

# A mine ends. Then what? Some reflections on best practice

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## Abstract

*With substantial progress in the practice of closing mines over the last three decades or so largely driven by better regulation and third-party standards, it is now technically achievable to close a mine to leave behind a 'safe, stable and non-polluting' site in harmony with regulatory requirements (long-term management requirements notwithstanding). However, such limited vision often does little to realise possibilities for rebuilding broader ecological integrity and enhancing people's lives for the long-term – particularly those in mining communities.*

*Mining sector practices (and policies) need further refinement to address such challenges, especially given the inevitable large-scale mine closures planned over the next couple of decades, and growing expectations for the responsible mining of critical metals and minerals to supply the green industrial revolution.*

*Reflecting on over 30 years of research and the stories presented in the recently published not-for-profit book, 102 Things to Do with a Hole in the Ground, this paper will highlight how such challenges have been turned into pragmatic opportunities as illustrated with examples from around the world. It posits the notion that (arguably) there are few if any new problems in the mine closure/transition and post-mining regeneration space; bespoke solutions have been developed that address them by balancing environmental, social and financial outcomes (somewhere) by mining companies, government, communities and/or unexpected actors. The main challenges to converting such liabilities into new opportunities are, therefore, of perspective, communication and will.*

*Building on the existing library of excellent mine closure good practice technical guidance, the paper will discuss further advances for doing more with our holes in the ground based on empirically derived, generic findings from the firsthand analysis of many hundreds of projects, including some non-mining examples too.*

**Keywords:** *mine closure planning, post-mining regeneration, compliance, best practice, transition, landscape narrative, community participation, creativity, unusual suspects, cultural identity, sense of place, restoration*

## 1 Introduction

Mines have finite lives, but their legacies (good and bad) may persist for generations. Over the coming decades coal mines will close on an unprecedented scale; simultaneously, increasing demands from growing populations, expanding wealth and the green industrial revolution will drive one of the greatest expansions of new mines in history. Society expects old mines to be closed responsibly and for the surrounding communities to experience a just transition, and that new mines will meet higher standards of environmental and social management (including closure) than is the norm today.

Today's mining industry actors (companies, government and civil society) know how to close and rehabilitate mine sites according to best practice to leave a site that is safe, physically and chemically stable, ecologically sustainable, that addresses the socio-economic transition while being cost-effective and that minimises long-term risks and the need for post-closure care (see ICMM 2019). While there are some good (even inspiring) examples of what can be achieved with old mines sites that rebuild ecological integrity and enhance the lives

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and livelihoods of the people connected with them, the international norm sits below this level of expectation, which will need to be achieved in the future to implement better post-mining outcomes for mines.

Many mine operators (and their stakeholders) are satisfied with being legally compliant with their environmental and social management obligations (including mine closure); however, there are many jurisdictions with sub-par regulations and/or poor enforcement. Also, most regulatory frameworks were promulgated when societal expectations were lower and when the climate and nature emergencies were less urgent and less prominent. Today, it's probably fair to say that simply complying with regulatory obligations will be unlikely to meet societal expectations for a just transition, climate mitigation and adaptation, and rebuilding ecological integrity at a landscape scale.

Best practice goes beyond basic compliance with a more holistic and progressive approach to generate better environmental and social outcomes. The examples in this paper highlight practices that could and should apply more widely; they show that the hurdles to achievement often thrown-up as reasons not to do something have been surmounted. This paper promotes the following tenets:

- It seeks to stimulate discussion about how best practice can become the norm.
- It posits the notion that (arguably) there are few if any new problems in the mine closure and post-mining regeneration space – bespoke opportunities have been developed to address them that balance environmental, social and financial outcomes, somewhere, by mining companies, government, communities and/or unexpected quarters.
- To move such practices from the unusual to commonplace and to avoid the frustration of reinventing the wheel, we need to address the key challenges of perception, will and communication.

This paper explores what can be learned from exceptional examples to push practice forward. It reflects on over 30 years of personal, international experience and empirical research, with cases drawn from the new, not-for-profit book, *102 Things to Do with a Hole in the Ground* by the same author (Whitbread-Aburatat & Lowe 2024), to which the reader is referred, and even non-mining examples to illustrate specific points.

Firstly, the paper outlines some generic obstacles to achieving best practice and how these have been overcome using real examples that have worked. It then synthesises generic lessons of broader applicability for application to closure/regeneration challenges everywhere. The paper seeks to promote a changing mindset to encourage a more holistic approach from conventional closure planning that minimises end costs towards perceiving an operating mine as a transition catalyst to drive new socio-economic, cultural and environmental values beyond the end of mining.

## **2 Addressing common challenges through the creative repurposing of mine site features**

Conventional compliance-focused closure planning and delivery may satisfy regulatory obligations, but generally creates relatively little of new value to support surrounding people and their environment after mining. This section explores successful examples in relation to general mine site features where the obstacles to best practice have been overcome. It takes a site focus rather than considering wider issues such as limits to regulation and weak closure planning, the point being that whatever the context, the site focused challenges have been addressed and the limitations in technical difficulties, weak closure planning, regulatory limitations, completion criteria and relinquishment, successful solutions have been developed and implemented. Note that the examples are not mutually exclusive.

The paper can only provide a taste of the rich diversity of post-mining repurposing flavours; it aims to showcase what is achievable in spite of the barriers that challenge creativity in the post-mining theme.

