980s additional regional groups formed in the Hunter Valley coal mining region, the WA Goldfields and Central Queensland, which have continued to the present.

(3) Environmental concerns – particularly pollution

Ecological influences on MR&C emerged in both Australia and around the world in the 1980s. In 1982, Greening Australia was founded to protect, restore and conserve Australia's native vegetation. From the outset, this organisation was engaged in mine rehabilitation, with one company citing a 29-year environmental conservation and sustainability partnership (*Growing stronger together* 2011, 10). A parallel organisation, Landcare, was born in the mid-1980s. Landcare encouraged landholders to work 'in their own social group to solve their own local land conservation problems in their own way'

(Curtis et al. 2014, 177). Landcare was applied to productive farming as well as catchment and biodiversity protection.

Environmentalism gained global momentum in the 1980s contributing to a heightened awareness of industrial pollution amongst MR&C practitioners. However, that awareness was not always translated into action in a timely manner in Australia (O'Riordan 1999). In contrast, the USA enacted the *Surface Mining Control and Reclamation Act* 1977 (SMCRA) for coal mines (US Government 1977 in sub-chapters 2–9). While Australia did not adopt national measures like SMCRA, Australian practitioners did connect at an individual level with the American Society for Surface Mine Reclamation which influenced the thinking of Australian practitioners.

Toward the end of Phase 1, the global mining sector recognised the pollution of acid and metalliferous drainage (AMD) from mining operations. The Canadian government, supported by industry (Mining Association of Canada), recognised the value of cross-jurisdictional technical knowledge sharing about AMD problems. For example, the Canadian Natural Resources agency hosts the Mine Environment Neutral Drainage program (MEND/NEDEM 2019). In Australia, the AMD legacy impacts of several historic mines, like Mount Morgan, Queensland (Unger et al. 2003), and Mt Lyell, Tasmania (John Miedecke and Partners Pty Ltd 1996), became clear as they approached the end of production. An inaugural AMD forum, held in Tasmania in 1990, recognised the need for greater technical exchange among professionals and researchers to improve practices.

(4) Concern about uranium mining legacies

The Australian government took a leadership role in MR&C when proposals for new uranium mines emerged in the 1970s, during the height of international nuclear non-proliferation concerns. When the Ranger Uranium Mine was approved the related Fox Inquiry (Fox 1976, 1977) drew attention to historical uranium mine legacies. Specifically, during the late 1970s the Australian government committed to investigate environmental legacies associated with the former Australian government-owned Rum Jungle copper and uranium mine in the Northern Territory; leading to the first phase of this mine's rehabilitation in the 1980s (Richards, Applegate, and Ritchie 1996)

Summary

These four developments show Australians focused on local and regional, empirically-based, technical-environmental aspects of MR&C such as revegetation, and soil conservation. Practitioners also recognised that research and knowledge sharing between professionals were valuable in mining regions. This first phase saw initial action on challenging issues, such as AMD and mining legacies, as disparate initiatives. However, these relied on insightful leadership often from rehabilitation professionals rather than a systematic approach led by regulatory authorities.

The positive developments from this time include sound knowledge-building by practitioners, supported by the development of manuals and texts, to improve soil and spoil management practices for agricultural uses. 'Outlier' mining companies in Western Australia and the Northern Territory committed to a long-term investment in rehabilitation research to support native ecosystem re-establishment (Koch and Hobbs 2007; McNally, Unger, and Peters 1996; Koch 2015). Finally, this phase saw the formation of

regional rehabilitation knowledge-sharing groups of practitioners, some temporary and some persisting.

Phase 2: the 1990s to 2005 – complex challenges 'outside the fence'

From roughly 1990, advances in technology enabled deeper and larger open-cut mines and rapid expansion in production (Mudd 2009). With these changes, a second phase mirrors the growing complexity of MR&C practice with increased recognition that mines have the potential to affect environments and communities beyond their spatio-temporal boundaries. The acknowledgment of issues emerging 'outside the fence' extended the scope of responsibility and potential liability for governments, MR&C professional bodies and mining operations.

