

PLANNING REPORT

RESEARCH PRIORITISATION PLAN

2021–2024



Australian Government
Department of Industry, Science,
Energy and Resources

AusIndustry
Cooperative Research
Centres Program



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FOREWORD

The mining industry is a major contributor to the financial well-being of Australia. We take mining products for granted in our everyday lives, yet the industry remains poorly understood. It is sophisticated and highly innovative, notably in resource exploration, extraction and processing. But this innovative approach does not extend to environmental management and social engagement, which increasingly present as areas of major risk. In a more socially and environmentally focussed world, the mining industry urgently needs to redefine its 'core business' and expand its vision beyond the mine site gate.

This requires a re-think of what the mining cycle really entails, from the community it creates through to the legacies it leaves. It will necessitate a level of innovation in the expanded definition of core business, far more comprehensive than what has been achieved to date and recognition that post-mining industry stakeholders are as important as mining itself. How companies of the present embrace this challenge of integrating planning for a post-mining future will determine the industry's future license to operate. It is incumbent upon all of us to work towards this broader and more integrated approach to the mining industry.

CRC TiME is playing a key facilitating role by, providing a non-combatant space for mining companies, communities, regulators, and suppliers. The outcomes of this consultation and research will bring much needed social and environmental innovation to drive cultural change and reposition the industry, and the communities it depends on, for a sustainable and productive future. More constructive partnerships will assist in setting policies that help drive post-mining economic growth and wellbeing.

This Research Prioritisation Plan redefines 'core business' for the industry and provides a framework for progress where there are often conflicting desired outcomes. Eight priority themes are identified for innovation that will optimise the net benefits of mining projects for all stakeholders. Through our Cooperative Research Centre model in Australia, we are uniquely positioned to drive logical and sensible discussion in this complex and emotive space. Emerging from thought leadership across CRC TiME's 75 partners, this Plan frames the innovation needed to drive cultural change and position the industry and the communities it depends on for a sustainable and productive future.

Dr Bruce Kelley

Chair

COOPERATIVE RESEARCH CENTRE FOR TRANSFORMATIONS
IN MINING ECONOMIES



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EXECUTIVE SUMMARY

This Research Prioritisation Plan sets out research priorities for the next three years of activity within the Cooperative Research Centre for Transformations in Mining Economies (CRC TiME).

CRC TiME is a partnership of more than 70 collaborating organisations from research, industry, government, community and suppliers who will work together to deliver a bold vision – to unite Australia’s regions in the development and delivery of economic, social and environmentally resilient post-mining futures.

This document is written in three sections:

- 1. Research Context:** Information framing the research program that includes goals, global trends and drivers, generalised principles for undertaking research in CRC TiME, program structure, and key themes.
- 2. 2021–2024 Programs and Priorities:** which systematically documents the goals, challenges, themes and priorities related to each research program within CRC TiME.
- 3. Reference Material:** Includes the goals and milestones agreed with the Commonwealth Government.

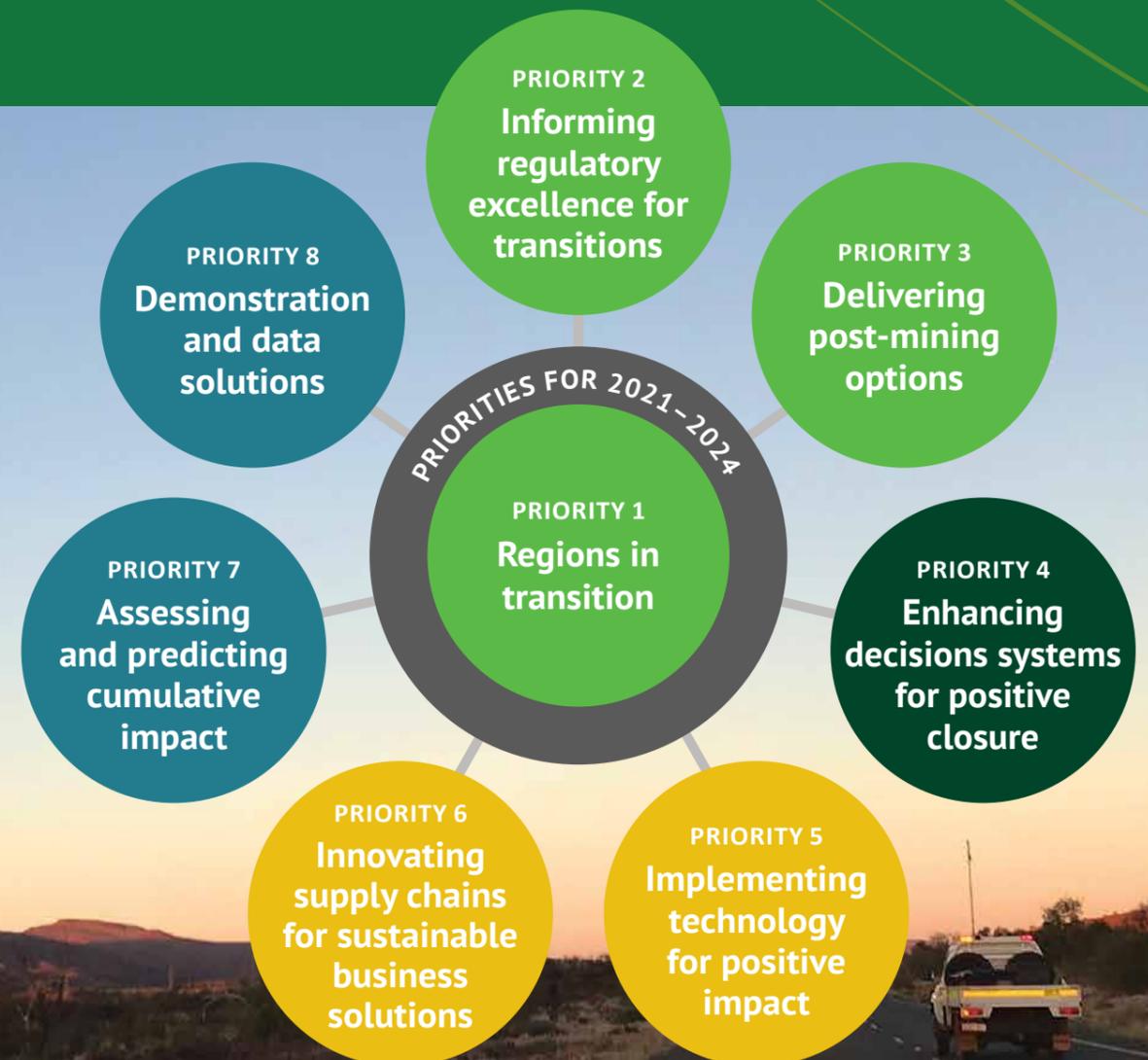
At the heart of this plan is a set of eight priorities, developed consultatively with CRC TiME partners, which are key to sustainably transforming regions post-mining.

Less than 5% of closed mines have successfully transitioned through relinquishment to post-mining land use, despite mining being framed as a temporary land use.

These priorities therefore set out a necessarily broad research agenda aimed at unpacking the social, economic, environmental, technical, political and institutional interactions to directly and positively impact post-mine regions.

Each of these priorities, has a problem statement, goals, objectives, and priority research questions and will be explored through research projects that sit under four program areas.

Enabling mine closure and relinquishment is a national priority for the resource sector and regional communities, with over 4000 operating mines in Australia, 180 due to close in the next decade and less than 20 relinquished



- PROGRAM 1: Regional Economic Development
- PROGRAM 2: Risk, Evaluation and Planning
- PROGRAM 3: Operational Solutions
- PROGRAM 4: Data Integration, Forecasting and Scale



RESEARCH CONTEXT

The Cooperative Research Centre for Transformations in Mining Economies (CRC TiME) brings together over 70 leading mining and mining service companies, regional development and First Nations organisations, State and Commonwealth governments and research partners. This unique coalition brings scale and coordinated investment to address the complex challenges underpinning mine closure and relinquishment.

CRC TiME was initiated in 2020 with a 10-year, \$29.5 million Commonwealth investment through the Australian Government's Cooperative Research Centre (CRC) Program, providing a research vehicle fostering sustained industry, research, and community collaboration. Combined with partner contributions, CRC TiME has seed funding of \$135 million and is hosted jointly by the University of Western Australia and the University of Queensland.

Building partnerships to deliver post-mining futures

CRC TiME's vision positions successful closure as a cornerstone of the mining industry, creating enduring value and benefit for all Australians. Our mission is to bring together diverse stakeholders to help reimagine and dramatically transform Australian mine closure outcomes by enabling:

- mining core business to facilitate appropriate land stewardship beyond the completion of mining
- community and First Nations people to drive post mine transitions
- increased investment in the planning and delivery of closure objectives.
- Australian equipment, technology and service suppliers and environmental management companies to position as global leaders in mine closure innovation with the capacity to develop and export this knowledge around the world
- the expansion and diversification of regional and Indigenous businesses to meet growing domestic rehabilitation and closure demand and develop future entrepreneurial opportunities
- growth in Australia's profile as the world leader in sustainable mining, closure, and post-mining futures.

Benefitting many stakeholders

The estimated impact to the Australian economy of CRC TiME is \$2.4B over 10 years, through:

- strengthened social license to operate and closure planning for mining companies
- continued investment in Australian resources
- genuine and beneficial partnerships with First Nations people
- reduced risk of unfunded, abandoned liabilities for states and territories
- sustainable ecosystems and livelihoods post-mining for dependent communities
- increased access to global opportunities in a billion dollar mine closure industry.

OBJECTIVES: What does success look like?

Over the next 5 years and beyond, the work of CRC TiME will:

- decrease the amount of time taken to get mining projects started while giving confidence to community that rehabilitation and closure commitments can be achieved
- create an investment environment that attracts regional investment, enables innovative post-mine projects and supports First Nation post-mine enterprise development
- support the transformation of how we mine through the incorporation of mine closure as part of core business
- improve regulatory efficiency and administration costs through shared understanding and agreement on the process of prioritisation of efficacious policies. Improved access to recognised standards and frameworks
- identify, prioritise and enable opportunities for technologies and innovative solutions that can be commercialised to meet national demand and exported in the global closure market
- ensure Australia's technology, services and primary resources sectors can capitalise on opportunities for re-purposing of mining infrastructure, associated water resources and mined land
- support the workforce of the future through training and education programs that address skills gaps and recognise opportunities created by transforming mining economies
- enable evidence-based decisions that can balance economic, social and environmental outcomes across spatial and temporal scales relevant to mining.





A RESEARCH AGENDA FOR A COMPLEX WORLD

The research program in CRC TiME will challenge the status quo, question how well current systems work and force a re-examination of the manner in which mining systems, regional planning, regulatory regimes, social groups and professional teams work together and the power balances (or imbalances) between them¹.

Due to the longevity of mining projects, and the even longer post-mining periods that follow, the research agenda explicitly considers the dynamic nature of the earth and the global trends that are shaping it. The plan must ensure that no single worldview dominates, and yet produce tangible outcomes. CRC TiME partners will need to respect alternative perspectives and find common ground to deliver on our shared vision.

GLOBAL DRIVERS

Global drivers are indicating that it is timely to address these complexities, for the resources sector to remain sustainable in an uncertain world.

- **Supply and Demand:** Demand for commodities continues to grow – faster than the rate of growth of populations, agricultural and energy products and GDP. Resource use continues to intensify. At the same time, demand is diversifying as new minerals become critical to support the development of new energy and communication technologies. Under this intensification and diversification, new sources of supply are being investigated – new mineral deposits, further value delivery from existing operations or valuable products from recycling or re-use. The resources industry continues to grow globally.

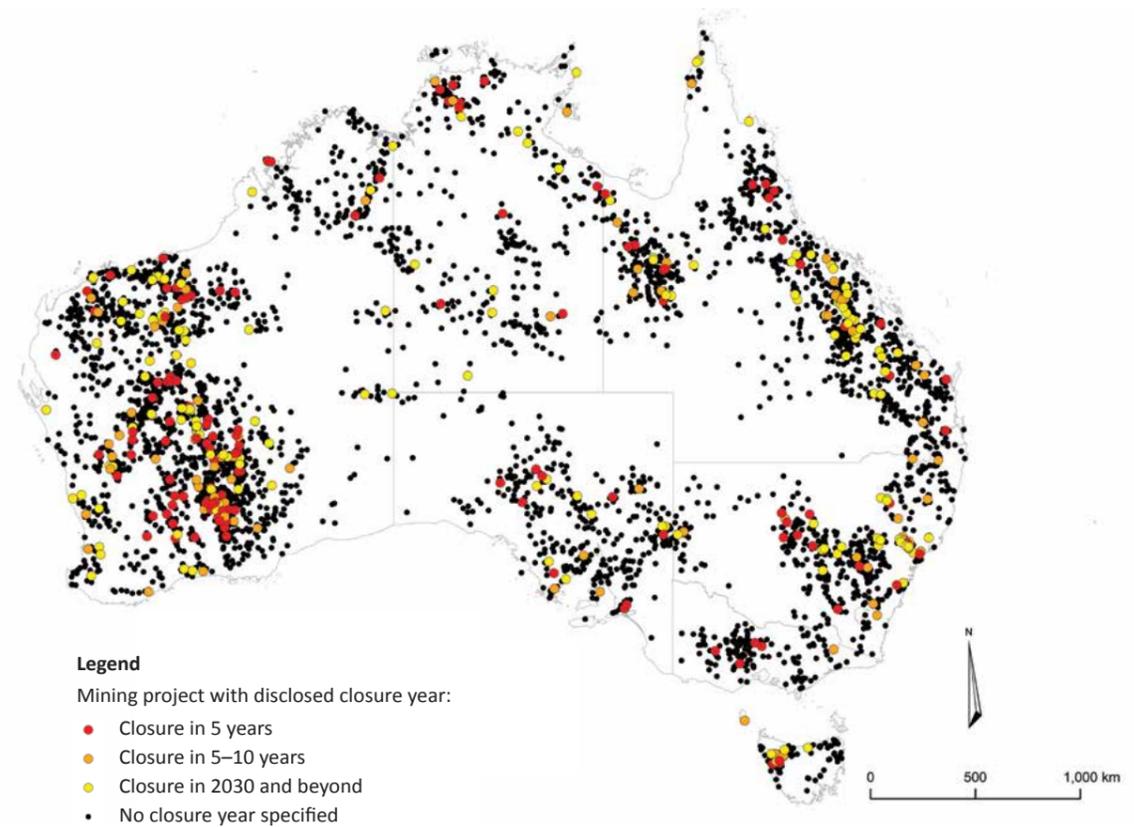


FIGURE 1. Planned mine closures

Source: Sustainable Minerals Institute, The University of Queensland, from the S&P Global Market Intelligence database

- **Sustainable Development:** Year on year, global events re-enforce the importance of the worldwide struggle for sustainable development. The current 17 United Nations Sustainable Development Goals are a universally accepted framework driving increasing attention on concepts such as the circular economy, poverty alleviation, equity, diversity and inclusion, energy efficiency, innovation, and education. The resources sector can contribute positively to all 17 goalsⁱⁱ but only if responsibly governed.