## 2.1 Voids

To state the obvious, mining activities create either underground or surface voids that subsequently may present challenges of geotechnical stability, subsidence, steep slopes and access issues in relation to public safety. Backfilling is a common way to address such issues, usually with mineral wastes, but also – in open pits – municipal wastes as landfill. Veolia’s Woodlawn Eco-Precinct in New South Wales, Australia, has elevated this approach. The old base metal mine receives municipal waste from Sydney and, using novel bioreactor technology, converts this into methane that is captured and burned to generate power. The waste heat produced supports a horticultural facility and a fish farm.

Secure underground voids with relatively constant ambient conditions are useful for storing a range of things: the caverns of England’s Winsford Rock Salt Mine are home to DeepStore, the UK’s largest underground storage facility housing a significant proportion of the National Archives, while on the Arctic archipelago of Svalbard, the NordGen seed bank is housed in an old underground coal mine. The conditions underground are also suitable for storing food and drink products: Moldova’s Mileştii Mici, the world’s largest wine cellar, occupies 55 kilometres of former limestone mine workings, and in Italy’s Aosta Valley up to 60,000 truckles of Fontina cheese produced by an alpine dairy cooperative mature in the (very smelly!) tunnels of the abandoned Preslong copper mine.

The underworld geology – and depths – of several mines around the world have also proven ideal for establishing physics laboratories for researching the nature of matter and understanding the universe. Australia’s Stawell Underground Physics Laboratory is being constructed in Victoria’s operational Stawell Gold Mine to study the nature of dark matter and, on completion, will comprise the first underground physics laboratory in the southern hemisphere.

Underground mine workings are ideal for adventure and adrenalin-fuelled recreation. Go Below Underground Adventures in North Wales guides small, adventurous groups for several hours exploring the mysterious tunnels and caverns of an underground slate quarry, essentially a subterranean via ferrata with an accompanying dose of industrial and social heritage. When underground workings become flooded this does not preclude adventure: the abandoned Bonne Terre lead mine in Missouri, USA, has become a renowned scuba diving destination with about 25 diving trails exploring the submerged underworld.

Surface voids are used for storing water for re-use or power storage. The San Jose mine open pit of Peru’s Yanacocha gold mining complex, high in the Andes, has been repurposed for water storage to irrigate almost 1,000 hectares of agricultural land. Water is stored for a different purposes in the two open pits of the closed Kidston gold mine, which are being repurposed as a pumped hydro power storage facility, despite the remoteness of the site.

Sometimes open pit voids are just impressive to gaze over and attract many people to do just that. The Big Pit diamond mine void sits in the middle of the historic South African city of Kimberley and is visited by around 90,000 people per year. This sense of theatre has been exploited in other places where the pit walls provide ideal growing conditions for spectacular garden-based visitor destinations, such as the UK’s Eden Project formed in a worked-out China clay quarry, and the Butchart Gardens on Canada’s Vancouver Island, which were created by the former limestone quarry manager’s wife over 100 years ago.

## 2.2 Mine water

Mine water – particularly when contaminated with acid and/or potentially toxic elements – poses a significant global challenge to the mining industry; but the majority of mines do not have particularly problematic water chemistry, although this fact is often lost in mine water debates. When acid or neutral drainage does occur at closure, ongoing mine water treatment – active or passive – is required ‘in perpetuity’. For major instances, there is no obvious ‘walk-away’ solution to dealing with this. That said, there are examples globally when innovative approaches have been taken to turn such aquatic liabilities into assets.

At the University of Ohio Athens, USA, a professor of art and a professor of engineering have collaborated to produce a range of high-quality artistic pigments from the state’s largest abandoned coal mine acid drainage

seep. The pigments were commercialised by Gamblin, the artists' paint manufacturers. This formed the inspiration to scale-up operations, with federal funding from the Abandoned Mine Economic Revitalisation Program, to build a bespoke plant to treat all of the water from the seep and produce high grade iron oxide pigments for American industry. It will be operational in 2026/27 (John Sabraw, pers. comm. 15 August 2024).

In South Africa, Thungela's eMalahleni Water Reclamation Plant in Mpumalanga Province treats up to 40 million litres of coal mine water per day, from five opencast and underground coal mines (both operational and closed). The treated water leaving the plant supplies 20% of the municipality's potable water needs. Close-by at Mafube colliery, mine water of reasonable quality is being used to demonstrate the potential for agricultural irrigation, leading to dramatic increases in maize production compared to normal, rain-fed control plots.

The Mettiki fish hatchery in Maryland, USA, uses treated Mettiki Coal mine water to nurture hundreds of thousands of rainbow trout each year. It results from a successful partnership between the company and the state's Department of Natural Resources.

Mine water may also be a geothermal heat resource. In the UK, geothermal heat is extracted from the water in flooded coal mine workings beneath the city of Gateshead and is used in the district heating of city centre buildings.

### 2.3 Mineral wastes and landforms

An imposing feature of mine sites are the mineral waste structures that will dominate their surroundings 'in perpetuity' (Chapman & Kemp 2019), forming the backdrop to the sense of place of generations of people who live there – now and in the future. Alongside the aesthetics aspects, such structures could become sources of environmental contamination, potentially for centuries. Their design and construction requirements dictate that they must be geotechnically stable, but often hydrological stability is overlooked – witness the common appearance of gully erosion on closed mineral waste structures.