Recognition of common global problems related to large-scale mining encouraged further organised knowledge sharing on prominent issues of rehabilitation according to principles of ecologically sustainable development (ESD) (Buckley 1992; Brundtland 1987; Needham 1999). Australia connected more substantially with global initiatives and organised knowledge-sharing on specific issues such as AMD. Mitigating and managing geochemical and biodiversity risks came to prominence during this phase. Investing in research became more common, and 'linear systems' to manage environmental risks were introduced. While biodiversity became a more significant goal for mine rehabilitation by state regulators, Australians did not follow the lead of overseas examples on abandoned mines and mining legacies where national initiatives built knowledge that supported the professionals managing state/provincial abandoned mine programs. Four prominent Phase 2 developments in MR&C are described below.

(1) New scientific disciplines to mitigate cumulative environmental problems

During this phase, soil scientists lost their prominence and companies turned to new disciplinary expertise to address cumulative and long-term problems of waste and water management. For example, ecologists promoted the return of biodiversity to mined land and *closure* became more formalised (Mulligan 1996, 2014; Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia 2000; Cummings 2014). Meanwhile, geochemists focussed their attention on AMD guided by the initiatives of international organisations and local consulting expertise. The MEND program in Canada, mentioned in Phase 1, extended its collaboration to initiate a series of international AMD conferences. The International Network for Acid Prevention (INAP) was formed in 1998 and this group later coordinated the development of the online Global Acid Rock Drainage (GARD) guide. Finally, social scientists raised awareness of the influence and significance of stakeholder acceptance by communities not just industry and government (Owen and Kemp 2013).

Following the International Society for Ecological Restoration's (SER) definition for ecological restoration as 'the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed', the Australian society (SERA) developed a standard for ecological restoration with six key principles (Society for Ecological Restoration 2004, 3). These guided *restoration* as the activity to deliver *recovery*, as the outcome sought (Society for Ecological Restoration Australasia 2017, 2).

(2) National and state ESD regulation and an SD focus for mining

Global events such as the World Commission on Environment and Development (WCED) and the Rio Earth Summit encouraged the Australian government to adopt Ecologically Sustainable Development (ESD) policies. The mining industry also embraced the ESD concept with mining executives in the World Business Council for Sustainable Development (WBCSD) forming the Global Mining Initiative (GMI) to undertake a rigorous study of the socio-environmental issues facing the mining industry. The Mining Minerals and Sustainable Development (MMSD) initiative outlined the way to apply Sustainable Development (SD) to the mining industry. MMSD interpreted ESD as requiring a *triple bottom line* approach, not only demonstrating environmental sustainability but also social and economic sustainability (Elkington 1997; Mining Minerals and Sustainable Development Project 2002). The GMI and MMSD led to the formation of the International Council on Mining and Metals (ICMM) which developed guidance and support for member companies seeking to reform the environmental and social performance of mining (International Council on Mining & Metals 2006).

The United Nations Conference on Environment and Development (UNCED) Earth Summit Conference, held in 1992, sought to reconcile worldwide economic development with protection of the environment. Members of the UN, including Australia, committed to pursue economic development in ways that protected the environment and non-renewable resources. From this forum, Agenda 21 outlined global strategies for mitigating and managing environmental harm (United Nations Conference on and Development 1993). Part of this agenda recommended strengthening of legal and institutional capacity as well as consultative processes because of the importance of local government and involvement of communities in sustainable development. Reinforced by these initiatives, integrated catchment management in Australia adopted a regional governance model with involvement beyond government. Landcare, founded as a volunteer organisation during Phase 1, now required funded programs and strategic regional support that was more comprehensive. This led to NRM (Natural Resource Management) bodies in a multi-level 'nested' governance structure comprising multiple Landcare groups that formed Landcare networks, within catchment management groups (Curtis et al. 2014, 187). In addition to integrated catchment management, strategic catchment activity addressed legacy mine rehabilitation. Examples include support by the Fitzroy Basin Association, for water treatment at Mount Morgan historic mine (Unger et al. 2003) and Landcare Funding to remediate legacy tailings downstream of the historic Mt. Lyell copper mine in Tasmania (Koehnken 1997).