Closure and relinquishment are an essential element of responsible resource development.

- **Human Rights and Responsibilities:** As our globally connected societies mature, emphasis and attention on human rights is reshaping all aspects of life. The role and responsibilities of the corporate sector comes under increasing scrutiny, inequality in all its forms is being challenged and the rights of First Nations people are increasingly recognised. Globally, the resources sector has the power to significantly influence outcomes for local communities and to drive inclusive and respectful practices amongst its' workforce. One

aspect of this is the power of corporations to affect (positively and negatively) the lives and values of First Nations people. This is a tense issue in Australian regions, where the resources sector generally strives for beneficial long-term outcomes for Australian First Nations. The importance of supporting ways of life that close the gap between Indigenous Australians and other citizens does not stop at mine closure. Focusing on the rights of First Nations Peoples is a central tenet of CRC TiME.

- **Responsible Resource Development:** Twenty years ago and ahead of its time, the Mining, Minerals and Sustainable Development (MMSD)ⁱⁱⁱ project identified the importance of the resources sector delivering benefits to the regions in which it operated whilst also managing the risks it presented for future environments and society. In the 20 years since then, the International Council of Mining and Metals (ICMM) is now firmly established as a peak body for responsible resources development. The ICMM's recently released, 'Mining with Principles' initiative articulates the importance of mine closure as a non-negotiable stage in the mining value chain, recognising mining as a temporary land use.

- **Ethical Investment:** The future of the resources sector is dependent on the availability of capital to fund new projects. Increasing interest in ethical investment is resulting in the exponential growth of capital funds requiring investment in projects reporting to high standards of ESG (environmental, social, governance) principles. The ability to close and relinquish a mining asset is a key issue of confidence for ethical investors.

If a mine cannot be closed effectively and without conflict, the investment cannot be fully realised and the mining lifecycle remains open.

- **Climate Change:** Any aspiration to deliver healthy ecosystems and livelihoods for post-mining futures must consider the consequences of climate change. Our changing climate is now dramatically influencing the way land is managed, the value placed on water benefits to regional economies, the demand for new resources and the demand for renewable forms of energy. These issues will influence which options for mines and economic repurposing are viable in different contexts. They also drive demand for new critical minerals required for renewable energy technology and for businesses that deliver to circular economy principles.
- **Digital Transformation:** The massive consequences of information and communication technology on our lives is not yet fully understood. Automation, machine learning and digital communications continue to increase productivity and efficiency in the way we work and affect the nature of jobs and skills. Less known are the long-term consequences of digitally enabled relationships on culture and the nature of family, conflict, and the political economy. These issues will affect the manner in which people can participate economically in post-mining land-use, the skills required to participate and the aspirations of the regional communities and First Nations stakeholders looking to make their future on the formerly mined land.

None of these drivers are new, and their impact on the resources sector has been the subject of much prior analysis. Such analyses have typically been undertaken for and on behalf of one of the key stakeholder groups involved in either: developing regions, delivering resources, regulating mining, and/or strategic planning for regions. These groups all come from very different ways of knowing (epistemologies) and thinking (mental models) about the issues affecting their core business. This Research Prioritisation Plan intentionally blends, these worldviews to chart a forward agenda that better links mining economies to post-mining economies.

EMBRACING DIVERSITY

A key focus for CRC TiME will be the transitions in the use of mined land. Land lies at the heart of the Australian economy and the psyche of Australians. These lands have been under the uninterrupted stewardship of Australia's First Nations peoples for thousands of years. Mining as a land use occurs over decades – a disruptive activity. The impacts of mining on the land can emerge over centuries and the social and cultural impacts on First Nations peoples way of life can be traumatic. The values and 'worldview' of First Nations peoples differ markedly from the more profit driven motivations that emerged from western cultures and colonisation. First Nations peoples have a connection to country that demands respect from any venture in Australia. CRC TiME will engage respectfully with individuals, organisations and First Nations leaders that can speak the wisdom and articulate the needs of their multiple nations.

Additionally, those who live in Australia's cities owe much of their lifestyle to those who live and work on the land. From the days of the early settlers, Australia's regions have attracted residents from diverse cultural backgrounds. These regionally based individuals and groups are many and varied, and all have a contribution to make to the ongoing post-mining use of the land and re-purposing of mining infrastructure. Mining is a significant agent of change in regional Australia, and recognizing the value of social capital created through mining will be critical in enabling the delivery of positive post mine futures. CRC TiME will work closely with partners in regional hubs to build relationships and support long-term connections with regional communities.



FACILITATING CHANGE THROUGH RESEARCH

THEORY OF CHANGE

In the face of this set of complex and interconnected set of drivers and stakeholders, it is important CRC TiME operates within a framework designed to ensure its research delivers impactful results. CRC TiME will apply a theory of change model to achieve this^v.

The theory of change identifies how inputs, activities and outputs combine to deliver outcomes across different timeframes. In the short-term, new knowledge, skills, and motivations can be developed. As a result of this, behaviours and practices can be altered. In the long-term, these changed behaviours and practices can drive new conditions for the delivery of economic, social, and environmental benefit.

Strategically, this approach gives rise to a high-level program logic for CRC TiME (Figure 2). Importantly, it drives a clear need to connect CRC TiME's research activities with its adoption activities. CRC TiME will actively invest in connections, partnerships, adoption and capacity building activities ensuring outputs from research are fit for use and able to transform practice.

This connection between research and adoption activities will be critical to the delivery of impact. Research projects will need to clearly articulate how the outputs from research will be used to deliver outcomes that increase the possibilities for developing sustainable post-mining prosperity. Collaborative partnerships lie at the heart of this and CRC TiME will create an environment where researchers, stakeholders and end users work together at all stages of project development.

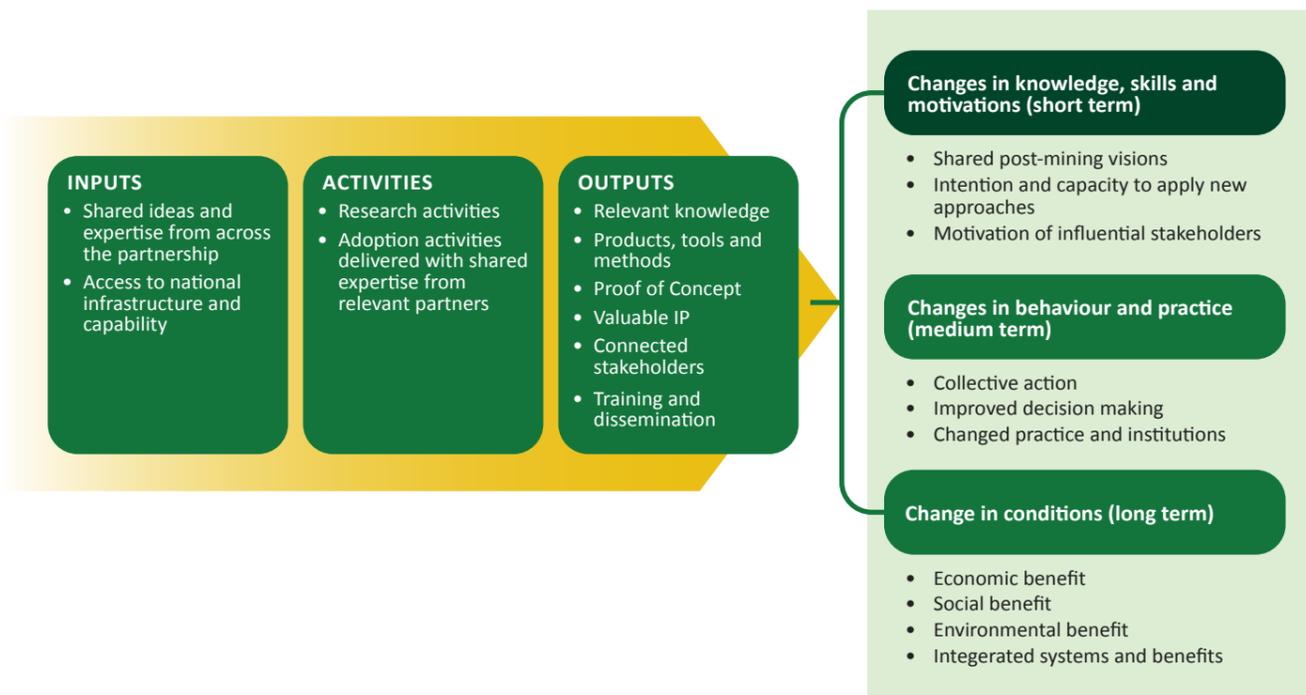


FIGURE 2. CRC TiME generic program logic derived from the *Theory of Change*

PARTNERING FOR RESEARCH IMPACT

CRC TiME’s path to impact is fundamentally dependent on its unique partnership model. By bringing together engaged participants from organisations representing researchers, mining companies, regional communities, suppliers, first nations and governments, CRC TiME is developing a knowledge base that combines thinking from different industries and life experiences.

Using participatory, collaborative and action learning approaches, CRC TiME will create research projects that respect and integrate multiple perspectives and disciplines, enabling competing values and institutional interactions to work together. Research will be co-designed and co-developed, bringing in a broader range of knowledge, ensuring outputs are fit for purpose and useable and stakeholders are empowered to take ownership of solutions.



FIGURE 3. CRC TiME’s Partnership Groups

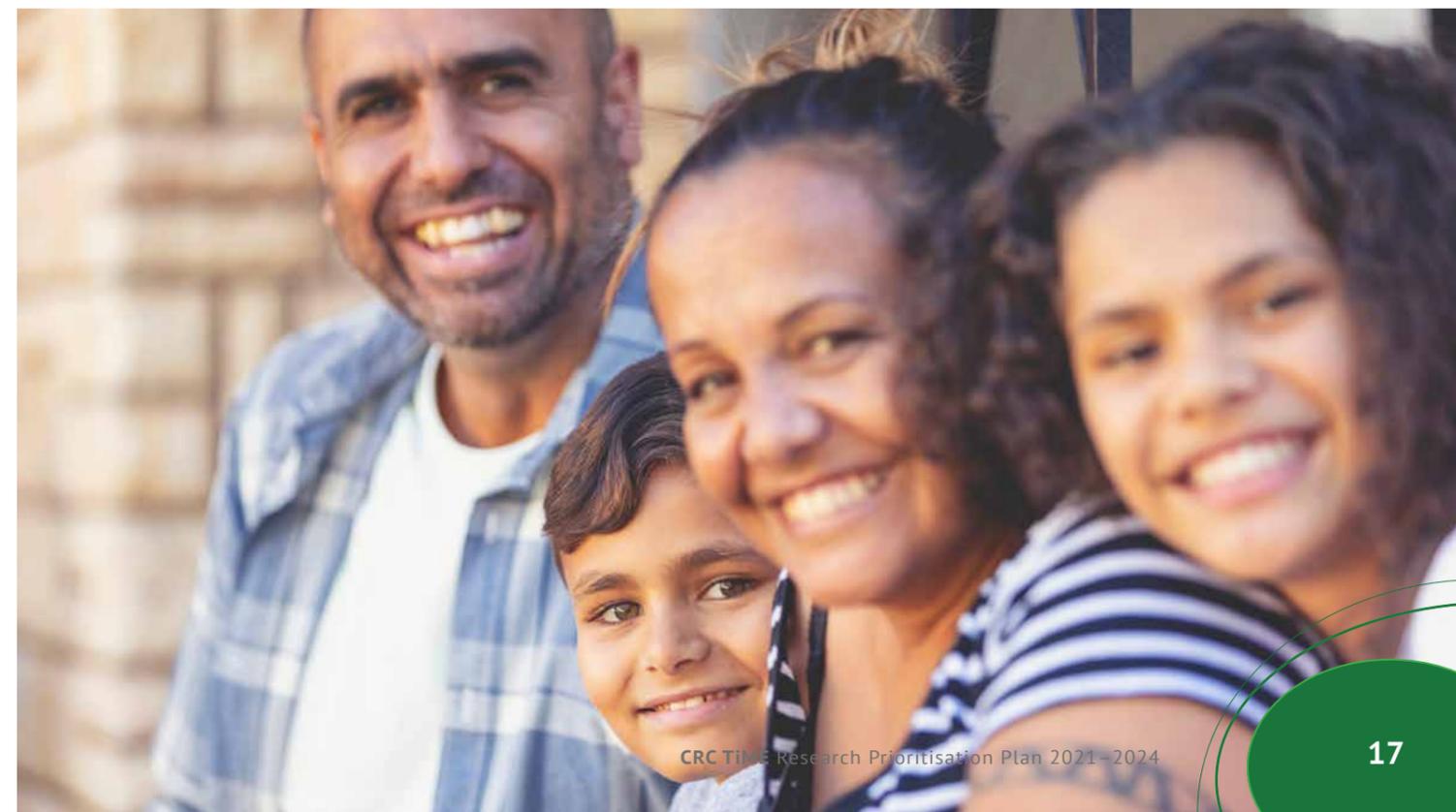
EMPHASISING PLACE-BASED RESEARCH THROUGH REGIONAL HUBS

A core organisational principle for CRC TiME is to create a safe space for stakeholders to come together to have hard conversations. To facilitate these conversations, we are creating ‘regional hubs’, that bring together groups who share the same geography and regional contexts. Bound by a shared sense of place, constructive dialogue between stakeholders with different perspectives can be encouraged. Regional hubs enable investment priorities to focus on issues that bring stakeholders together and create a shared vision, rather than driving them apart. Regional hubs form a unique aspect of CRC TiME’s thinking about how to foster impact through partnership. They are also a mechanism for addressing the significant issue of very different regional contexts at state, local and ecosystem scales. Each hub will have different contexts, histories, stakeholders and networks, are at different stages of mine life cycles and have varying and unique opportunities to create post-mining sustainable communities.