Fluvially focused geomorphic reclamation, such as those using the GeoFluv-Natural Regrade approach, uses locally collected stream drainage network data to model a natural-looking, post-mining landform that is suited to the prevailing climate, thus minimising erosion. The EU-funded Life Ribermine project demonstrates this technology at an abandoned China clay quarry in central Spain and at Portugal's abandoned Lousal pyrite mine where the GeoFluv design interacts with an acid neutralising soil cover system (Donoso et al. 2023). Geomorphic landscape restoration is officially considered best practice for managing extractive industry mineral wastes in the European Union (European Union 2018). It has also been used successfully on a larger scale on some of the waste rock dumps at BHP's Mt Arthur coal mine in New South Wales' Hunter Valley in Australia.

A more artistic approach to post-mining landforms can be found in Northumberland, UK. Sculpted from 1.5 million tonnes of coal mine overburden, Northumberlandia: The Lady of the North is a landscape sculpture of a reclining nude that has become a publicly accessible, cultural and ecological asset. It was the brainchild of the mining company, and the landowner and mineral planning authority gave permission for the landscape artist, the late Charles Jencks, to create his masterpiece. The landform is covered in a biodiverse sward and is managed by the local wildlife trust. Ownership was passed to the not-for-profit Land Trust, along with an endowment from the mining company, which is used for managing the site's long-term liabilities.

Mineral wastes have long been re-mined/re-processed for the new mineral values many of them contain. Doing so offers the opportunity to also rehabilitate a mine site to a standard that would otherwise have been impossible. The New Century Mine in northwest Queensland, Australia, is re-using the original plant to reprocess old tailings to extract the residual zinc. The residual tailings are then pumped as backfill into the old open pit. Instead of being demolished, the plant has been given a new life and, once re-processing is complete, there will be an empty tailings impoundment, potentially with a functional dam available in a water scarce area.

Regeneration is a social enterprise start-up, created by RESOLVE with support from Rio Tinto, that extracts valuable metals and minerals from mine wastes while simultaneously rehabilitating the site. Their Salmon Gold project in Alaska has demonstrated the economic viability of extracting residual gold from abandoned placer mine wastes and restoring the river channels to promote the return of viable populations of salmon and other anadromous fish. These are of significance to the region's indigenous people and the gold is used as green gold in the supply chains of Apple, the jewellers Mejuri and others.

A new re-use for in situ tailings offers potential in climate change mitigation. Arca Climate Technologies are demonstrating at a commercial scale that ultramafic tailings can mineralise atmospheric carbon permanently (potentially on a large-scale).

## 2.4 Infrastructure, buildings and equipment

A typical mine closure plan states that the buildings will be demolished and cleared, equipment will be sold or scrapped, and infrastructure will be similarly removed. There are exceptions, but generally little creative thought is given to how such features could be repurposed or re-imagined. As well as reducing closure costs, repurposing may offer new community or commercial assets, while avoiding the development of greenfield areas to supply similar facilities.

Ireland's closed zinc and lead Lisheen mine is being reinvented as a National Bio-economy Campus thanks, in part, to the renewable wind energy in the vicinity of the site. Its closure plan, built on a vision of the site becoming a green energy hub, was originally developed by Anglo American, then subsequently implemented by Vedanta. Wind turbines were installed during operations to reduce the pumping costs of this wet underground mine and formed the basis of the closure vision of a renewable energy hub. The electrical infrastructure installed to support the windfarm was then used by others in the vicinity to install many more wind turbines. The vision evolved with the ready supply of green energy into a bio-economy concept based on low-carbon growth and resource efficiency. Now, land and buildings at the site are slowly realising this vision and have become Ireland's National Bio-economy Campus.

Sometimes a site's infrastructure and structures may be too large and complicated and culturally too important to demolish. Germany's Zollverein Coal Industrial Complex in the Ruhr's urban-industrial heartland was dubbed 'The most beautiful mine in the world'. Its complex of well-built, Bauhaus-inspired buildings and structures were kept as an industrial monument to the foundation of a region's cultural identity. Today they form a 70-hectare cultural and ecological parkland, incorporating the Museum of the Ruhr, the Red Dot Design Museum, performance spaces, offices and workshops and space for 130 companies, and a seasonal swimming pool and ice rink. It is vegetated by a naturally recolonising forest that is publicly accessible and connects directly to the Ruhr's network of trails. Zollverein is a UNESCO World Heritage Site that celebrates the region's industrial-cultural identity while exploring the post-mining culture that is still evolving. It attracts 1.5 million people per year, mostly from outside the region.

Mining people are often too close to the action to fully appreciate the wonder and potential engendered by the giant buildings, voids and structures appreciated by those who rarely experience them. There is an opportunity here to capitalise on this phenomenon. Usually the enormous surface coal mining machines are unceremoniously demolished with explosives, then scrapped. During the closure of the Golpa-Nord open pit lignite mine in eastern Germany, an onsite workshop was being held with Bauhaus Dessau design students. Understanding the draw of the defunct machines, they persuaded the miners not to demolish the massive structures and instead preserve them onsite. Today they tower over an amphitheatre created on a peninsula surrounded by the pit lake. The Ferropolis – City of Iron destination is an open air museum and monument, but also a state-of-the-art rock concert venue (amongst other things). People from across Germany visit the site, climb the machines in awe and connect with what went before.

## 2.5 Nature

As an industry we know a great deal about how to avoid and minimise damage to nature and restore it when damage is done. Compliance with re-vegetation requirements is a necessity, but sometimes well-meaning regulations deliver unintended consequences that mean the end point is compromised.