(3) Research and knowledge sharing improve understanding of common challenges

National and international forums began linking professionals and practitioners with researchers to facilitate knowledge-sharing on a global scale. Several universities and organisations began to focus on mine MR&C during this phase (Table 2)

A further global network formed in response to the closure of multiple uranium mines and mills. This renewed focus on uranium-specific MR&C was supported by the Uranium Mining Remediation Exchange Group (UMREG) which held its first meetings in the USA and Germany from 1995 (International Atomic Energy Agency 2011) with Australian leadership and participation.

Table 2. Sample of Australian MR&C research initiatives.

University/ Sponsor	Research Group	Date established
University of Queensland (UQ)	Centre for Mined Land Rehabilitation (CMLR)	1993
UQ	Australian Centre for Mining Environmental Research (ACMER)	1998
University of New South Wales	Australian Centre for Sustainable Mining Practices	2009
Curtin University WA	Mine Rehabilitation Group in the School of Environmental Biology	Late 1980s–1990s
Curtin University WA	ARC Centre for Mine Site Restoration (CMSR)	2017
University of WA	Australian Centre for Geomechanics (ACG)	1992
University of WA	Mine Closure Conferences (ACG with partners)	2006 – annual conferences commenced
Australian Coal Association Research Program (ACARP)	1992 commenced funding for safety and production research initially	1997 MR&C research began
University of Tasmania	Australian Research Council – Transforming the mining value chain (geochemistry of wastes)	2015
Charles Darwin University, NT	Environmental Science Learning and Teaching – restoration ecology	2002
University of Newcastle, NSW (previously based at University of South Australia)	CRC CARE moved to Newcastle to expand into mine R&C	2015 (since 2019 in collaboration with TFI for Mine Rehab conferences)

The Australian government further supported knowledge sharing by producing a series of Best Practice Environmental Management in Mining booklets (BPEM) (Needham 1999) engaging industry, government, consulting and research professionals in the writing process. At this time one booklet dealt with revegetation and rehabilitation but none dealt specifically with mine closure and completion (Environment Protection Agency 1995).

(4) Attention to benefit distribution and, long-term consequences including mining legacies

Community and government discontent about the balance of benefits and costs of mining focussed on a number of issues. One concern related to profits from finite resources moving offshore and led to reviews and eventual tax reform (McLaren and Passant 2015). As well, the broader issue of managing Australia's short term windfalls from resource extraction for long-term gain (Cleary 2011) drew attention to the long term consequences. With growing global attention to long-term consequences and mining legacies, initially, NGOs paid more attention to MR&C than either governments or industry in Australia. The first mining-related NGO lobby group in Australia, the Mineral Policy Institute, formed in the late 1990s to raise awareness of mining legacy risks. Elsewhere, the Canadian National Orphaned/Abandoned Mine Initiative (NOAMI), multi-stakeholder working group, addressed key challenges of mining legacies by informing policy and practice.

The Australian Tax Review (Australian Government 2010) recommended ways to broaden the tax base and make the tax system more equitable, one form of which was an economic land rent tax based on super profits such as generated during mining booms (McLaren 2014). By replacing state mining royalties with a national land rent tax on profits (for all land) a more equitable tax could be created, especially during

mining booms. The mining boom in the early years of the twenty-first century negatively impacted other industries including manufacturing and tourism. The community and governments were also concerned about the profits from finite resources moving offshore with insufficient national benefit from the wealth or long term planning for Australians (McLaren and Passant 2015). Problems with implementation led to the politically contentious proposal being modified to a Mineral Resources Rent Tax (MRRT). This modified rent tax was repealed in 2014 (O'Callaghan and Graetz 2017; McLaren and Passant 2015). The very public dialogue between industry and government surrounding these tax reforms heightened society's awareness of mining and the need for Australia to manage the short term returns from it sustainably, for the long-term (Cleary 2011, 57).