FIRST NATIONS INCLUSION

Through innovative partnerships with First Nations leaders, CRC TiME will explore opportunities for economic diversification that connect cultural, social and economic value systems and create intergenerational value to support sustained prosperity for communities following mine closure. First Nations leadership will help set strategic directions and implement activity in the development and delivery of the research programs. Protocols and guidelines will be established to help:

- strengthen First Nations knowledge and impact within CRC TiME research through culturally appropriate engagement
- create trusted relationships and ensure free, prior and informed consent (FPIC) in sharing of knowledge, developing and implementing projects
- build strong partnerships between First Nations Peoples and key stakeholders
- share and weave knowledge and values into new understandings between First Nations and other stakeholders
- grow networks between First Nations peoples impacted by mining
- communicate the beliefs, values, and expectations of First Nations peoples post mining.





FRAMING THE RESEARCH

CRC TiME research projects are bound by agreed goals, established structures and approved criteria.

COMMONWEALTH MILESTONES: WHAT WE NEED TO DELIVER

A set of CRC TiME milestones and outputs for the period 2020–2030 as agreed with the Commonwealth Government. Refer Appendix 1.

RESEARCH STRUCTURE: HOW WE ORGANISE OURSELVES

To achieve the CRC TiME Vision and Commonwealth agreed milestones indicated in Appendix 1, CRC TiME research projects sit within four program areas:

- PROGRAM 1: Regional Economic Development**
 This program aims to provide stakeholders with the structures, tools, networks and skills to envisage and assess a range of relevant post-mining options.
- PROGRAM 2: Risk, Evaluation and Planning**
 This program aims to develop improved decision-making processes across the life of a mine to optimise cost effective and successful closure and relinquishment.

- PROGRAM 3: Operational Solutions**
 This program aims to develop operational interventions to reduce the long-term post-closure risks to infrastructure, landforms, water, ecosystems and people, and deliver fit for purpose post-mining land use.
 - PROGRAM 4: Data Integration, Forecasting and Scale**
 This program aims to make a step change in the culture and behaviour around data sharing, transparency around mine closure and translation of technologies and solutions from the laboratory to mine environments.
- These programs will host the development of research projects. As described in the previous section, research inquiry within these programs must be set in the context of the collaboration, regionality and inclusion described above. Integration, transdisciplinarity, collaboration, inclusion and engagement are principles that cut across all activity and we are seeking to develop projects that are demonstrable and build capacity in CRC TiME’s regional hubs.

RESEARCH PRINCIPLES	RESEARCH PROGRAMS				REGIONAL HUBS
Stakeholder Engagement	PROGRAM 1: Regional Economic Development	PROGRAM 2: Risk, Evaluation and Planning	PROGRAM 3: Operational Solutions	PROGRAM 4: Data Integration, Forecasting and Scale	Pilbara
Transdisciplinary					South Western Australia
Integration					Bowen Basin
First Nations inclusion					Latrobe Valley
Communication and Adoption					Northern Territory

FIGURE 4. Research delivery framework that connects research with use and impact

PROJECT DEVELOPMENT PROCESS: HOW WE DEVELOP IDEAS

A project development process that encourages substantial dialogue and negotiation between intending project parties and the CRC TiME research team at all stages of the project lifecycle has been established^{vi}. This is illustrated below and highlights the importance of an inclusive conceptual development step early in the project lifecycle.

PROJECT SELECTION CRITERIA: WHAT WE LOOK FOR

Projects are evaluated against the following set of selection criteria:

- Relevance:** The extent to which the project fits within the overall scope of CRC TiME.
- Alignment:** The extent to which the project will contribute to the CRC strategy and Commonwealth milestones.
- Additionality:** The extent to which the project adds value over other projects to a particular Commonwealth milestone.

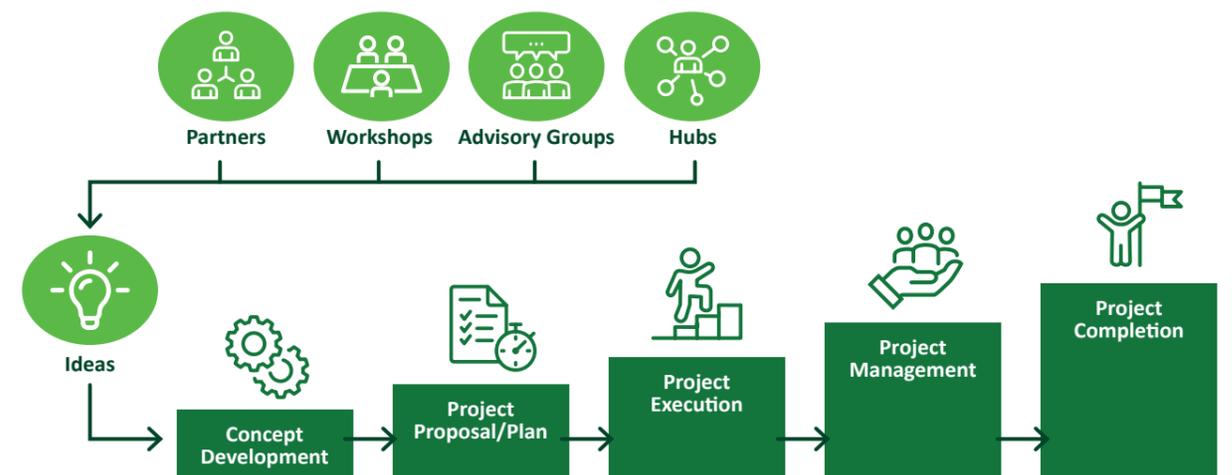


FIGURE 5. CRC TiME Project development process

- **Novelty:** The extent to which the project is innovative and inventive in terms of new ideas, integration of ideas, application of ideas or introducing ideas from other sectors.
- **Value for Money:** The leveraging of funds and the ratio between the project costs and its potential to add value.
- **Delivery:** The quality of the project team and the complexity of the project.
- **Path to Impact:** The likelihood of the project to deliver impact in terms of three specific dimensions:
 - The level of support from end users and their integration within the project team.
 - A clear adoption pathway identifying next steps for uptake and translation of results.
 - The delivery of First Nations outcomes and the level of appropriate First Nations inclusion in the project.

More detail on how these criteria are applied at different stages in the project development process is given in the Project Development Guidelines^{vi}.

PRINCIPLES OF OPERATION: THE WAY WE WORK

At the heart of CRC TiME research is a commitment to collaboration, integration, and co-development. The development of the CRC TiME research program involves multiple partners with diverse experience and knowledge in all stages of project development and adoption. Rather than a linear model of research delivery, CRC TiME projects embed communication, capacity building and adoption alongside research to enable:

- **Innovative strategies and outcomes:** through multidisciplinary and critical thinking.
- **Capacity building and knowledge transfer:** through vehicles for learning, outreach and engagement which build the knowledge base across stakeholders and offer opportunities more broadly to increase engagement with the sector (e.g. youth, First Nations groups, politicians).
- **Creation of social capital:** through a safe space where stakeholders can build trust and develop networks.

- **Collaborative learning:** where stakeholders come together, discuss complex issues, and learn what is needed and how to achieve it.
- **Collaborative action:** where shared knowledge results in alignment of goals and collective action.

INVESTMENT FOCUS: HOW WE INVEST

CRC TiME commenced with a commitment of \$130 million over 10 years made up of cash committed from the Commonwealth Government, CRC TiME partners and in-kind investment from CRC TiME partners.

This investment is being channelled into project activities that catalyse the interface between mining and post-mining operations, with CRC TiME:

- leveraging funding from multiple partners onto projects addressing shared goals.
- pooling cash and in-kind resources to bring partners from different walks of life into project design and delivery.
- undertaking strategic activities relevant to the transition from mining to post-mining operations, including student scholarships.
- supporting the delivery of impact from research through adoption, translation, commercialisation, education, training, and capacity building.
- attracting additional funding onto projects from external partners to deliver impact toward the vision of CRC TiME.

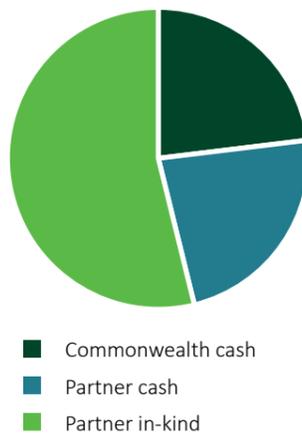


FIGURE 6. CRC TiME initial investment model

FOUNDATIONAL INVESTMENT: WHAT WE HAVE DONE ALREADY

During 2020/21, CRC TiME invested funds into a portfolio of foundational research projects ranging from 6 to 18 months long, designed to:

- build networks of practice in key areas
- combine knowledge from different stakeholders in these areas
- identify gaps in knowledge
- develop frameworks for innovation and platforms for knowledge.

The 22 foundational projects were funded through a cash investment of \$1.8 million with a matching in-kind investment from CRC TiME's partners.

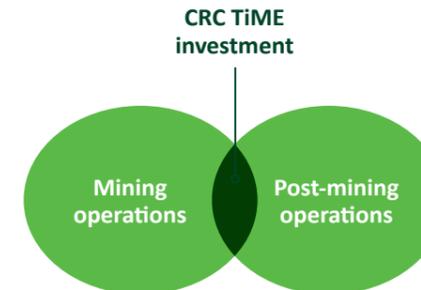


FIGURE 7. CRC TiME investment will focus on the nexus between operational mines and post mine development

CRC TiME Foundational Research Projects

FOUNDATIONAL THEME	ID	FOUNDATIONAL RESEARCH PROJECT
Reviewing current practice governing the development of options for post-mining regional development	5.1	Defining our Path to Impact
	5.2	Foundations for Indigenous inclusion
	1.1	Towards a framework for cumulative impact assessment
	1.2	Post-mining land use – a review
	1.3	Mapping the regulation of mine closure
Understanding current approaches to risk, evaluation and planning	2.1	Understanding stakeholder values in post-mining economies
	2.2	Exploring the issues in mine closure planning
	2.3	Current tools, techniques and gaps in evaluating mine closure
	2.4	Quantifying risks and opportunities in mine closure
Constraints to the delivery of operational solutions	3.1	Integration of biophysical aspects of mine closure planning
	5.3	Transitions and climate change
	3.2	Transforming disparate approaches to remote sensing and monitoring to industry best practice
	3.3	Mine site water: options for extracting value from open pits
	3.4	Returning ecosystem resilience
	3.5	Mined landform stability for regional benefit
	3.6	Barriers to reducing acid and metalliferous drainage (AMD) risk
3.7	Comparative closure: assessing the biophysical closure challenges of different mining methods	
Platforms for integrating data, demonstrating innovation and building scale	4.1	Dynamically transforming environmental assessment through a shared analytics framework
	4.2	Mine Rehabilitation Trials Online (MRTO)
	4.3	Network of demonstration and testing sites
	4.4	CRC TiME Knowledge Hub (e library)
	4.5	Abandoned mines in Australia



2021–2024 PROGRAMS AND PRIORITIES



PRIORITY IDENTIFICATION

During the 12 month foundational period, CRC TiME has built its research management team, implemented foundational research projects, established governance processes and systems including a Board, Advisory Committees, and project management protocols and tools. Over the next three years CRC TiME will consolidate research in priority areas that have emerged from consultation with partners and findings from foundational projects. An overarching goal for the next three years will be to build and demonstrate a culture of collaboration within CRC TiME which is seen as a mechanism for overcoming a trust deficit that still exists between the industry and other stakeholders in mine closure and relinquishment.

DEVELOPING PRIORITIES THROUGH CONSULTATION

Consultation with stakeholders from industry, government and community has occurred during the development of a successful CRC TiME bid (through 2019/20) and in its foundation year (through 2020/21). Over that period, more than 1000 individuals were engaged through face-to-face workshops, online

webinars, one on one meetings and surveys. The Board of Directors, together with supporting committees considering research, impact and risk, have built strategy and priority development. More than 200 ideas for research were received from partners and advisory committees and steering groups were established to help focus these ideas into the 22 foundational research projects.