After mining, mountaintop removal coal mining sites in the USA's Appalachia region were mandated to be compacted and revegetated with quick-growing, non-native, herbaceous plants to protect the denuded surface from erosion. The intention was that forest trees would recolonise such areas and, eventually, the forest would return. The aggressive nature of the groundcover plants, which were also a fire risk, created an arrested succession in which the forest could not re-establish. It was the role of federal Office of Surface Mining and Reclamation and Enforcement (OSMRE) inspectors to assess the success of the progress of reclamation. Even though mining companies were employing the correct procedures the forest was not returning. Two OSMRE inspectors realised the shortcomings of the mandated practices they were enforcing and, with University of Kentucky scientists, developed a more progressive approach to achieve the forest recovery requirements. They formed the Appalachian Regional Reforestation Initiative to research and implement their new Forestry Reclamation Approach. Working alongside other organisations, such as Green Forests Work, well over 100 million trees have now been successfully planted on approaching 70,000 hectares of land.

Indigenous people's ancient associations with their land offer a mutually beneficial opportunity for post-mining ecological restoration. In Western Australia's Pilbara, BHP's Yandi iron ore mine is approaching closure. Initiated by indigenous employees at the mine, the Banjima Land Rehabilitation Partnership is a unique ground-up collaboration between the company, the Traditional Owners, a vocational training provider and horticultural/ ecological experts to train and employ the Banjima (the Traditional Owners) in land rehabilitation. It offers a pathway to transferable skills, qualifications and future employment in a remote, sparsely populated region where there will be a demand for such skills and deep understanding of Country well into the future.

## 2.6 Land and landscapes

Mine sites are often left as stark discontinuities in a landscape, with idiosyncratic landforms, contaminated soils, denuded land and derelict buildings. Most see the negative, but some perceive opportunity in such dereliction and are motivated to manifest positive change from it.

When the Duisburg-Meiderich's Thyssen Ironworks in western Germany's industrial Ruhr region closed in the late 20th century, the main challenge was determining what to do with its towering structures and buildings and 200 hectares of contaminated land. Tensions arose between those who wanted demolition and clean-up versus those who could see potential in the site's cultural significance. Ultimately the latter group won the argument and, today, the ironworks is a hybrid landscape park celebrating industry, culture and nature. The site attracts over one million visitors annually to climb over the structures, attend cultural events and explore the structures. A gasometer has even been converted into a diving centre! But the park and its hardy biodiversity were instrumental in establishing a new ecological paradigm – industrial nature (<https://www.landschaftspark.de>). The site's brownfield ecology is a novel community of local species finding refuge, exotic garden escapes and others originally accidentally imported with the iron ore. Some areas were left to develop naturally, undisturbed, forming an industrial 'wilderness'. The rich ecology of over 700 species includes numerous rare and protected animals and plants – even the Western Ruhr Region Biological Station has an onsite presence. It has influenced the re-vegetation practices of other expansive, contaminated, post-industrial areas in Germany and beyond.

The relatively benign and extremely infertile gold tailings of Gold Field's Abosso Goldfields Damang mine in Ghana are now a diverse and productive agroforestry system. The initial substrate infertility was addressed by planting leguminous trees and herbaceous plants, which increased soil nitrogen and organic matter over several years. Following consultations with local land users, a range of food and cash crops, including coconut, cacao, maize, oil palm, citrus, cocoyam, plantain and vegetables grow side-by-side in an integrated system.

The tailings pond itself is a self-sustaining wetland with fish and economic plants, such as sugarcane, bamboo and raffia palm, and it enriches the local ecology too.

The development of the UK's Eden Project is another example. Created in a 160-year-old China clay quarry, there was no soil available to create what would become an iconic botanical visitor attraction. The Eden team made 80,000 tonnes of artificial soils from recycled China clay mineral wastes and composted waste materials, and used these as the growth media for a horticultural landscape that attracts up to one million visitors per year from around the world.

## 2.7 Mining communities

Best practice dictates that social transition planning should occur throughout the life of mine (LOM) (ICMM 2019), but this is not reflected in most regulatory frameworks and is not carried out to a high standard at most mines. An excellent example of social transition in action is provided by Anglo American's Kumba Iron Ore in South Africa's Northern Cape province. Its remote Sishen open pit iron ore mine is one of the world's largest and it is the main driver of the local economy – particularly for the town of Kathu. The company has embarked on a major initiative to create an agribusiness hub as part of its broader effort to drive sustainable economic diversification and community development across the mining area that will outlast the remaining 14-year LOM. The company is using its land assets, logistical infrastructure, capital and convening authority to catalyse commercial farming businesses – large and small – with attendant services, offtakes and small business start-ups. This includes trial plantings of nut trees on the mine's waste rock dumps, horticultural trials on the mine's non-operational land, high productivity polytunnel cooperatives, honey production and more. Building local skills and small businesses is critical, so in partnership with commercial mega-farmers, they are investing in training programmes with an emphasis on work experience and apprenticeships for youth and women.

The damage to land and landscapes referred to in the previous sections influence external perspectives of a place, which disincentivises investment and the inward movement of skilled people into the area. Communities may enter a 'spiral of decline' that, once begun, can become almost irreparable. But there are examples where such community decline has been turned around.

Elliot Lake, Ontario, was once the 'Uranium Capital of the World'. Constructed in the mid-20<sup>th</sup> century in a region of dense forests and lakes to house the workers at the area's lucrative uranium mines, when uranium mining ended, unemployment rose and the population declined. However, the beautiful, peaceful surroundings and surplus housing stock at cheap prices were marketed to urban retirees in other parts of the province (retirees do not need jobs and have disposable income). The purpose-built mining settlement has successfully remodelled itself as a retirement community. It is now also attracting younger professionals and families with the capacity for hybrid working and an interest in outdoor wilderness activities. Although remote, the town is close enough to the Trans-Canada Highway that it offers a pleasant overnight option on long journeys, and it is growing as a four-season outdoor tourism destination, including the development of new hotels.