(5) Systematising environmental management

Growing awareness of increasing environmental complexity, plus the need to comply with regulations for immediate operational risks and alongside long term environmental risks, resulted in conflicting attempts to systematise environmental management. One example is the International Organisation for Standardisation's Environmental Management System EMS (ISO 14001) (SAI Global Limited 2016) that documents procedures to ensure repeatability, efficiency and standardisation. The mining industry in Australia was an early adopter of EMS (ISO 14001 adds up 2006). This was encouraged by governments in Australia, such as Queensland, where a discount on rehabilitation financial assurance was offered to those companies that were ISO 14001 accredited. However, ISO 14001 did not encourage the integrated and holistic systems view that would have translated the ESD rhetoric into practice (Lavery 2011). Instead, the systemising of environmental management, embraced by both companies and regulators, caused a burgeoning of paperwork.

Summary

During Phase 2, Australian practitioners incorporated additional forms of MR&C knowledge, especially geochemistry, ecology and the social sciences. This demonstrated recognition that mining impacts extended beyond soil stabilisation and onsite vegetation to impact downstream catchments, land uses and communities beyond the mine. International initiatives and growing awareness of environmental consequences resulted in Australian policy and practice on ESD. Practitioners began to embrace the triple bottom line rhetoric and a broader understanding of the environment as connected with social and economic factors outside the spatio-temporal boundaries of mines. One notable consequence was the development of a series of booklets on best-practice environmental management in mining coordinated and published by the Australian government's Environment Protection Agency. In addition, states took action, for example, MR&C in New South Wales adopted a regional planning focus to address biodiversity goals by connecting wildlife corridors across the Hunter Valley mining region. However, bureaucratic approaches, and compliance focussed EMS did not lead to improved MR&C for the sector. Local improvements in MR&C occurred in some instances driven by professionals and networks of knowledge in mining regions. Attention to rehabilitation was not accompanied by a focus on closure as a holistic task that involved reconciling large mine voids and waste heaps and stakeholders expectations about sustainable post-mining

land uses. Hence, MR&C knowledge-building and practice was unable to keep pace with the growing mining footprint and the associated technical challenges of large constructed landforms, including final voids.

Phase 3: 2005 to the present (2019) – liabilities and residual risk, 'pass the parcel'

Since 2005, MR&C is not a priority during up-cycles in commodity demand caused by a rush to commence or expand mines. However, there is public unease as external stakeholders' awareness of mining's legacy liabilities grows. Companies are increasingly challenged about MR&C outcomes in their quest for community support and approval for mining, or gaining social licence to mine (Bainton and Holcombe 2018b). This social licence represents the level of acceptance or approval by non-contractual stakeholders (Browne, Stehlik, and Buckley 2011) who can, in often informal yet powerful ways, block or delay projects if they are not convinced of their merits. Similarly, community and NGO stakeholders have questioned government legitimacy and effectiveness as a regulator of the sector (Roche and Judd 2016; Environment Victoria 2014). Stakeholders themselves now seek greater involvement and influence with a rising expectation of a net-positive legacy from mining, whereas mining companies try to offload risk. In the last few years, governments are paying attention to MR&C in regions where multiple mine closures are anticipated and international bodies are giving attention to critical risky features in particular tailings storage facilities, in response to failures and inquiries. Four trends evident during Phase 3 are described below.

(1) Preaching of leading practice is not matched in performance

International, national, industry and government guides produced in this phase demonstrate that although a quantum of critical knowledge exists, it is not embedded in practice in Australia. For instance, the Australian government's updated series of *Leading practice: sustainable development in mining* includes separate booklets profiling the process of mine closure as distinct from mine rehabilitation (Australian Government 2016a, 2016b). Closure includes environmental rehabilitation but is broader as it encompasses socio-economic aspects of mine completion. However, the leading practices outlined are not yet widespread. In another example, impact assessment processes in Australia are dated (circa 1970) and 'are due for overhaul' (Ross and Carter 2012) but the main subsequent change is a backward step in devolution of environmental approval powers to the states from the Australia government (McGrath 2014). Further, the Australian mine closure strategic framework developed in 2000 (ANZMEC and MCA) has not been updated to keep pace with changing stakeholder expectations. However, reference is made to the need for early closure planning, life of mine rehabilitation and legacy site management, in the recent Resources 2030 Taskforce report on Australian resources as the government seeks to grow the Australian mining sector by ensuring it is globally competitive (Australian Government 2018b). In order to improve the sector's environmental performance there are recommendations for nationally consistent approaches for MR&C (Australian Government 2018b, 63). However, Southalan's (2019) review of this report and other regulatory documents observes that Australian regulation lags