In each and every conversation over this period, CRC TiME has gathered information on the priorities it should pursue through the initial stages of its research program. Throughout this process, industry, researchers, community, governments, and suppliers have shared two common desires:

1. to increase the certainty and confidence with which institutions, organisations and people involved in mining regions can move through the closure process to embrace post closure opportunity; and
2. to decrease the risk of adverse long-term social, and environmental outcomes.

All stakeholders are keen to see an efficient and effective handover of the formerly mined land to an appropriate post-mine economic activity.

Equally, all are concerned about not taking on liability for managing any as yet unknown environmental consequences of past-mining on that land.

These two concerns sit in opposition to each other, which is seen as the reason why so few minesite leases have been formally relinquished globally. Delving deeper, the range of concerns, aspirations, values, knowledge, and perceptions that underlie these shared desires vary markedly between stakeholders:

- Communities wish to understand the options available to them and work proactively to bring them about.
- Governments wish to ensure that regions can continue to engage in economic activity beyond mining but do not want to end up with accountability for unfunded liabilities such as contaminated land.
- Suppliers wish to be able to grasp opportunities from post-mining land use and confidently build up the business case for investing in these opportunities.
- The mining industry wishes to be able to move on leaving a positive legacy in the region, ideally without having to manage any trailing environmental and social issues.

Problematically, views on what closure and relinquishment look like over the time scale of mining operations and what is an acceptable level of long-term risk can be very diverse, making it extremely difficult to reach any form of consensus about when it is appropriate to handover land use from a mining company to a future land user.

The complexity of these issues suggests that transitioning mining economies through closure and beyond is a wicked problem. Wicked problems require collaboration, co-operation, trade-offs and experimentation to move forwards. Success in addressing a wicked problem is generally measured by a sense of key issues being ameliorated and achieving a mutually acceptable outcome by major stakeholders. By identifying and tackling the key issues involved in creating the complexity in the system, progress can be made towards addressing the wicked problem overall.

If a problem:

- involves many stakeholders with conflicting priorities;
- if its roots are tangled;
- if it changes with every attempt to address it;
- if you've never faced it before; and if there's no way to evaluate whether a remedy will work

...chances are good that it's wicked.

(J. Camillus 'Strategy as a Wicked Problem', Harvard Business Review, May 2008, 99-106)

EMERGING PRIORITIES

CRC TiME has used its consultation process to identify the following priority research areas for the next three years:

PRIORITY 1 – Regions in transition

The people and places facing transition in mining regions need to be at the heart of decisions relating to mine closure, relinquishment, and post-mining economic opportunities.

PRIORITY 2 – Informing regulatory excellence for transitions

The multiplicity of policy frameworks and regulations at national, state and local scales are complex, inconsistent and sometimes incommensurable and can work against the delivery of positive post-mining outcomes for mining regions.

PRIORITY 3 – Delivering post-mining options

The development of conditions that promote post-mining investment is limited by lack of opportunity to develop shared visions of the future and share delivery of that future through a measured and streamlined process of transition.

PRIORITY 4 – Enhancing decision systems for positive closure outcomes

Operational decision making prioritises short term productivity over long term provisioning for closure and beyond, which can limit options for the delivery of positive post-mining outcomes and reduce attention on reducing residual risk.

PRIORITY 5 – Implementing technology for positive impact

Technology interventions during mining can increase the chance of moving through closure and beyond by reducing residual risk, but implementation can be inhibited by lack of investment and siloed thinking.

PRIORITY 6 – Innovating supply chains for sustainable business solutions

Innovative business models to ensure the sustainable supply of goods and skills to support healthy ecosystems and livelihoods post closure mitigating 'business as usual' mind sets.

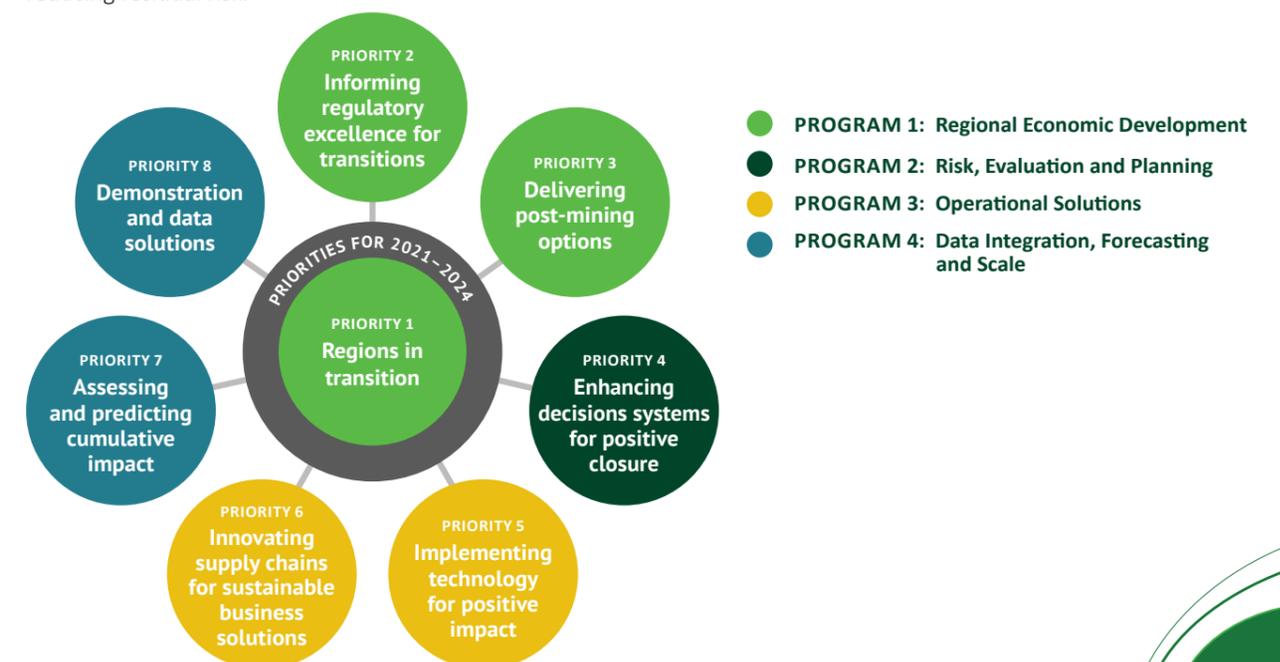
PRIORITY 7 – Assessing and predicting cumulative impact

Site based approaches to regulation and concerns about risk attribution inhibit the assessment of cumulative impacts and their impact in mining regions.

PRIORITY 8 – Demonstration and data solutions

The digital age has opened new opportunities for sharing data and analytics for environmental assessment and ecosystem forecasting which can aid regional scale planning for healthy and sustainable post-mining ecosystems.

These emerging priorities will form the basis of research projects to be taken forward over the next three years through CRC TiME's four program areas.





PROGRAM 1: REGIONAL ECONOMIC DEVELOPMENT

OVERVIEW AND PATH TO IMPACT

The delivery of sustainable post-mining prosperity has to commence with a shared vision of the future that all stakeholders can work towards. The regional Economic Development program provides stakeholders with the tools, networks and skills to envisage and assess a range of relevant options. By building confidence in a shared vision of a sustainable future, investment can be encouraged to deliver it.

The core challenge is that stakeholder buy-in to the concept of a post-mining future is limited, especially at the community level. Post-mining economic development requires that potential options are:

- **Feasible** – in terms of technical capability and the suitability of the land, soil, vegetation and other assets to support the option
- **Desirable** – in terms of the enthusiasm and capacity of the regional stakeholders to develop the option
- **Realistic** – in terms of commanding the investment of resources necessary to deliver the option.

Complex, collaborative and informed decision making is required to navigate these elements simultaneously. However, the ability to enter into such collaborative processes is limited by:

- a continued trust deficit between the community and the mining industry
- fragmented and inflexible policy frameworks and siloed approaches in regulating mine closure
- inadequate consideration of the socio-economic aspects of post-mine transitions
- low public confidence in current approaches
- poor integration of individual mine closure plans with local and regional strategies.

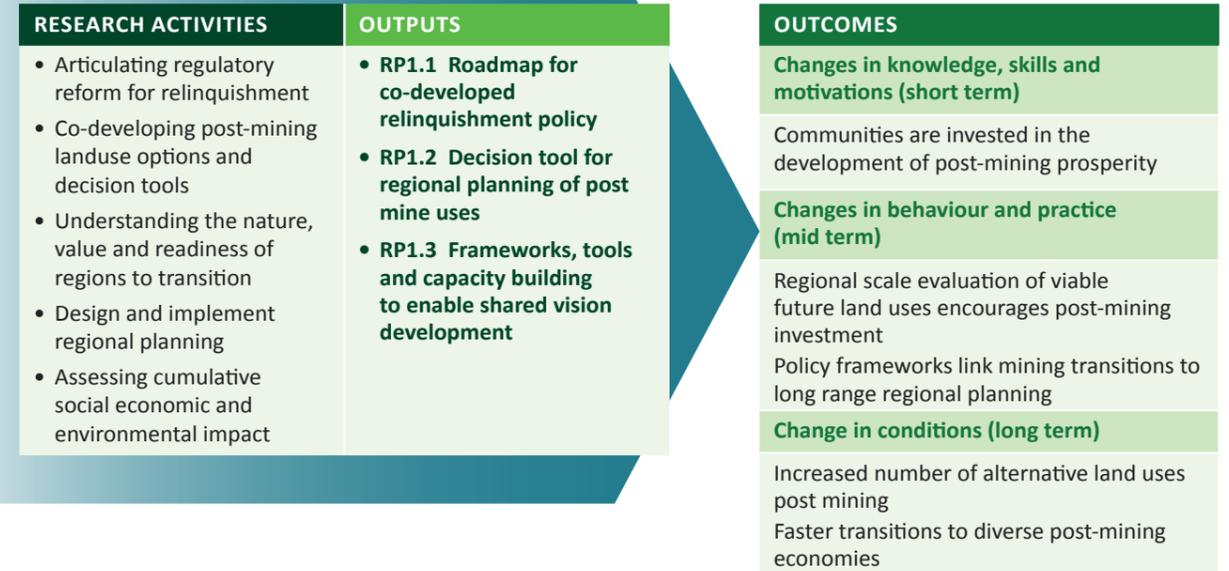


FIGURE 6. Program 1 – Path to Impact

The program will identify mechanisms for collaboratively building a shared vision of post mine options that will deliver socio-economic gains to regional communities. It will identify leading practice in the existing policy landscape and investigate gaps and blockages that are impeding successful relinquishment. It will articulate a roadmap for policy reform and decision pathways that actively integrate regional land use planning, cumulative impact assessment and mine closure planning.

Re-purposing and alternative land use assessment tools will be developed and the settings identified that best enable post mine economic diversification. New community engagement approaches will be tested using participatory and action research methods, designed to improve the quality of stakeholder input to final land-use decisions as well as criteria for mine closure. This will include development of innovative governance models, networks, and business models centered around regional hubs.

2021–2024 PRIORITIES

The priority in the Regional Economic Development program is to unpack the reasons preventing the development of shared and credible post-mining futures. Of all mines self-reporting as 'closed' in 2019, 95% remain largely inactive.

Of 1,804 mines captured in the S&P global market intelligence database, only one was identified as relinquished with about 5% being reported as in rehabilitation or 'care and maintenance'.

This data shows that, despite popular examples of post-mining economic activity, the processes for transitioning land use through closure and beyond are not effective.

Unlocking those processes requires investigation and sharing of the needs, concerns and interests of all stakeholders involved in the transitioning process.

The Regional Economic Development program will pursue this through three priorities addressing:

1. The nature of the transitions required.
2. The manner in which policy and regulation help or hinder these transitions.
3. The benefits and drawbacks of different options for post-mining land use in different contexts and processes to support multi-stakeholder decisions about post-mining futures.

PRIORITY 1: REGIONS IN TRANSITION

Mining regions lie at the heart of CRC TiME. These regions will undergo a range of different transitions (economic, environmental, social, climatic, governmental, cultural, institutional) as mines close, mining companies withdraw and post closure economies develop. Positive outcomes for the people and places in these regions are the central tenet for the CRC TiME research.

Although the definition of ‘region’ is ambiguous, it carries with it the implication of activities and interests that are greater than a single minesite. Therefore, a regional transition is not solely the concern of any single minesite operator. A range of actors are involved in the transitions, with differing roles and variable capacity and resources to fulfil those roles. This priority will explore how the range of actors, factors and changes can be kept in perspective with each other.

Problem Statement

In a dynamic world, regions, ecosystems and people undergo many transitions and it can be difficult to have effective dialogue between stakeholders about how to respond. Value and risk are perceived differently by different people and these perceptions can change over time. Strategies, visions and plans at the local and regional levels may be absent or may exist on different timeframes. Hence the capacity and maturity to engage in transition planning is highly variable, potentially limiting the quality of decision processes and the legitimacy of decision outcomes.

Goal for 2024

The three year goal is to develop tools and test them through case studies to demonstrate their value in building the capacity for regions to engage in transition planning.

Key Commonwealth Output

RP1.2 Decision tools for regional planning of post mine uses:

Software tools to assist governments, industry and other stakeholders develop holistic approaches to basin and landscape post-mine planning. The tools will consider dynamic and cumulative impacts of alternative options for mine re-purposing.