In remote north-eastern Tasmania, the erstwhile tin mining township of Derby is experiencing its third incarnation. Established as a 19<sup>th</sup> century open pit tin mining settlement, the mine closed in 1948 and the population dwindled to ghost town status. In the 2000s, two local mountain biking enthusiasts saw potential in the picturesque landscape and began developing biking trails through the forests with the support of the local council and state government. Today, Blue Derby's mountain biking offer is world-class, hosting the professional Enduro World Series races more than once and 80,000 visitors annually. Critically – and unusually – the trails start and end in the community, which has driven demand for cafes, shops, bike hire, bars and accommodation.

Best practice requires the ongoing engagement of communities around mine sites in closure planning, yet this often does not happen until too late. When it does, engagement can be formulaic rather than bespoke, and rarely addresses the power disparity. Leaving community engagement around closure to the end of the operational phase is too late to meaningfully enable their contributions to a closure plan. The more

favourable term ‘community participation’ is suggested in which early and ongoing involvement with communities in closure planning allows them to influence decision-making and – perhaps – even drive aspects of the process. Without effective early participation, it can be incredibly difficult to reconnect local people to an industrial landscape that many were excluded from in a way that allows them to inform the development of a landscape that doesn’t yet exist.

Bespoke solutions that recognise the uniqueness of individual post-mining situations are best, but require significant effort and time. The communities interspersed among Lusatia’s expansive opencast lignite mines in eastern Germany offer a masterclass in changing community perceptions and re-connecting people with place. The 10-year International Building Exhibition (IBA) Fürst-Pückler-Land programme was launched to address the disconnect between local people and their wounded landscape and explore potential futures in what would become a new lakeland landscape (<http://www.iba-see2010.de/>). Activities included public tours into the once-forbidden mining lands, plays and participative theatre. Notably the immersive Perception Workshops® methodology was developed and employed by an architectural sociologist and a sculptor/architect to discover the character and potential of a place by exploring the senses and reinterpreting that place, while bringing people together. One in situ workshop took former miners, former residents of lost villages and people with no connection to the regions around the mine sites to explore the same reality. Coloured by their individual backgrounds, they all perceived this reality differently. They shared their disparate perceptions with each other, encouraging mutual understanding of the relevance of different perspectives of the same place. Through these, and other creative and participative approaches, local people contributed in a meaningful way to the shaping of their future landscapes. However, the personal process of rebuilding a sense of place and reshaping a shared cultural identity is a multi-generational perspective.

## 2.8 Regional renewal

Reinventing mining regions after what went before is extremely difficult, costly and long-term, but urgency and impetus are growing – particularly in coal mining regions, and governments are taking steps to ensure more regional approaches to the rapid closure of many mines over a short timeframe.

There is some consideration of regional mine closure planning policy and catalysing economic diversification within major jurisdictions underway already. In 2021, the South African government’s Department of Mineral Resources and Energy released its draft National Mine Closure Strategy which emphasised the need for a regional approach to mine closure, suggesting collaboration in regional development between mining companies and other key stakeholders in a region (Department of Mineral Resources and Energy 2021). The urgency is reinforced by data such as from Cole (2024) that, of South Africa’s 230 operating mines, 48 could close in the next 10 years. In May 2024 the parliament of New South Wales, Australia, announced its inquiry into the beneficial and productive post-mining land use in recognition of the relatively large number of significant coal mines that will be closed over the coming decades (37 of the 50 large and active NSW mine sites are coal mines) (NSW Government 2024a, 2024b).

There are some (but relatively few) success stories of large-scale, post-mining regional renewal, and even these are really works in progress. Priorities such as coordinated economic diversification and collaborative large-scale environmental restoration are obvious; less apparent, but critically important to the success – or otherwise – of post-mining societies, is the respecting of cultural identity and the sense of place. The best examples address all of these themes.

The lignite mining regions of eastern Germany offer a world-class paradigm for post-coal regional renewal. On German unification, most of the mines in Lusatian and Central German Lignite Districts were forced to close. In the 10 years from 1989, 31 surface mining areas containing 207 surface voids and 43 lignite industrial complexes were decommissioned, affecting a cumulative area of over 1,000 km<sup>2</sup>. Ownership of these former state-owned enterprises was taken on by the German government. The work remains ongoing, complex, large-scale, long-term and costly. Three levels of government have overseen and implemented the stabilisation and rehabilitation of extensive tracts of land, which have been converted to agriculture, forestry, wind and solar energy generation, new commercial and industrial estates, new residential developments,



tourism and recreational facilities and nature reserves, and allowing extensive public access across the new landscapes. Critically, given the very few other options available, the surface mining voids were allowed to fill (or are still filling) with water and have been linked together and into the river systems to ensure turnover to help maintain water quality. Lakes with poorer water quality are actively managed with lime applying boats. The now navigable lakes and waterways have stimulated a new lake-focused tourism and recreational industry.

Creating the new physical landscape was one major challenge, but encouraging local people to see value and connect to that which they once shunned, or from which they were excluded, is a different challenge that cannot be solved by heavy engineering. In the predominantly rural, former Lusatian lignite district, the 10-year IBA Fürst-Pückler-Land referred to in Section 2.7, was instrumental in changing perceptions in a way that respected local cultural identity and tested new creative economic, social and cultural ideas.

### 3 Generic lessons

The empirical analysis of and reflections on hundreds of closure plans and post-mining projects in a diverse array of contexts across the world, indicates that there are patterns of behaviour and organisation that deliver success – and those that don't!