behind best contemporary practice because of the limited reference to, and use of, relevant international guidance and reports.

Regulatory guidance and capacity-building activities have not yet caught up with professional needs. Rather, support for stakeholders to understand and address the challenges of mine closure comes from the following alternative sources:

- industry peak bodies (e.g. the ICMM integrated mine closure toolkit 2008, updated in 2019), and their collaboration such as the 2019 Global Tailings Review (ICMM, UN Environment, and Principles for Responsible Investment),
- larger companies that are sharing knowledge more widely to improve the capacity, performance of the whole industry (e.g. Anglo American's SEAT Closure Toolbox), and
- professional bodies like Australian National Committee on Large Dams that produce guidelines that include closure of tailings dams (ANCOLD 2019); and AusIMM through its Sustainability Committee (Keogh 2009) which became the Community and Environment Society in 2013 (C&E Society 2014) and through publications (e.g. 'From Start to Finish') (McCullough et al. 2018), and
- academic conferences (e.g. 'Mine Closure', Australian Centre for Geomechanics, University of WA; 'Life of Mine', Centre for Mined Land Rehabilitation, University of Queensland with AusIMM; 'Mine Rehab', Tom Farrell Institute, University of Newcastle) (see Tables 1 and 2 for dates and details).

(2) Avoiding the risks associated with closure, rehabilitation and relinquishment

One method mining companies use to avoid tackling financial, social and environmental risks at the end of mine life is to sell the mine. As mines become depleted or unprofitable, a common strategy is for larger multi-national mining corporations to sell them to lower-capitalised, smaller mining companies often at a greatly discounted price. For example Rio Tinto sold Blair Athol coal mine for $1 to the smaller company TerraCom; and a similar transfer occurred for Isaac Plains coal mine in Queensland (Roche and Judd 2016). Another example is the transfer of ownership of mature assets to Indigenous communities. While hailed as a success for companies and Indigenous communities, the MR&C liabilities of these operations are rarely discussed (Topf 2017).

A reason smaller mining companies and Indigenous communities agree to this arrangement is the prospect of deriving economic value in waste by exploring the principles of the circular economy for mining wastes (Mudd 2013; Memary et al. 2012; Lèbre, Corder, and Golev 2017). For example the Chinese owned company, MMG sold Century Zinc mine to New Century Resources; and, Mount Morgan mine was sold by explorer, Perilya, which sold it to Norton Goldfields which engaged with mine operator Carbine Resources to investigate residual metal values in wastes (Lèbre, Corder, and Golev 2017). Community and NGO organisations, however, interpret these transfers as liability shifting processes. Therefore, the practice is colloquially referred to as 'pass the parcel'. Governments favour this option as it limits job losses (Watson and Olalde 2019) and at a local level, communities hope the practice unlocks extended prosperity through employment and demand for local businesses (Terzon 2018). However, if the last link in the ownership chain does not successfully close the mine, the benefits are undermined and the negative impacts only temporarily deferred (Watson and Olalde 2019).

A further practice employed by mining majors is to simply cease production and classify a mine as under *care and maintenance*. While this is not a legal term, it is used by industry to describe a hiatus in production. It differs from 'closure' as it involves temporary cessation of operations not permanent closure, and therefore does not require demonstration of progress towards satisfaction of completion criteria (Department of Premier and Cabinet et al. 2017; Queensland Government 2018a). The danger of this approach is that mines can exist in a state of *care and maintenance* for years, if not decades, creating environmental, social and economic harm.