Relevant CRC TiME foundational projects

- 5.1 – Defining our Path to Impact:** Impact from the CRC will arise from changes in the availability and use of knowledge and information, driving changes in processes, behaviours and structures to promote positive social, economic and environmental outcomes in regional Australia. This project is using consultation and the concept of collaborative governance to better define what need to change in order to deliver this impact.
- 5.2 – Foundations for Indigenous Inclusion:** First Nations are a critical and unique stakeholder group for whom the CRC must deliver positive outcomes. This project is working with First Nations to develop a set of principles for ensuring Indigenous perspectives are appropriately included in all aspects of research project design, development and delivery.
- 5.3 – Transitions and climate change:** This foundational project is articulating current approaches to connecting climate change and closure transitions and outline some broad climate scenarios for use in subsequent climate related research projects.
- 2.1 – Understanding stakeholder values in post-mining economies:** This project is exploring the diverse interpretations of ‘value’ by stakeholders associated with a mine (financial, tangible and intangible, measurable and non-measurable).

State of the Art

Many tools and service offerings exist to understand community attitudes around minesites and there are many studies looking at the evolving concept of ‘social license to operate’, the importance of social performance and the enduring benefit delivered to communities as a result of mining. However, because of a historical view that mine closure is an environmental issue, such community considerations are generally subordinate to rehabilitation or ecosystem risk considerations.

As a result, strategic planning at the regional level is variable, often lacking and/or dependent on a range of context specific factors (population, individual leadership, proximity to towns, transport, infrastructure, heritage and past history). These same factors combine to create different contexts in

different regions which can work against the compilation and sharing of experiences between different regions. A recent consortium has compiled a set of reports documenting the social aspects of closure^{vii}.

Although it is generally a requirement that closure planning involves community consultation, such dialogue is typically conducted between the mining company and respondents from community (or on occasion, between government sponsored research and the community). It is rarely undertaken between multiple parties, for example more than one mining company, First Nations people, governments and community. Examination of mine closure as a social performance issue is limited^{viii}. Where such examples exist they are often self-developed in response to specific leadership (an example is the MITEZ- the Mount Isa, Townsville economic zone where seven local councils have come together for regional development purposes).

As a result, the ability of local community to exercise their voice in regional planning is highly variable and a systematic approach to capacity building for regional planning is typically non-existent (although some examples do exist^{ix}). Few methods exist that can balance multiple and variable value systems and help movement towards optimum outcomes.

Project Areas

Two gaps emerge which CRC TiME will seek to address through research:

- the development and application of a systematic approach to understanding the factors, actors and changes affecting different regions approaching closure, together with a growing knowledge base of how to assist regions in different contexts prepare for transition
- the ability to model the diverse values existing in a region and inform decision making about possible post-mining land uses and infrastructure re-purposing.

Additionally, the development of regional hubs facilitated by CRC TiME will provide networks for identifying appropriate capacity building to support regions in transition.

PROJECT AREAS	BENCHMARKING ‘READINESS TO TRANSITION’ IN REGIONS APPROACHING CLOSURE	MODELLING DIVERSITY IN VALUES TO DETERMINE ACCEPTABILITY OF ALTERNATIVE OPTIONS
Research questions	<ul style="list-style-type: none"> How can we benchmark a region’s readiness to transition through closure and what does this look like across multiple sites? What capacity building is required to enable the development of multi-stakeholder regional planning around mine closures? What has been done around the world to assist transition planning in regions? 	<ul style="list-style-type: none"> What processes exist that incorporate diverse social values in closure and how might they change decision making? How do power dynamics affect the ability to influence transition planning and what consequences does that have? How can meaningful relationships with First Nations Australians be developed that enable positive post mine transitions?
Desired Output	Demonstrated tool and training modules for benchmarking preparedness to transition across multiple sites	Frontier research publications and associated guidelines for assessing stakeholder diversity and its impact on transition dynamics

PRIORITY 2: INFORMING REGULATORY EXCELLENCE FOR REGIONAL TRANSITIONS

Regulation and policy for mine closure is driven by the States/Territories and applied on a site by site basis. Jurisdictional requirements vary and do not necessarily consider regional planning – which can be developed in different government departments or at a more local level. There can be tension and conflict as:

- Governments aim both to encourage mining investment but also to manage and mitigate post-closure residual risks to other land use values and avoid unfunded liabilities for mine sites that no longer have an active tenement.
- Mining industry entities aim to maximise economic returns to meet their corporate and fiduciary duties while addressing regional community and employee interests, which may be distinct.
- Regional communities, including First Nations people, welcome the economic opportunities from mining investment but question whether post-mine residual risks limit alternative environmental, social and economic opportunities.

As a result, decisions cannot be made with confidence – hence they are often lacking, to the detriment of the people in the region under consideration. This priority will explore how these issues can be harmonised to increase certainty in planning for closure.

Problem Statement

The regulatory frameworks (law and policy) governing mine closure address three key issues:

1. The post-closure relinquishment of production tenure and the transition to post-mine land uses with clear responsibilities for residual risks for economic and environmental values.
2. The post-mining social transition of the regional community.
3. The particular impacts on First Nations cultural, social and economic interests.

Regulatory frameworks vary in their requirements and the consistency of their application. While the past decade has brought some significant reforms to the regulatory frameworks of the various jurisdictions, there are still concerns that the legislation does not yet

provide the clarity required to enable confident and flexible decision-making for the long-term transitions in mining economies.

Goal for 2024

Regulatory reform is under consideration to better align closure regulation and land use planning at the regional scale and implement national standards for cooperative regulatory frameworks promoting effective social transitions.

Key Commonwealth Output

RP1.1 Roadmap for co-developed relinquishment policy: The roadmap will identify a policy reform pathway with a focus on removing constraints that are currently preventing transition to successful relinquishment.

Relevant CRC TiME foundational projects

- **1.1 – Towards a framework for cumulative regional impact assessment:** This project is examining the state of the art in the application of assessments at regional scales, and will look at the level of integration between social, economic and environmental aspects.
- **1.2 – Post-Mining Land Use:** This project is identifying key issues for the development of successful post-mining land use and will examine case studies from different contexts against this categorisation.
- **1.3 – Mapping the regulation of mine closure:** This project is reviewing current practices in the regulation of mine closure and examine the level of harmony or not between the various regulatory framework.

State of the Art

A range of policies and regulations exist at national, state and local scales to govern mining activities and regulate mine closure and impact all mining operations. These have grown up over time to be complex, inconsistent and sometimes incommensurable. In some cases, historically developed regulation can work against positive outcomes for regions. In other cases, recent reforms have resulted in pockets of regulatory excellence at the State level in respect of Native title and traditional ownership.

However, gaps remain and standards of implementation differ, particularly from a comparative national perspective. In terms of tenure relinquishment, a nationally harmonised approach for clearly facilitating the transition to post-mine land uses and identifying clear responsibilities for managing residual risks does not exist. In terms of promoting post-mining social transitions, the connection between mining legislation and land use planning is informal. This leads to questions over the key rights and duties of industry and community stakeholders in essential governmental decisions. In terms of First Nations cultural heritage, how well does the First Nations heritage and native title legislation integrate/harmonise with the customary laws of the First Nations peoples and mining legislation?

Project Areas

Two gaps emerge which CRC TiME will seek to address through research:

1. the development of national guidelines and standards for mine closure, including clearly articulated responsibilities for managing residual risks, promoting post-mining opportunity and protecting cultural heritage
2. identification of optimal regulatory processes and proposal of improvements in statutory or policy provisions, required to give legal effect to these processes.

PROJECT AREAS	NATIONAL GUIDELINES FOR EXCELLENCE IN REGULATING MINE CLOSURE AND SOCIAL TRANSITION	RECOMMENDATIONS FOR REGULATORY REFORM
Research questions	<ul style="list-style-type: none"> • What are the optimal processes and criteria for relinquishment of production tenure and the transition to post-mine land uses with clear responsibilities for residual risks? • What are the optimal regulatory techniques for implementing those processes and criteria? • How can the mine closure and tenement relinquishment process better facilitate industry and government engagement and cooperation with local communities and stakeholders to optimise mine site rehabilitation and minimise residual risk? • How might new or adapted standards and administrative processes assist in effectively addressing existing barriers to relinquishment? 	<ul style="list-style-type: none"> • What is the role of mining, land use planning and native title legislation? • How well do these legislative frameworks integrate/harmonise with each other? • What are the regulatory reforms required for consistent, harmonised national closure and relinquishment guidelines? • What are the reforms needed for cooperative legislative frameworks across all areas of law which impact mining? • Are there adaptations to the mining tenement system that would allow for partial, staggered and/or flexible mine site rehabilitation and tenement relinquishment?
Desired Output	Leading practice guidelines to regulation for Australian mining regions facing closure	A roadmap for developing leading practice governing mine closures through regulatory reform

PRIORITY 3: DELIVERING POST-MINING OPTIONS

The purpose of this priority is to build collaborations that can support the creation of viable post-mining repurposing options by creating the conditions required to attract the investment of finance, assets and people. It will explicitly build a knowledge base of examples from around the world of how mined land, mining infrastructure, engineering assets and local livelihoods have been transitioned and the factors that determined their success or otherwise. Research will also be undertaken that explores the process required to develop options that are viable (in terms of land use), desirable (in terms of stakeholders) and realistic (in terms of investment).

Problem Statement

All transitions to a post-mining economy are context specific and dependent on conditions prevalent in the region. This has limited the extent that common lessons have been learned in terms of what drives successful post-mining for repurposing, the processes that are most effective delivering them and the challenges that inhibit them. The handover from mine operator to post-mining land use is of great concern to industry, governments and communities but few opportunities exist for all three stakeholder groups to work together to develop shared visions of the future. Understanding which post-mining repurposing and processes work and which don't work, is a critical knowledge gap.

Goal for 2024

Post-mining land use options can be systematically compared across multiple dimensions (social, cultural, economic and environmental) and systematic processes exist to evaluate the applicability of post-mining use options to specific contexts.

Key Commonwealth Output

RP1.2 Decision tool for regional planning of post mine uses: Software tools to assist governments, industry and other stakeholders develop holistic approaches to basin and landscape post-mine planning. The tool will consider dynamic and cumulative impacts of alternative options for mine re-purposing.

Relevant CRC TiME foundational projects

- **3.1 – Integration of biophysical aspects of mine closure planning:** This project is building a conceptual model of how the many biophysical issues related to mine closure interact and affect options for post-mining landuse.
- **1.2 – Post-Mining Land Use:** This project is identifying key issues for the development of successful post-mining landuse and will examine case studies from different contexts against this categorisation.
- **1.3 – Mapping the regulation of mine closure:** This project is reviewing current practices in the regulation of mine closure and examine the level of harmony or not between the various regulatory framework.

State of the Art

There are notable examples of post-mining repurposing around the globe, some of which gain significant attention as exemplars of good practice. However, a recent analysis of more than 100 examples of mine repurposing identified that the most sustainable involved significant intervention from the relevant state government⁸. This calls into question the efficacy of current practices for considering post-mining land uses in closure planning.

However, the highly context-specific nature of different regions means that there are few contemporary, globally systematic collections of transition options and experience. The most notable was produced ten years ago (101 'Things to do with a hole in the ground')⁹. It is therefore difficult to substantiate how well current practices are working, and what the conditions are for a successful transition. Processes that simultaneously and collaboratively seek post-mining land use options that are feasible (in terms of land use), desirable (in terms of local communities) and viable (in terms of attracting investment) are limited.

Project Areas

Two gaps emerge which CRC TiME will seek to address through research:

1. the development of an encyclopedia of case studies on post-mining repurposing around the globe, together with an assessment of the conditions for success or inhibition. This can be used to inform site specific considerations as regions move towards closure transitions
2. the development of a process or set of processes where regional stakeholders can work with Governments to collaboratively and simultaneously consider repurposing options in terms of feasibility, desirability and viability. This will need to draw strongly on existing tools, processes and institutions and integrate their application.

PROJECT AREAS	REPURPOSING CASE STUDIES FROM AROUND THE WORLD	COLLABORATIVE DECISION PROCESSES TO DEVELOP REPURPOSING OPTIONS
Research questions	<ul style="list-style-type: none"> • What experience of post-mining repurposing exists in Australia and what were the conditions that enabled repurposing? • How do these compare to global examples of successful mine relinquishment and repurposing? 	<ul style="list-style-type: none"> • Can we systematically identify and assess viable next asset and land use options based on regional characteristics and historical data? • What are the socio-economic drivers that incentivise next use initiatives and how do these influence the conditions for relinquishment? • How can we unpack the term 'perpetual' as it relates to First Nations intergenerational lived experience?
Desired Output	High-end and high-profile product Comprehensive global review of post-mine relinquishment and repurposing case studies'	Repurposing toolkit and leading practice guidelines



PROGRAM 2: RISK, EVALUATION AND PLANNING

OVERVIEW AND PATH TO IMPACT

Sustainable post-mining prosperity is fundamentally dependent on the actions of the mining company during operations. The technology and processes used for extracting and processing ore, managing wastes and spoils and interacting with the workforce and the community combine to determine the levels of residual risk and/or post-mining opportunity. This then determines whether relinquishment can occur and rules in or out different options for post-mining ecosystems and livelihoods. Therefore, the decision processes used in planning a mining operation are a critical determinant, both of relinquishment and of post-mining success. The Risk, Evaluation and Planning program develops improved decision-making processes across the life of a mine, with a specific focus on the optimisation of cost effective and successful closure and relinquishment.