Given the well-known generic challenges above and the fact that all of them have been demonstrably addressed somewhere, and coupled with the easy availability of excellent technical guidance on closure, why are we still having these discussions? How do we move from 'compliance' to 'best practice' and beyond? What needs to happen so the best becomes the norm?

The good news is that there are signs of a shift in the mindsets of some industry actors from one of end of mine cost minimisation and financial provisioning for physical closure and rehabilitation, to one of socio-economic, environmental and cultural value generation throughout and beyond the LOM. However, the industry as a whole is behind the curve; the shift needs to become more widespread, joined up and faster.

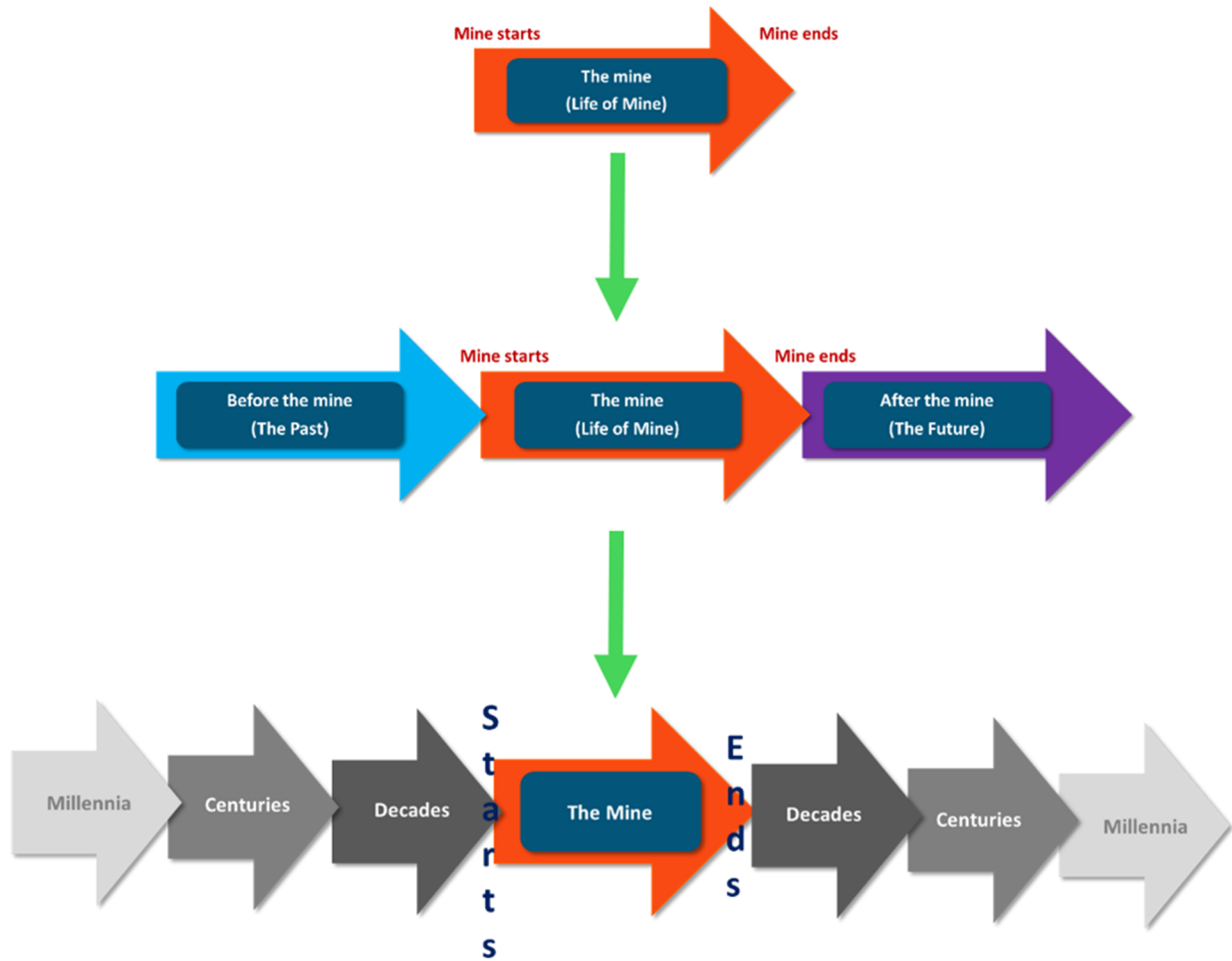
This section discusses this progressive mindset with reference to the examples introduced earlier in this paper. The shift is assisted by addressing perspectives and language around closure/transition and encouraging approaches that accommodate these. Note that these learnings are not mutually exclusive, indeed most are mutually supportive.

#### 3.1 Landscape narrative

Encouraging a new mindset amongst mining practitioners could begin by reframing the narrative around closure/transition and exploring what it means in the sense of 'landscape'. The widely accepted definition of 'landscape' developed by the European Landscape Convention states:

*“Landscape’ means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors’ (Council of Europe 2000).*

A landscape narrates a story about a place and people. The story began before mining and will continue long after it. The mine itself can be regarded as one chapter in the landscape's story. Considering a mine as just a part of a wider landscape, both spatially and temporally, initiates a shift in perception of the mine site and what came before and will come after. How we open, operate and then close a mine directly affects how the post-mining story – and its people and nature – will flourish, or otherwise (Figure1).