(3) Regulatory attention to closure risks and legacy liabilities

Research indicates more mines close prematurely (75%) than reach the planned end of mine life (Laurence 2006) and many closed mines have an unforeseen requirement to manage aspects like water, in perpetuity (Byrne 2013). There is growing awareness by governments that regulations that address mine *rehabilitation* do not adequately address *closure*, and the long-term management of risks that remain after closure.

The myth that mines require only limited monitoring and maintenance after closure is implied in most tools used by industry and regulators for calculating rehabilitation costs (Department of Environment and Heritage Protection 2017; New South Wales Audit Office 2017). Moreover, compliance-focused companies know that closure plans are not yet required in all Australian jurisdictions with most referring only to *rehabilitation* or *rehabilitation plans* (New South Wales Government 2013; Department of Environment and Heritage Protection 2014; Government of Victoria 2017). When closure plans are required, it is common for them to grossly underestimate closure costs (Sheldon, Strongman, and Weber-Fahr 2002). Regulators in some, but not all, Australian jurisdictions are beginning to recognise these risks. These regulators have begun reviews and reforms in: progressive rehabilitation, closure planning, assessment of risk, calculation of residual risk (the risks that remain after all of the MR&C work has been completed (Queensland Government 2018b)), and financial provisioning for closure. *Closure* is now included in Queensland legislation that requires a 'Progressive rehabilitation and closure plan' (Queensland Government 2018c).

In addition to the challenges of preventing legacy liabilities and funding existing liability, is the question of what to do about abandoned mines in the context of contaminated land legislation. At present, high environmental risk legacy mine sites are not placed on contaminated land registers (New South Wales Audit Office 2012, 2014). This means that these mines are not accounted for as a liability despite, or because of, this liability being larger than accounted contamination. While 'Polluter Pays' legislation (Joseph 2014) is common in Europe (European Commission 2019), the USA under the *Comprehensive Environmental Response, Compensation, and Liability Act* 1980 (CERCLA or Superfund) (United States EPA 2019) and Canada, it is not widely applied to mine wastes in Australia (Preston 2009; OECD 1992).

Legacy liabilities also extend to surrounding environments and towns. For example, in north Western Australia, mining of asbestos ceased more than fifty years ago, yet residents of the town of Wittenoom were encouraged to leave because of the prevalence of health harming asbestos in their town (De Klerk et al. 2013). Nevertheless, some residents remain and tourists continue to be drawn to the natural beauty of the gorges. Rather

than have those responsible for the contamination clean up the township, authorities formally de-gazetted Wittenoom township in 2007 (Michelmore 2019). This did not compensate traditional land owner concerns for residual impacts such as the subsequent death of family members who had worked for the mining company or deprivation of access to their traditional land (Melville 2019).

(4) More diverse stakeholders become active on MR&C

During Phase 3, a greater number of community and NGO groups, as distinct from industry and government, have become active about MR&C. The low-value sales of spent mines, increasing numbers of abandoned mines, and mining impacts outstripping MR&C progress have alarmed numerous groups and organisations. They challenge poor MR&C performance in every way possible and include:

- Australian Conservation Foundation,
- Lock the Gate,
- Environmental Defenders Office,
- The Australia Institute,
- T J Ryan Institute,
- Royal Society of Queensland,
- Sunrise Project and
- Mineral Policy Institute.

Climate change concerns, and changes in international demand for coal affect commodity prices, confounding the risks perceived by these groups and drawing attention specifically to coal sector MR&C. One way in which the sector has responded is by establishing the Upper Hunter Mining Dialogue initiated by the NSW mining industry in 2011 (Upper Hunter Mining Dialogue 2018). This forum is made up of over 70 stakeholder groups, including Landcare. Because of a growing list of ageing mine assets, communities and NGOs are also demanding the Australian government undertake more coordination which has resulted in a series of inquiries by the Australian Senate (Parliament of Australia 2017; Environment and Communications References Committee 2019) and the Council of Australian Governments (COAG) (Government of Western Australia 2017).