The core challenge for this program is the difficulty in quantifying a business case for responsible closure and relinquishment. This is exacerbated by:

- lack of capacity for integrated, long-term risk assessment and technology choices
- traditional valuation models leading to suboptimal decisions and unfunded liabilities

- lack of transparency and uniformity in assessing closure costs and liabilities
- limited understanding of the acceptable level of residual risk.

The research will focus on tools and methodologies that will assist mining companies make improved management decisions that balance short term operational objectives with long term objectives around mine closure and rehabilitation.

RESEARCH ACTIVITIES

- **Enhancing decision tools:** to support relinquishment and accommodate next land use decision making

OUTPUTS

- **RP2.1 Advanced evaluation framework for long life assets**
- **RP2.2 Real time predictive models**
- **RP2.3 Planning tools to identify transferrable residual risk**

OUTCOMES

- Changes in knowledge, skills and motivations (short term)**
Risk-return models identify the levels of risk and liability that are acceptable to the subsequent use proprietor
- Changes in behaviour and practice (mid term)**
Assessment of liability, total risk and residual risk considers environmental and social opportunities
Mining project evaluations incorporate the long term value proposition
- Change in conditions (long term)**
Efficiency gains and lower costs of capital
Reduced number of unfunded or abandoned liabilities

FIGURE 7. Program 2 – Path to Impact

2021–2024 PRIORITIES

The priority for this program is to reconsider the norms that drive mine closure planning and investment decisions and evaluate the potential outcomes if alternative metrics and weightings are used.

The use of a standard discount rate approach fails to recognise:

- the value of longer life assets
- the implications of decisions impacting further into the future
- intangible value relating to environmental and social capital.

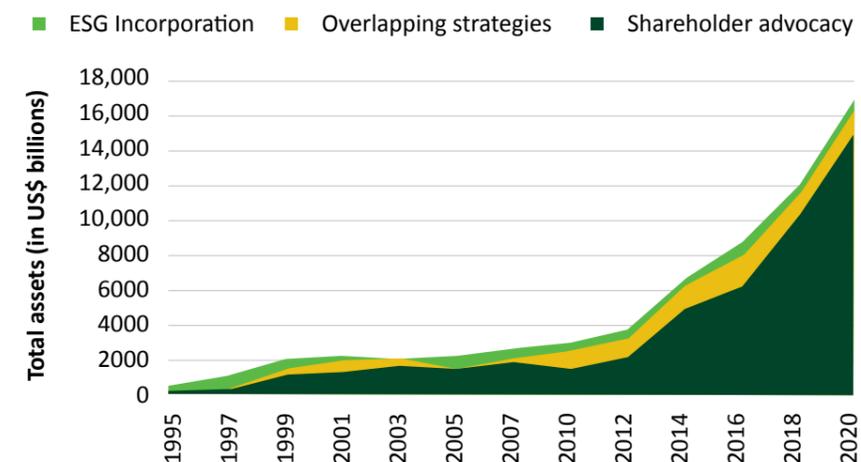


FIGURE 8. The US SIF Foundations' summary of sustainable investing in the United States since 1995

Source: US SIF Foundation

The standard discount rate approach results in a bias in the mathematics underpinning operational decision making. The issue has been documented in literature for fifty years although general discussion in the industry is limited.

As yet, no compelling business case for prioritising long term and intangible values in mine planning has been made, although some companies are beginning to consider the issue in their risk management strategies.

Increasing focus on ethical and Environmental, Social and Corporate Governance (ESG) investing is now bringing the issue to the fore. Capital funds under ESG guidelines are growing exponentially and driving a need for mining companies to demonstrate that ESG principles lie at the heart of their decision-making processes and the planning tools that support them.

Program 2 will therefore focus on a single priority in its first three years – to enhance decision systems for positive closure. It will explore the implications on mining of:

- expanded *inputs* to the mine planning process – to reflect intangible measures of value not yet fully incorporated into the operational planning systems
- alternative weightings during the mine planning *process* to evaluate how greater attention on long term value and risk would change mine plans
- the *interpretation* of the outputs from mine planning in terms of different perspectives on the risk-reward trade-offs that are made during the decision-making process.

Underpinning this priority is a continued focus on risk management theory and practice. Part of the issue inhibiting innovation in the mine planning process is the lack of a consistent scientific definition of residual risk for waste storage facilities (spoil piles, tailings) and final voids, and how they can be predicted through the life of mine. This ambiguity is a barrier to both transitioning sites to closure and investment in rehabilitation. Legislative changes are driving greater attention on managing residual riskⁱⁱⁱ and identifying clear closure criteria but they have yet to significantly impact on the net present value culture driving minesite operational planning.



PRIORITY 4: ENHANCING DECISION SYSTEMS FOR POSITIVE CLOSURE OUTCOMES

The purpose of this theme is to optimise operational decision tools to facilitate better provisioning for closure and beyond.

Problem Statement

Short term productivity goals tend to be prioritised over provisioning for long term closure outcomes and the main drivers of decision making are financial values, that do not adequately account for ESG considerations.

Goal for 2024

Social, economic, environmental and cultural heritage impacts are combined into harmonised systems for cumulative impact assessment by:

- **Broadening value-based inputs** to incorporate intangible factors that impact upon closure and relinquishment decisions, and incorporate them into the decision-making frameworks and planning processes
- **Calculating and weighting metrics** to address the temporal dissonance between costs and benefits by developing alternative approaches to calculating decision metrics, creating a more appropriate knowledge base for mine planning
- **Output interpretation** to identify trade-offs for different decision contexts based on the perspective/cultural view of the decision maker.

Key Commonwealth Output

RP2.1 Advanced evaluation framework for long life assets: This framework will allow for better decision making and more efficient operating behaviour over the life of mine through providing greater transparency around the real risks and costs of closure. Advanced evaluation framework for long life assets.

RP2.2 Real time predictive models: These models will predict the level of residual risk and liability remaining at a site upon completion of mining operations. This will aid in uniform liability reporting and setting objectives for business process improvements along the value chain.

RP2.3 Planning tools to identify transferrable residual risk:

Qualitative assessment will allow the user to quantify the acceptable level of residual risk and liability that can be transferred to subsequent land users upon relinquishment. The tools will analyse risk-reward trade-offs based on alternative land uses that will most likely follow the mining phase.

Relevant CRC TiME foundational projects

- **2.1 – Understanding values in post-mining economies:** This project is exploring the diverse interpretations of ‘value’ by stakeholders associated with a mine (financial, tangible and intangible, measurable and non-measurable).
- **2.2 – Exploring the issues in mine closure planning:** Planning for post-mining alternatives with accurate cost estimates is complex. This project investigates the key closure planning issues that inhibit the realisation of mine closure plans.
- **2.3 – Current tools, techniques and gaps in evaluating mine closure:** This foundation project is cataloguing practices, techniques and procedures currently employed to quantify mine closure costs and benefits and associated mine closure risk.
- **2.4 – Quantifying risks and opportunities from mine closure:** This project is developing a framework to assess a range of design options for mine closure plans including the quantification of associated risks and opportunities.
- **3.7 – Comparative Closure: assessing the biophysical closure challenges of different mining methods:** This project is identifying and contrasting biophysical impacts on post-mining land use of novel in-place mining methods relative to more traditional mining methods.

State of the Art

Highly sophisticated tools and techniques are available to the mining industry to undertake detailed mine planning and optimise operations through their productive life. These tools apply cutting edge processes to evaluate and reduce risk, optimise efficiency and maximise productivity. In general, they apply the norms of rational economics which tend to discount late-stage activities and struggle to incorporate non-financial values into the decision framework.

Mine planning is currently the domain of experts (in house and consulting). There is little scope for consultation on model inputs. Factors and concerns that are outside the control of mining companies, difficult to quantify and are a long time in the future have been treated as externalities in decision making resulting in:

- lack of capacity for integrated, long-term risk assessment and technology choices
- use of traditional valuation tools and investment models leading to suboptimal decisions and unfunded liabilities
- lack of transparency and uniformity in the assessment of closure costs and resulting liabilities
- limited understanding of the acceptable level of residual risk.

As a result, there is little systematisation in mine closure planning and moveable goal posts in what is expected when it comes to closure.

Project Areas

Three gaps emerge which CRC TiME is seeking to address through research:

1. decision making and mine planning processes that incorporate intangible measures of value
2. approaches that be applied with confidence to calculate risks and costs over long timeframes
3. residual risks and trade-off models that deliver optimal outcomes for key stakeholders.

PROJECT AREAS	INCORPORATING INTANGIBLE MEASURES OF VALUE	CALCULATING RISKS AND COSTS OVER LONG TIMEFRAMES	RESIDUAL RISKS AND TRADE-OFFS
Research questions	<ul style="list-style-type: none"> • How can we incorporate intangible measures of value within the decision-making framework? • How can we identify and quantify the intangible values which need to be considered in mine planning? 	<ul style="list-style-type: none"> • What alternative approaches exist to balance short term and long-term value and risk (temporal dissonance) within the decision calculations? 	<ul style="list-style-type: none"> • How do trade-offs differ in different decision contexts and from different perspectives and cultural views? • How would altered treatment of residual risks and trade-offs change mine design? • How can First Nation concerns be addressed within decisions regarding trade-offs.
Desired Output	New input metrics	Recommendations to adapt discounting models	Alternative mine plans using different trade offs



PROGRAM 3: OPERATIONAL SOLUTIONS

OVERVIEW AND PATH TO IMPACT

Action during mining operations and mine closure will determine the level of risk and opportunity for post-mining activity. The Operational Solutions program develops improved decision-making processes across the life of a mine to deliver operational interventions to reduce the long-term post-closure risks to infrastructure, landforms, water, ecosystems and people, and deliver fit for purpose post-mining land use.

The core challenge is limited opportunities to prove that innovations will enable mine closures and increase the chance of relinquishment. Key barriers include:

- siloed approach to technology deployment and data sharing
- fragmented supply-chains for the provision of rehabilitation goods and services to remote mines
- limited incentives to reduce the production of waste materials and increase re-use.

This research will focus on providing mining practitioners and the METS sector with the operational tools for improving the quality and sustainability of environmental outcomes from mine rehabilitation.

RESEARCH ACTIVITIES

- Create and refine remote systems to monitor progress against closure criteria
- Design, develop, test and validate viable novel technologies for rehabilitation and closure
- Analyse, develop, test and validate supply chain business solutions

OUTPUTS

- **RP3.1 Smart architecture for closure design (Incl. data storage and transfer protocols)**
- **RP3.2 Prototype risk management technologies for successful post-mine futures**
- **RP3.3. Business solutions for supply chain development**

OUTCOMES

Changes in knowledge, skills and motivations (short term)

Cost-effective technological solutions at selected intervention positions will reduce the long-term residual risk and/or maximise net benefit

Changes in behaviour and practice (mid term)

Emerging supply chain post mine land use businesses make informed investment decisions
Better design of operational and closure process by mining companies, regulators and communities

Change in conditions (long term)

Increase in value of mine closure market

FIGURE 9. Program 3 – Path to Impact

2021–2024 PRIORITIES

The biophysical impacts of mining on mined land and its environs are complex, interactive, and dynamic. They cannot be easily compartmentalised into single issue solutions. Mining industry operations are already encouraged to approach mine closure in a very integrated manner. The International Council of Mining and Metals (ICMM) recently published an integrated mine closure guideline, reproduced here with permission from the ICMM (Figure 10).

Many technical and process innovations to reduce post closure risks and legacies are known and in implemented on many sites. However, final relinquishment is inhibited by a sense that there are barriers preventing implementation of innovative solutions to known environmental issues. These barriers may be due to funding constraints, capacity limitations, supply chain problems, cultural issues or uncertain sustainability of skills. The traditional engineering and science-based approaches to mine closure innovation need to be enhanced by innovation in engagement processes and business models.

The program will therefore develop through two priorities:

1. Multidisciplinary approaches will be adopted to develop and implement integrated solutions that reduce risks across the traditional mine closure issues of water, wastes, landform and ecosystems.
2. Innovations in business models and supply chains will be developed to support delivery of these technology solutions to achieve cost effective and value adding outcomes.

Underpinning this program will be considerations regarding the future of the workforce and skills required to deliver these solutions.

INTEGRATED MINE CLOSURE



FIGURE 10. Mine closure as a dynamic and interactive process

Source: ICMM



PRIORITY 5: IMPLEMENTING TECHNOLOGY FOR POSITIVE IMPACT

The purpose of this priority is to identify cost effective innovation that can intervene at high risk points in operational or abandoned mines to reduce long term risks arising from mining operations and legacy mines.

Problem Statement

Despite the availability of mitigating technology, long term environmental and social risks from mining continue to arise leading to degraded landscapes, costs associated with legacy management and a lack of trust between mining operations and the community.

Goal for 2024

Innovation options at high risk points in the mining value chain have been either selected or fast failed as opportunities to increase positive post closure outcomes and decrease long term risk.

Key Commonwealth Output

RP3.2 Prototype risk management technologies for successful post mine futures: A suite of market-ready innovations to 1) intervene to prevent the creation of closure risks and 2) address critical closure risks and 3) quantify ecological responses to interventions.

Relevant CRC TiME foundational projects

- **3.1 – Integration of biophysical aspects of mineclosure planning:** This project is building a conceptual model of how the many biophysical issues related to mine closure interact and affect options for post-mining landuse.
- **3.2 – Transforming disparate approaches to remote sensing and monitoring to industry best practice:** This project is examining the dynamic and varied practices in remote sensing and the changing frontier of data quality they can provide, and are expected to provide.
- **3.3 – Mine site water: options for extracting value from open pits:** This project is looking at the state of the art in water remediation and use in open pits.
- **3.4 – Returning ecosystem resilience:** This project is looking at the state of the art in ecosystem remediation, restoration and rehabilitation.