**Figure 1 The landscape narrative from the perspective of the land through time. The ending of a mine should not mean the end of a viable post-mining landscape and its society**

The landscape planning and regeneration approaches developed in Germany to deal with the large-scale regional regeneration needs after the collapse of the lignite mining industry are probably the best exemplar of this kind of thinking (Section 2.8).

### 3.2 Catalysing mine transition

Understanding the landscape narrative, in relation to time, is a primer for discussion on closure as a process – transition – rather than a one-off project. The best practice guidance talks to this and requires closure planning to be implemented throughout the LOM, but this is often not the case in reality, even amongst some ICMM member companies.

ICMM’s good practice guidance progressively talks to ‘social transition’, rather than social closure. However, we need to go further and refer to ‘transition’ as a LOM activity that includes economic and environmental imperatives, as well as social. ‘Transition’ implies a prolonged time period and planned incremental change. Progressive rehabilitation and ecological restoration are prerequisites for mine transition planning and have been an expectation of mining operations for decades, yet adequate implementation (still) remains patchy.

Anglo American’s Kumba Iron Ore project exemplifies the kind of thinking required to use an operating mine to catalyse economic diversification away from mining during the LOM and assisting the post-mining transition, even when this may be well into the future (Section 2.7).

### 3.3 Thinking beyond the boundary

Mine sites are contained legally by permit boundaries and licence areas and physically by barriers such as fencing. These boundaries, augmented by barriers between institutions, departments and disciplines, often constrain thinking around closure design and planning too, deterring holistic approaches. Thoughts around connectivity across the boundary, which is essential for a viable post-mining landscape, are often secondary and include public access, ecological and hydrological continuity, landform continuity and cultural considerations.

We need a wider perspective that includes what sits beyond the mine boundary. If we figuratively consider a mine site as a jigsaw piece in a wider landscape picture, the picture is not complete until that jigsaw piece fully connects with its surrounding pieces. Such a perspective is underpinned by the other lessons outlined in this section.

There is another layer of constrained closure-related thinking which affects most of us. When considering closure, we tend automatically to focus on familiarity, namely other mines and closure projects, but there is much to learn from the non-mining parts of the regeneration economy. For example the reinvention of coal-fired power stations as iconic cultural backdrops on the banks of London's River Thames, namely the redundant Bankside Power Station restored as the Tate Modern art gallery, and the reinvention of Battersea Power station as a shopping and leisure destination and residential area, showcase what can be achieved with old power generation (and mining) structures elsewhere to add new values, instead of their eradication from the landscape and (eventually) local people's sense of place.

Rural regional regeneration doesn't just apply to mining either; Chilean Patagonia's resurrection as an adventure and sustainable travel destination after the work of conservation philanthropists Doug and Kris Tompkins changed the regional narrative from one of extraction (timber, hydropower) and damaging farming practices to one of regional conservation and landscape restoration, sustainable farming practices, local supply chains, and low impact tourism based on a network of new national parks (see Whitbread-Abrutat 2013).

### 3.4 Context is everything

Although there may be similarities, we are told that every mine and mining region is different; this therefore implies that their related closure processes and post-mining solutions need to be a bespoke response to an individual mine's context. Too often closure plannings are designed by rote with little real understanding of what should come next that will add long-term value to the lives and livelihoods of local people.

For example, tourism is often touted as a post-mining option to support ex-mining communities, but there are many examples of tourism ventures that failed because they were developed in areas without a pre-existing tourism industry (e.g. Gillette & Boyd 2024). The UK's Eden Project has been successful because it is a mass tourism destination (built in an old quarry), in a region that already had mass tourism infrastructure, services and a reputation in place. The principle being that a thorough understanding of the local culture, resources, capacities and assets is fundamental to determining a viable and enduring post-closure success story.

### 3.5 Inclusivity, collaboration and 'unusual suspects'

No one group of disciplines or specialists or stakeholders has all the answers to deliver best practice transition. Mining companies are not and should not be regeneration experts. The best closure/transition planning is multifaceted, complex, multidisciplinary and long-term, so responsibility for it should not fall solely on the mine's mining engineer or environmental manager. Best practice, long-term transition planning (and delivery) during the LOM requires local community and stakeholder involvement (or 'participation'), to bring fresh perspectives and creative ideas to the planning process. This practice could build on existing mine and community and stakeholder liaison processes although, surprisingly often, closure is rarely on the agenda of such liaison groups until very late in the day.

The necessity for meaningful collaboration with external interests is obvious when the regeneration of abandoned mine sites is considered. This is almost always carried out by non-mining company organisations that may see opportunity in the derelict site without realising they are in the mine transition game.

Often, novel and innovative approaches derive from unexpected quarters beyond the usual mining circles; the ‘unusual suspects’ can be instrumental in developing world-class solutions: witness the Eden Project founded by a former archaeologist and pop music songwriter; the acid drainage to pigments programme developed by a professor of art in collaboration with his engineering professor colleague (Section 2.2); and the US federal reclamation regulators who saw limitations in the regulations they had to enforce and consequently developed a more progressive solution to restoring the Appalachian forests (Section 2.5).

### **3.6 Community engagement consultation participation**

There are arguably two groups of stakeholders: those who do the doing (mines, companies, investors, government) and those who are done too (workers, communities, indigenous people). Such asymmetrical power relationships result in suboptimal and even damaging post-mining outcomes.

There is much existing guidance on community and stakeholder engagement in mining, including in the closure/transition phase but, despite this, there is significant room for improvement. To stimulate a new mindset, I use the word ‘participation’ to encourage the empowerment of local people (and other stakeholders) to maximise influence in decision-making over how the mine will affect their lives – influencing the ‘doing’. This requires investing communities with a meaningful stake in their own futures from the start, through trust-building by improved transparency, walking-the-talk and fair benefit-sharing (amongst other things) (Section 2.7).