Landcare is an enduring example of action by community stakeholders on NRM issues related to MR&C. It is referred to as an 'ethic, movement and model' founded on stewardship and volunteers (Robins 2018, 385) and has played a pivotal role in facilitating knowledge sharing and applied action as a model for community-based natural resource management (Curtis et al. 2014). Unfortunately, during this period, Landcare was subsumed into the *Caring for our country* program. This program undermined the regional model for NRM by centralising government control, prioritising measurable outcomes and adopting market-based delivery mechanisms to ensure immediate value was realised from public investments in NRM (Robins and Kanowski 2011; Tennent and Lockie 2013)

Regional communities, some of which have active environmental and Indigenous groups, have entered the fray. They are concerned about economic futures and favour using former mine sites for novel ecosystems and economic systems, including new industries, rather than having ex-mine sites permanently 'sterilised' or dormant, particularly

where compatible land uses are possible in buffer lands (Muswellbrook Shire Council 2017). The National Heritage listing of the city of Broken Hill and its mine (Australian Heritage Council 2015; Altenburg, Crocket, and Pearson 2016) challenges the assumption that rehabilitation should remove evidence of mining and establish vegetation as the main goal. Instead a sustained future use in cultural heritage tourism is possible (New South Wales Government 2013). Communities are also concerned about a social vacuum that could develop if the loss of a major source of employment results in a population exodus (Bainton and Holcombe 2018a). NGOs have, however, drawn attention to the employment opportunities possible if governments embark on abandoned mine rehabilitation (Lock the Gate 2016).

Academic organisations are another group in civil society that have been influential. They facilitate an 'evidence-based' approach to knowledge sharing and catalysing change. For instance, the Tom Farrell institute (University of Newcastle, NSW) has hosted nine annual mine rehabilitation conferences, most recently in conjunction with the Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (CRC CARE) (Figure 1). Some environmental researchers have worked with environmental practitioners to develop clearer standards for ecological restoration. For example, the Society for Ecological Restoration Australasia's (SERA) standards are voluntary and apply to all forms of ecological restoration, including mining (Society for Ecological Restoration Australasia 2017).

Summary

The current phase shows that implementation lags behind knowledge. There has been limited follow-up on global initiatives on biodiversity and mining legacy by Australian operators and regulators. The concept of sustainability is increasingly challenged by the existence of large inventories of abandoned/legacy mines and by community awareness of the liabilities of un-economic, unsatisfactorily rehabilitated mined lands. Community groups are increasingly voicing concern about the rate of progress on, and quality of, MR&C and are demanding greater accountability from both the mining sector and government.

Discussion: emerging lessons for Australia

This article reviews shifting priorities for, and stakeholders involved in, MR&C over the last 40 years in Australia. It is clear that communities, NGOs, and professionals, as well as governments, have been integral to transitioning Australian MR&C from an environmental focus on soils, landforms and vegetation cover within mining leases in Phase 1, to the recognition that impacts extend beyond the boundaries, particularly for water and biodiversity in Phase 2. This occurred at a time when global ESD initiatives influenced Australian government ESD policies that flowed on to state and territory governments. It is during the contemporary Phase 3, that the concept of *closure* as more than *rehabilitation*, is being realised. Previously overlooked, but challenging, environmental features like voids are now included in the closure discourse. Governments' dominant role in determining the nature and progress on MR&C, is now challenged, as other stakeholders seek to be involved. With far greater involvement of communities and NGOs during Phase 3, there are expectations that MR&C address longer time-frames of planning and management,

beyond cessation of mining as an additional regulatory phase that was previously neglected. The review points to potential for future developments.

Directions for the future

An optimistic trajectory would see national minimum MR&C standards that address in-perpetuity management, and legislation to address regulatory black holes, including legacy site management by governments. MR&C would ensure socio-economic value creation integrated with environmental rehabilitation as progressive closure with social transition (Post-Mining Alliance 2007; Post-Mining Alliance, IUCN, and ICMM 2008; Bainton and Holcombe 2018a; ICMM 2019). This trajectory would feature cross-functional integration, 'systems thinking', and multidisciplinary and interdisciplinary research (Lavery 2011). Regular and effective two-way stakeholder engagement throughout the mining life cycle would become routine, not just for mining approvals and not left until too late in the mine's life to influence outcomes (Browne, Stehlik, and Buckley 2011). Importantly, Indigenous rights and interests would be more central to MR&C instead of being largely invisible (O'Faircheallaigh 2013; Smith 2018; Northern Territory Department of Mines and Energy 2013).