- **3.5 – Mined landform stability and its impact on transitioning for regional benefit:** This project is looking at the state of the art in reducing risks through the geotechnical engineering of final landforms for closure.
- **3.6 – Barriers to reducing acid and metalliferous drainage (AMD) risk:** This project is looking at the state of the art in the remediation of acid metalliferous drainage and in particular the barriers to the implementation of some of the known solutions.
- **3.7 – Comparative Closure: assessing the biophysical closure challenges of different mining methods:** This project is developing conceptual model of how alternative mining methods impact on closure risks.
- **4.3 – Network of Demonstration and testing sites:** This project is identifying a set of demonstration sites operated by CRC TiME partners and the opportunities they provide to test different transition issues.

State of the Art

Many innovations have emerged over the past decade to prevent, reduce or rectify long term environmental and social risks from mining. These innovations are at all technology readiness levels and many different scales. Some are being actively developed through the sustainability strategies of mining companies. Such innovations may include:

- sensing technology to monitor and model impact and determine where and when to intervene (eg. remote sensing, biodiversity modelling, geochemical measurements)
- technologies for the reduction or mitigation of long-term risk to ecosystems, waterways and people (eg. tailings management, engineered covers for spoils and waste dumps, flocculation in pit lakes, geotextiles and membranes)
- early interventions in the mining process to reduce the generation of wastes and contaminants at or near source (eg. dry stack tailings, bulk ore sorting, reprocessing).

However, investment in technology to reduce post closure risks and enhance positive outcomes can be considered a cost burden on core business. A clear business case for operational intervention to reduce long term risk is not yet in place. Clearly connecting the development and application of innovative closure technologies to reduce key business risks, contribute to sustainability metrics and enhance whole of project value is needed.

Climate adaptation is a core part of most mining companies' sustainability strategy. However, climate change is generally considered in terms of how it affects operations, rather than how it will affect ecosystems and landforms, post tenure. Under regulations that often require return of the land to its previous use or state, the long-term resilience of the ecosystem under climate change is a secondary consideration.

Additionally, stakeholders looking to repurpose mined land, place value on water and land and the ecosystems it supports. Mining operations are highly efficient at the management of water use. However, where water quality or availability is compromised, there is a knock-on consequence for ecosystems and livelihoods and conflict and tension can result.

Project Areas

Two key areas emerge which CRC TiME is addressing through research. Both require approaches to research that bring together lines of enquiry that have traditionally been separated and both have implications for engineering changes to mining and processing flowsheets:

1. **Ecosystem resilience under climate change:** Ecological engineering, rehabilitation, geotechnical stability and landform restructuring all aim to rebuild productive post-mining land. Climate change is a critical issue for stakeholders and climate adaptive restoration design and implementation is essential in creating resilient ecosystems.
2. **Long term water quality solutions:** The impact of mining on water quality and quantity can give rise to a range of risks and opportunities affecting ongoing land use, ecosystem function, landform stability and quality of life.

PROJECT AREAS	ECOSYSTEM RESILIENCE UNDER CLIMATE CHANGE	LONG TERM WATER QUALITY SOLUTIONS
Research questions	<ul style="list-style-type: none"> • What options for engineering sustainable ecosystems on mined land can be developed into a nationally significant strategic solution? • What does ecosystem resilience to climate change look like? • What remote technologies are best for assessing change in rehabilitated ecosystems? 	<ul style="list-style-type: none"> • What options for delivering and monitoring healthy waterways around mined land can be developed into a nationally significant strategic solution? • What options for waste reduction, recycling and reuse can be developed into nationally significant strategic solutions?
Desired Output	<ul style="list-style-type: none"> • Technology trials implemented on networked demonstration sites around Australia. Enhanced commercialisation and cross sector technology transfer • Remote systems for monitoring ecosystems 	Technology trials implemented on networked demonstration sites around Australia

PRIORITY 6: INNOVATING SUPPLY CHAINS FOR SUSTAINABLE BUSINESS SOLUTIONS

Under this priority, CRC TIME will implement foundational research to understand and innovate systems around mine closure activities to ensure their continuity through closure and beyond. This could include innovation in systems, processes, financial models, labour and skills supply and co-purposing.

Problem Statement

Technology options to mitigate post closure risks can exist but remain unadopted if there are concerns about the continuity and availability of funding, skills or goods.

Goal for 2024

The supply chain for closure has been mapped, vulnerabilities in the system identified and recommendations for new business models proposed.

Key Commonwealth Output

RP3.3 Business solutions for supply chain development: Supply chain maps that will assist businesses supplying goods and services to post-mine ventures to make informed investment decisions.

Relevant CRC TIME foundational projects

Insights will emerge from all Foundational Projects.

State of the Art

The supply chain for closure can be examined through many lenses – technological, skills supply, knowledge development, geographical location and value contribution. In its recent update, the Mining, Equipment, Technology and Services Growth Centre (METS ignited) identified several opportunities for the development of supply chains to improve mining’s social, safety and environmental performance including: “Adaption and application of leading practices in social licence with environmental and economic sustainability. Energy efficiency including closed energy loops, application of renewables, hybrids, and the ‘electric mine’. Improving remediation and rehabilitation techniques for old, ongoing and future workings. Establishing a cohort(s) of academic and industry leaders to develop the economic, social and environmental performance associated with [the] industry’s technological innovation”^{xiv}

All of these have the potential to deliver positive post closure outcomes, and all have the potential to generate ‘value’ from closing mines that could extend well beyond the mine operation. However, they require creative approaches to ensure the sustainability of supply and delivery of ‘value’ before, during and after closure.

Project Areas

The key goal is to map the supply chain for successful closure and relinquishment and develop new business models to ensure their sustainability through the process and beyond.

PROJECT AREAS	VALUE GENERATION FROM CLOSING MINES
Research questions	<ul style="list-style-type: none"> • What is the market outlook for promising innovations? • How can supply chains for promising innovations be sustainable in the long term? • How can First Nation business development opportunities in mine rehabilitation and closure best be advanced? • What skills are needed to support sustainable supply chains and what organisational barriers to implementation exist?
Desired Output	Comprehensive map of supply chain for closure





PROGRAM 4: DATA INTEGRATION, FORECASTING AND SCALE

OVERVIEW AND PATH TO IMPACT

Regional futures are influenced by the cumulative economic, environmental, cultural and social impacts from mine sites and other industries and practices across the region. Mining companies and governments maintain a number of very large and complex data sets that if aggregated and interrogated, could drive innovation, predict and forecast ecosystem outcomes, and mitigate social, environmental, and economic risks. In addition, access to demonstration mine sites is a key barrier to driving research and innovation and moving technologies and solutions from the laboratory to market.

The purpose of this cross-cutting program is to make a step change in the culture and behaviour around data sharing, transparency, and the science around mine closure and translation of technologies and solutions from the laboratory to mine environments. The core challenge is that historically, collaboration on testing, sharing data, knowledge and insights about closure is limited. Additionally, the use and application of data to understand impacts has been siloed into different discipline areas.

The program will focus on two aspects of aggregating data and knowledge from individual mine sites:

1. frameworks and tools for aggregating, assessing, and predicting cumulative impacts at a regional scale
2. platforms to enable the demonstration of innovative technologies and solutions, and the aggregation and interrogation of mine site (and other related) data to drive innovation, predict and forecast ecosystem outcomes, mitigate risk and improve environmental, social, and economic performance.

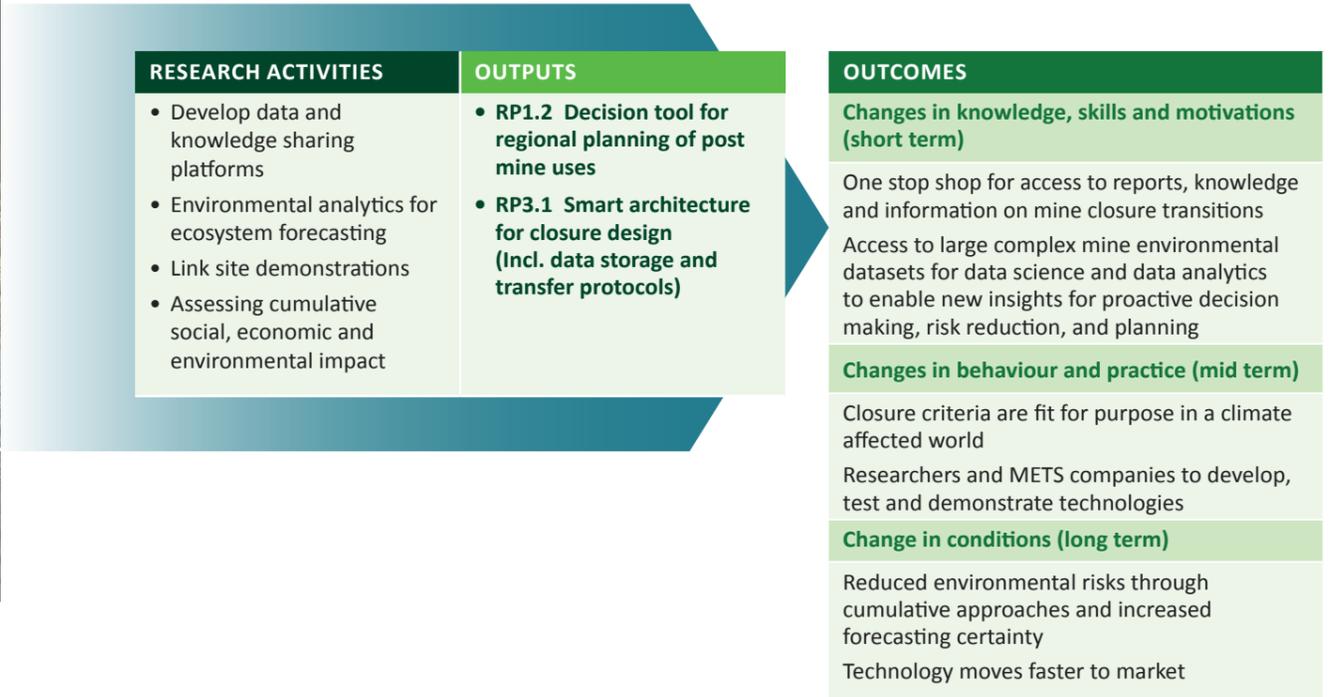


FIGURE 11. Program 4 – Path to Impact

2021–2024 PRIORITIES

The priority for this program is to demonstrate the potential new knowledge arising from the aggregation of multiple data across multiple sites and multiple disciplines. Initially, the program will focus on two themes addressing different aspects of aggregating data and sharing knowledge from individual mine sites into:

1. optimising tools for assessing and predicting cumulative impacts and trajectories at a regional scale
2. building a network of shared data from pilot studies at multiple sites to scale up knowledge about potential solutions for managing ecosystem risk.

Underpinning this program will be considerations on the future of the workforce and skills required to deliver these solutions.



PRIORITY 7: ASSESSING AND PREDICTING CUMULATIVE IMPACT

Mine closure is typically regulated at the mine site scale, but communities experience impact at the scale of the landscape. Tools for assessing cumulative impacts at a regional scale do exist but are not yet widely regulated. Therefore, they are not systematically applied and are rarely integrated across different interests. The purpose of this priority is to develop an agreed systematic approach to the assessment of cumulative social, economic and environmental impacts on the scale of regional landscapes.

Problem Statement

There is a disconnect between the closure of a single mine (mine site scale) and regional planning (regional scale). Mine closure planning is tightly regulated but the assessment of cumulative regional impacts and ecosystem trajectory assessment is not. Ambiguity over who develops (and funds) regional scale assessments and concerns about the attribution of residual risks have hindered the incorporation of cumulative impact assessments into long-term planning in mining regions. This is despite there being general agreement across stakeholders that such assessments are needed to underpin regionally based decision making and planning. Cumulative regional impact assessments provide a mechanism for bringing together the outputs from planning tools such as Indigenous land use agreements, mine closure plans and minesite-scale environmental and social impact assessments.

Goal for 2024

Social, economic, environmental, and cultural heritage impact frameworks and digitally harmonised systems for cumulative impact assessment and prediction are developed. Predictive tools to forecast ecosystem outcomes, and mitigate social, environmental, and economic risks are demonstrated at a regional hub.

Key Commonwealth Output

RP1.2 Decision tool for regional planning of post mine uses: Software tools to assist governments, industry and other stakeholders develop holistic approaches to basin and landscape post-mine planning. The tool will consider dynamic and cumulative impacts of alternative options for mine re-purposing.

Underpinning CRC TiME foundational projects

- **1.1 – Towards a framework for cumulative regional impact assessment:** This project is examining the state of the art in the application of assessments at regional scales, and will look at the level of integration between social, economic and environmental aspects.
- **2.1 – Understanding stakeholder values:** This project is exploring the diverse interpretations of ‘value’ by stakeholders associated with a mine (financial, tangible and intangible, measurable and non-measurable).
- **3.1 – Towards an integrated model of biophysical impacts:** This project is building a conceptual model of how the many biophysical issues related to mine closure interact and affect options for post-mining landuse.
- **4.1 – Dynamically transforming environmental assessment through a shared analytics framework:** This project is ensuring processes for assessing mining cumulative impact are integrated into a national initiative examining the role of digitally enabled strategic environmental assessment.