### **3.7 Science-based decision-making**

Good design and engineering are critical aspects of mine closure planning and delivery, but underpinning all of this is the critical – but often overlooked – role of applied science, often in very difficult circumstances. The role of science in identifying solutions to post-mining problems, developing and testing knowledge and demonstrating better understanding are critical to the buy-in of both internal and external stakeholders.

Scientific rigour goes hand-in-hand with the academic process and its focus on research papers, grants and peer recognition. This process, though, can be constraining with its focus on short-term, timebound projects to fit within funding programme timeframes, and the unfortunate practice of reinventing the wheel. In the realm of mining transition and post-mining regeneration, the traditional approach needs to be augmented with credit given to ‘action research’ that demonstrates, motivates and delivers meaningful change on the ground. For instance, the Life Ribermine geomorphic restoration demonstration project in Spain and Portugal has shown a new and better way to create stable mineral waste dumps economically but, importantly, has developed a long-term demonstration site for others to understand the technology and adapt learnings to different scenarios elsewhere (Section 2.3).

### **3.8 The generalist**

No one is an expert on every aspect of mine closure/ transition, but that expectation is commonly foisted on one or two people at a mine who are given the brief to ‘develop the mine closure plan’. A coalition of subject matter specialists, community and stakeholder participants and regulators is required to produce a viable best practice transition plan. A key role that is often overlooked is that of the closure generalist, or ‘closure integrators’ (sensu Ferguson 2024). Their role is to sit outside the departmental, institutional or disciplinary boundaries with an overarching and holistic view of the transition of a place, to assemble the jigsaw of a transition plan from the seemingly disparate pieces. They need to challenge conventions, champion innovations and be prepared to be unpopular for a while, after all ‘a jack of all trades is a master of none, but oftentimes better than a master of one’.

### 3.9 Creativity as the transition superpower

UNCTAD (2008) describes creativity as:

*'...the formulation of new ideas and to the application of these ideas to produce original works of art and cultural products, functional creations, scientific inventions and technological innovations'.*

'The word 'creativity' is associated with originality, imagination, inspiration, ingenuity and inventiveness' (UNCTAD 2008). At a fundamental level it is simultaneously:

*'an inner characteristic of individuals to be imaginative and express ideas; associated with knowledge, these ideas are the essence of intellectual capital. Similarly, every society has its stock of intangible cultural capital articulated by people's identity and values.'* (UNCTAD 2008)

The term 'creativity' and its derivations are noticeable by their absence in the common best practice mine closure guidance (and Mine Closure conference proceedings!); but there are many examples of excellence in mine transition and the regeneration of abandoned mines relies heavily on creativity as a process. In other parts of the regeneration economy, such as urban and industrial revitalisation, creativity in the planning process and the stimulation of regeneration through encouraging creativity clusters or communities is well-established. Mine closure/transition/regeneration planning can learn from other sectors of the regeneration economy, but also from how creativity was embedded in successful post-mining transformations, such as the Eden Project, Butchart Gardens, Northumberlandia, Zollverein and the revitalisation of German lignite landscapes (Sections 2.1, 2.3, 2.4 and 2.8).

### 3.10 Cultural identity and sense of place

Entwined with creativity as essential human characteristics are 'cultural identity' and 'sense of place'. Cultural identity is a personal, complex and dynamic part of an individual's self-perception based on how that individual infers:

*'their own attitudes, beliefs, emotions, and internal states by observing and interpreting their own behaviours and external cues'*(<https://www.thebehavioralscientist.com/glossary/self-perception>).

Sense of place is derived from:

*'the emotive bonds and attachments people develop or experience in particular locations and environments. ... It is also used to describe the distinctiveness or unique character of particular localities and regions'* (Foote & Azaryahu 2009).

Cultural identity and a sense of place are particularly strong in places where a mine is germinal to a community's origin story. They are forged through common purpose with a fundamental physical backdrop of industrial structures and landscape to emotively attach to, sometimes over many generations. When the mine closes, it is common to remove all traces of those physical foundations of sense of place and identity, meaning the community may be figuratively cast adrift and even experience emotions of collective grief. Mining societies in particular are on a cultural journey that needs to be respected and allowed to evolve sensitively, with the roots of people's and communities' origin stories respected.

Fortunately, there are examples where closure has been done more sensitively, where such features are conserved and embellished with new purpose and re-used in ways that respect the past but articulate a new future. This has been notably successfully manifested at Zollverein and the North Duisburg Landscape Park and the lignite landscape regeneration – all in Germany (Sections 2.4, 2.6 and 2.8).

## 4 Conclusion

It is clear that to meet societal expectations of mining industry performance in relation to the climate and nature emergencies and to deliver a just transition, the mining industry and its actors need to move beyond basic regulatory compliance. The examples in this paper show that we know how to develop and deliver best practice, often at equivalent or even lower cost than the alternative. Collectively we need to do better, although there remain difficulties in delivery in jurisdictions with poor regulation and under-performing companies; but globally the main challenges are of perspective, will and communication – yet we also know how to address these. So, what’s stopping us?

Finally, any landscape tells a unique story of aeons of interactions between uncountable generations of people and their land. The landscape experienced today is just the current chapter in that long narrative. The opening of a new mine begins another instalment in the landscape’s tale, which ends when mining ceases. That instant should not be the end of the story, but should herald a vibrant new chapter.

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