An optimistic trajectory would also be more sensitive to context and include more local knowledge. In this respect, local government would have greater input on mine approvals to ensure MR&C meets local government and community needs to help overcome the often-neglected socio-economic dimension of closure planning. For example, collaboratively designed and planned use of buffer land has the potential to maximise beneficial outcomes, as with the Landcare model of grass-roots engagement with local knowledge. Context sensitivity, following leading principles of engaging stakeholders throughout a mine's life is as important as progressive rehabilitation of land (Whitbread-Abrutat, Kendle, and Coppin 2013). Regional planning frameworks could integrate multiple dimensions of mining activities and associated MR&C, providing a platform for dialogue and conflict resolution in all mining regions. Involvement of diverse yet relevant expertise from agencies and disciplines currently under-represented in MR&C, would allow for greater innovation in a range of areas (e.g. cultural heritage, tourism, regional development, infrastructure, planning). Demonstration sites of mine transformation to beneficial post-mining land uses (both legacy and contemporary) could create focal points for knowledge sharing and learning. These changes will require a more widespread proactive 'beyond compliance' approach for MR&C by industry (Stevens and Dixon 2017).

If Australia does not alter the way the mining sector addresses MR&C, a more pessimistic trajectory would be most likely. The *status quo* would continue with a reactive, minimalist, compliance focus by industry. This lack of initiative and multi-stakeholder engagement would restrict MR&C improvements needed for successful closure and relinquishment. Without proactive leadership from industry on MR&C, government would be forced to impose what industry may consider cumbersome legislative requirements, conduct audits, and pursue inquiries. Abandoned mines would continue in an ambiguous environment of regulatory black holes and reactive programs where valuable resources are wasted and key stakeholders excluded. Cultural heritage values and other potential socio-economic benefits from regeneration, as more than MR&C, would not be realised under this trajectory. Further unfortunate outcomes are possible such as rehabilitation practices

that remove evidence of mining ignoring heritage conservation for significant sites; leaving mines in un-rehabilitated limbo; or passing an impacted environment either to an ill-equipped future mining company or individual landholders. Without legislative clarity and cross-jurisdictional consistency on critical elements of MR&C, along with cyclical knowledge losses there would be continued creation of legacy liabilities for future generations. The result of knowledge loss would put the mining sector into a repeating loop characterised by restudying what is known without shifting to new and innovative areas of research leaving government in the position of potentially introducing policies that have failed elsewhere.

Conclusion

This study of the Australian mining sector asks the question, 'how have priorities and stakeholders in Australia's mine rehabilitation and closure (MR&C) practice shifted over the last four decades?' From the data presented, we suggest that this has evolved through three phases. The current phase reveals growing public attention to MR&C alongside a plateauing of performance standards. Ineffective regulations and regulatory silos, artificially separate elements of MR&C that are interrelated, thereby generating gaps and ambiguity. By drawing attention to turning points, advances and regressions in MR&C priorities we have highlighted promising avenues for improved management of MR&C in Australia and internationally.

At present, Australia is facing an uneven future for MR&C, not unlike periods in the past. There are some companies, jurisdictions and regions showing leadership and serving as models for others to learn from, but there is no consistent shift toward improved understandings and practices across Australia. If their lead is followed and lessons are learned, there is potential for a fourth phase of MR&C to emerge that is characterised by: coordinated action from multiple stakeholders, regeneration of socio-economic value, long-term planning horizons, low residual risks, cross-disciplinary understanding and integrated regulatory processes. With these supports in place, it would be possible to create opportunities for beneficial processes and sustainable post-mining uses facilitating a smoother transition to post-closure.

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