State of the Art

The potential of cumulative regional impact assessments (CRIA) is well recognised. CRIA sits in a constellation of practices including social and environmental impact assessments, strategic assessments, mine closure plans, Indigenous land use agreements, and regional development plans. Several frameworks exist for the incorporation of CRIA into existing impact assessment processes. There are some excellent examples of strategic assessments and regional plans, however, CRIA approaches can vary widely and are not systematically applied in mining regions.

The level of maturity and detail between social, environmental and cultural impact assessments varies significantly. CRIA offers an approach that can bring these drivers and processes into conversation with each other, however, there are few examples of attempts to do this. The most effective elements of these adjacent tools need to be brought together to realise the emerging, state of the art, CRIA. It is not yet clear what level of detail and knowledge is required for all the elements of a CRIA (social, environmental, cultural, economic) to be commensurate within a single assessment framework.

The interests, expectations and possible roles of community groups and First Nations peoples in CRIA are also unclear. CRIA has largely been driven to date by industry and governments.

Cumulative environmental assessment is emerging as a major tool for addressing strategic environmental impacts from many different large-scale operations. The digital revolution is enabling large quantities of data to be aggregated and analysed within a single framework by multiple stakeholders. It is important to consider CRIA for closure within this broader landscape. Digitally enabled approaches may also provide a mechanism for treating past cumulative impacts in a constructive manner. This is currently lacking, in part because few stakeholders are keen to take on accountability for legacy impacts. However, without a means of addressing past impacts, it is difficult for stakeholders to progress together constructively.

Additionally, approaches exist for forecasting ecosystem evolution through trajectory assessments. These are in the early stages of application at minesites but suggest there are significant opportunities for improving regulatory and industry approaches to risk assessment and closure criteria.^{xiii}

Project Areas

There will be two broad priority research areas:

1. broadening the parameters within cumulative impact assessment for closure
2. connecting to national scale initiatives on digitally enabled strategic environmental assessment.

PROJECT AREAS	BROADENING PARAMETERS IN CUMULATIVE IMPACT ASSESSMENTS FOR CLOSURE	ECOSYSTEM FORECASTING AND STRATEGIC TRAJECTORY ASSESSMENT
Research questions	<ul style="list-style-type: none"> • What are the regulatory drivers and changes required for cumulative impact assessment at regional scale to be implemented and successful? • What does an integrated cumulative assessment look like when applied at a regional scale? How should First Nations cultural values be incorporated in the assessment process? • Who should resource CRIAs? (particularly if initiated by community or First Nations groups) • How can digital science be used to streamline the collection, interrogation, and interpretation of diverse impact data? 	<ul style="list-style-type: none"> • How do we develop the tools to enable prediction and forecasting of ecological outcomes for regional assessments and closure criteria? • What analytics are required to underpin these solutions? • What are the implications of such projections for closure criteria and residual risk?
Desired Output	<ul style="list-style-type: none"> • New framework and toolkit for connecting the environmental, social, environmental, and cultural dimensions of cumulative regional impact assessment • Case studies outlining the benefits of CRIA’s to regional decision making and management for the life of mine 	Tools to enable ecosystem outcome predictions and forecasting for closure planning

PRIORITY 8: DEMONSTRATION AND DATA SOLUTIONS

The uptake of new technologies and innovations has been slow at mines due to the costs, large-scale and high risks associated with development and testing versus tried and proven approaches. A fraction of the vast amounts of data held by mining companies and governments is easily available for shared learning, decision making and opportunities for research and innovation. This priority will build the data science and platforms necessary to demonstrate innovative technologies and solutions, and aggregation and interrogation of data to drive innovation, predict and forecast ecosystem outcomes, and mitigate social, environmental, and economic risks.

Problem Statement

Sharing data from different mine sites is limited for many reasons and often results in research duplication, repetition of errors and mistakes, wasted funds and resources and additive benefits of knowledge and findings addressing similar challenges of what works and what doesn't. Data aggregation at mine sites over time could enable the prediction and forecasting of ecosystem outcomes for decision making and management and development of realistic closure criteria. Historically, uptake of new technologies and innovations has been slow at mines due to the costs and risks associated with development and testing versus tried and proven approaches. The inability to gain access to testing and demonstration sites are key barriers identified for innovation and moving technologies from the laboratory to market.

Goal for 2024

Build a network of demonstration mine sites to showcase outcomes from CRC TiME programs and innovations from technology and service providers. Develop innovative data science and knowledge platforms for aggregation and interrogation of data to drive innovation outcomes.

Key Commonwealth Output

RP3.1 Smart architecture for closure design (Includes data storage and transfer protocols):

A knowledge platform and suite of modelling tools to address shared problems between miners, community and regulators, providing quicker access to relevant knowledge, tools and data.

Relevant CRC TiME foundational projects

- 4.1 – Dynamically transforming environmental assessment through a shared analytics framework:**
 This project is ensuring processes for assessing mining cumulative impact are integrated into a national initiative examining the role of digitally enabled strategic environmental assessment.
- 4.2 – Mine Rehabilitation Trials Online (MRTO):**
 This project is developing a prototype data platform and protocols for managing and integrating experimental data from multiple sites.
- 4.3 – Network of demonstration and testing sites:**
 This project is identifying a set of demonstration sites operated by CRC TiME partners and the opportunities they provide to test different transition issues.

- 4.4 – CRC TiME Knowledge Hub (e-library):** This project is creating a search engine so that CRC TiME can provide a 'one stop shop' in terms of accessing available literature on mine closure and post-mining transitions.
- 4.5 – Abandoned mines in Australia:** This project is pulling together the data from various state-held and private databases on abandoned mines around Australia to identify a national dataset and diagnostic.

Project Areas

There will be two broad priority research areas:

- aggregation and interrogation of mine site data to address challenges for closure
- development of a network of demonstration mine sites

PROJECT AREAS	AGGREGATING AND INTERROGATION OF DATA TO ADDRESS CHALLENGES FOR CLOSURE	DEVELOPMENT OF NETWORK OF DEMONSTRATION MINE SITES
Research questions	<ul style="list-style-type: none"> How can we aggregate, share, and interrogate diverse data from multiple stakeholders, studies, and minesites? What data platforms are needed for new insights, knowledge transfer and innovation for closure planning and decision making? 	<ul style="list-style-type: none"> How do we prioritise demonstration mine sites for environmental, cultural, and social technologies and solutions? What process is needed to identify and fast track innovative technologies and solutions for demonstration at mine sites? How do we fund and support demonstrations at mine sites?
Desired Output	<ul style="list-style-type: none"> Data and knowledge platforms for the aggregation and interrogation of mine site (and other related) data to address challenges Case studies to demonstrate the benefits and value of data aggregation 	Platform and process to enable demonstration of innovative technologies and solutions at mine sites (lab to market)

REFERENCE MATERIALS

Goals and milestones in the Commonwealth Agreement

OUTPUT	MILESTONE NUMBER	MILESTONE DESCRIPTION	MILESTONE END DATE
RP1.1 Roadmap for co-developed relinquishment policy: The roadmap will identify a policy reform pathway with a focus on removing constraints that are currently preventing transition to successful relinquishment	1.1.1	Policy review: Develop map of policy and regulatory landscape	30/12/2021
	1.1.2	Uncertainty analysis: Complete assessment of gaps, ambiguities and counter-productive outcomes	30/06/2022
	1.1.3	Strategic foresighting: Complete socio-economic consequences of alternative policy settings	31/12/2022
	1.1.4	Socio-economic modelling: Optimal trade-offs for stakeholders identified for alternative policies	31/12/2023
	1.1.5	Deliver final roadmap	31/12/2025
RP1.2 Decision tool for regional planning of post mine uses: Software tools to assist governments, industry and other stakeholders develop holistic approaches to basin and landscape post-mine planning. The tool will consider dynamic and cumulative impacts of alternative options for mine re-purposing	1.2.1	Land use planning review: Complete review and gap analysis of regional land-use planning tools	31/03/2022
	1.2.2	Attribute analysis: Key attributes for integrating post-mine futures into regional planning identified	31/12/2022
	1.2.3	Future land use model build: Models developed to predict the interrelationships between attributes	30/06/2025
	1.2.4	Training materials: Software tools and training modules developed to build capacity for collaborative regional planning	31/12/2026
RP1.3 Frameworks, tools and capacity building to enable shared vision development: This program will identify mechanisms for collaboratively building a shared vision of post mine options, that will deliver socio-economic gains to regional communities	1.3.1	Value aggregation. Tools for aggregating community values developed	30/12/2023
	1.3.2	Opportunity analysis: Trade-offs for different opportunities and constraints quantified	30/06/2024
	1.3.3	Dynamic modelling: Dynamics of typologies, options and trade-offs modelled	31/6/2025
RP1.4 Integrated systems and training: It will investigate gaps and issues in the existing policy landscape that are impeding successful relinquishment, and articulate a roadmap for policy reform. Decision tools for improved planning will be developed for integrating regional land use planning with mine planning. New community engagement approaches will be developed and tested using participatory research methods	1.4.1	Integrated modelling: Algorithms developed to integrate qualitative and quantitative data	31/12/2026
	1.4.2	Educate 20 PhD students to become leaders in community engagement and regional development	1/01/2030
	1.4.3	Develop training modules and communication materials relating to community engagement and regional development	1/01/2030

OUTPUT	MILESTONE NUMBER	MILESTONE DESCRIPTION	MILESTONE END DATE
RP2.1 Advanced evaluation framework for long life assets: This framework will allow for better decision making and more efficient operating behaviour over the life of mine through providing greater transparency around the real risks and costs of closure. Advanced evaluation framework for long life assets	2.1.1	Value concepts: Next generation value propositions for a mining project conceptualised.	30/06/2022
	2.1.2	Quantification: Intangibles associated with a mining project quantified	31/12/2022
	2.1.3	Cost modelling: Methodologies for aligning costs and benefits over time developed	30/06/2023
	2.1.4	Option evaluation: Next generation mining project option evaluation framework developed	30/06/2025
RP2.2 Real time predictive models: These models will predict the level of residual risk and liability remaining at a site upon completion of mining operations. This will aid in uniform liability reporting and setting objectives for business process improvements along the value chain.	2.2.1	Parameterisation: Integrated total mining risk parameters identified	30/06/2023
	2.2.2	Optimisation: Optimisation models assessing unmitigable site liability developed	30/06/2024
	2.2.3	Prediction: Predictive algorithms and continuous monitoring needs embedded in optimisation tools	30/06/2025
	2.2.4	Risk assessment: Risk reduction quantified for different rehabilitation activities	30/06/2026
RP2.3 Planning tools to identify transferrable residual risk: Qualitative assessment will allow the user to quantify the acceptable level of residual risk and liability that can be transferred to subsequent land users upon relinquishment. The tools will analyse risk-reward trade-offs based on alternative land uses that will most likely follow the mining phase.	2.3.1	Alternative potential land uses for a region categorised	31/12/2022
	2.3.2	Acceptable residual risk quantified for each land use category	30/06/2024
	2.3.3	Progressive activities to achieve relinquishment identified	31/12/2024
	2.3.4	Optimal mix(es) of progressive activities identified	31/12/2025
	2.3.5	Educate 10 PhD students as leaders in mining and capital markets	1/01/2030
	2.3.6	Develop training modules and relevant communication materials for investment analysts, project planners, governments and regional planners	1/01/2030

OUTPUT	MILESTONE NUMBER	MILESTONE DESCRIPTION	MILESTONE END DATE
RP3.1 Smart architecture for closure design (Incl. data storage and transfer protocols): A knowledge platform and suite of modelling tools to address shared problems between miners, community and regulators, providing quicker access to relevant knowledge, tools and data.	3.1.1	Scope requirements: Establish data needs: Quantitative/qualitative models and data requirements reviewed	31/03/2022
	3.1.2	Needs analysis: Gap analysis for model, data and sensor requirements completed	21/12/2021
	3.1.3	Platform development: Data governance protocols and shared data platforms developed	30/12/2024
	3.1.4	Interoperable architecture in place: Scalable and dynamic information system architecture delivered	30/06/2025
RP3.2 Prototype risk management technologies for successful post-mine futures: A suite of market-ready innovations to 1) intervene to prevent the creation of closure risks and 2) address critical closure risks and 3) quantify ecological responses to interventions	3.2.1	Constraints analysis: Specific high-risk points in the mining value chain identified	30/06/2025
	3.2.2	Technology solutions with potential for broad commercialisation tested and either prioritised or fast failed	30/06/2022
	3.2.3	Priority technologies adapted and refined to optimise commercial result	30/06/2024
	3.2.4	A suite of new prototype technologies designed and commissioned for pilot testing	30/06/2029
	3.2.5	Prototypes validated at demonstration sites	30/06/2022
RP3.3. Business solutions for supply chain development: Supply chain maps that will assist businesses supplying goods and services to post-mine ventures to make informed investment decisions.	3.3.1	Current post-mine land use supply chains analysed	30/06/2024
	3.3.2	Market analysis and projection for future post-mine supply chains quantified	1/01/2025
	3.3.3	Business models and technologies that present scalable solutions prioritised	1/01/2027
	3.3.4	Test and validate solutions at demonstration sites	3/12/2030
RP 3.4 Training content and courses for integrating post closure outcomes into the workforce: The Program will also educate 20 PhD students as leaders in mine closure operations, supply chain, and technology development.	3.4.1	Microcredentialling courses for closure proficiency developed	30/06/2022
	3.4.2	Master of Closure programme delivered	1/01/2024
	3.4.3	Mine planning training incorporates closure scenarios	1/01/2025
	3.4.4	Technology specific skills development offered for prototype technologies	1/01/2027
	3.4.5	Educate 20 PhD students as leaders in mine operations, supply chains and technology development	1/01/2030

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