

STRATEGY SUPPORT FOR FUTURE SUSTAINABLE MINING



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MANDELA MINING PRECINCT
MINDS FOR MINES

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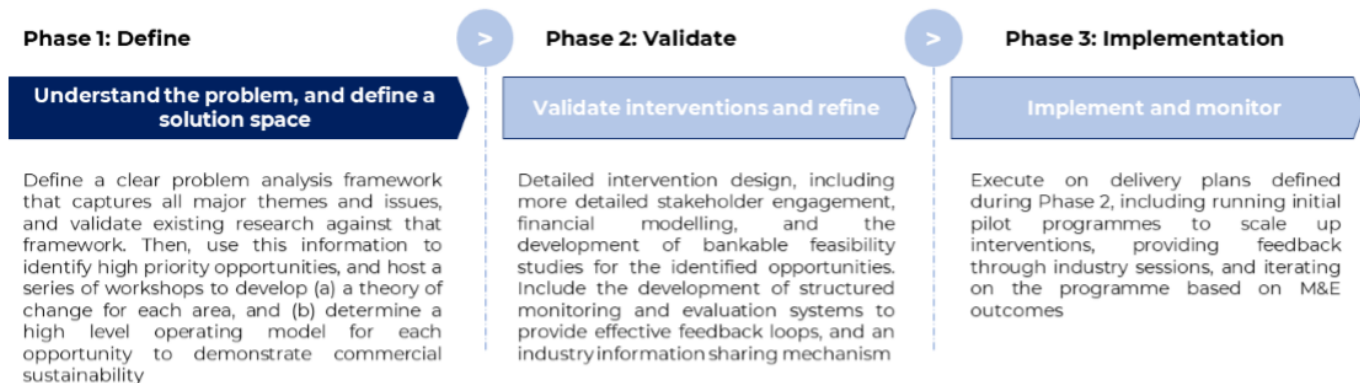
EXECUTIVE SUMMARY

Through its Longevity of Current Mines (LoCM) programme, The Mandela Mining Precinct has partnered with the Research Institute for Innovation and Sustainability (RIIS) to support the programme to develop a scope of work for future sustainable mining.

The ultimate intention of this work study is to explore a future outlook for sustainable mining in South Africa's PGM, Au, and Chrome mining industries, specifically looking at mechanisms to shift current liabilities into valuable assets across 3 critical challenge areas, and identify the relevant actors driving that process:

- Environmental custodianship and rehabilitation beyond life of mine
- Energy optimization and management ensuring future sustainable operations
- Water consumption and management ensuring future sustainable operations

Three separate yet interdependent phases have been identified for undertaking. The first phase is intended to understand the problem and define a solution space through a literature analysis and engagement with stakeholders; the second phase is intended to validate findings and intervention areas identified in the first phase and refine an impact pathway and intervention model going forward; the third phase is intended to implement the conceptualized solutions and ensure strong feedback mechanisms are in place to enable response and adaptation where necessary. This is illustrated in the figure below.



The six milestone reports submitted under this work package LoCM21WP7 is part of Phase I with the main deliverable to Understand the Problem and Define a Solution Space. Through a desktop review and extensive stakeholder engagements, it set the path to establish the purpose of this phase, which are to uncover the literature and insights into the challenges and opportunities present in the targeted mining industries, following the contribution to the development of enterprises that are able to convert mine liabilities into assets and have a positive impact on the environment, communities, economy, and continued commercial viability of the mine.

Phase 1 have delivered four interdependent milestones:

- Define the Problem Space (Appendix A);
- Review Existing Information (Appendix B);
- Interviews and Consolidation Workshops (Appendix C); and
- Final Synthesis (Appendix D).

The first milestone is designed to understand the scope of the issue, identify the relevant documentation and stakeholders, and define our analysis approach and framework.

The second milestone is designed to conduct a desktop review of the existing documentation and consolidate findings into our research framework. To ensure a deep contextual understanding of the problem, interviews have been conducted with stakeholders and key experts to fill in any gaps in information, refine our understanding, and seek deeper insights.

The third milestone is designed to conduct a series of workshops with internal and external (to the mining companies) stakeholders to verify and confirm our problem definition space and build a shared understanding of the challenged faced and potential solution areas to pursue in subsequent phases of the programme.

The fourth milestone is designed to report the final synthesis.

This report is documenting and refining the outcomes of phase 1, which include the summary of the findings and give a solution base for developing a structured approach in phase 2: Validation of the programme.

AIM OF RESEARCH PROGRAMME

The aim of the research programme is to establish a scope of work for Future Sustainable Mining, in particular looking at how the programme can create ‘sustainable businesses for collective value’. This work is focused on the PGM, Au, and Chrome industries, which broadly includes the following critical challenge areas:

- Environmental custodianship and rehabilitation beyond life of mine
- Energy optimization and management ensuring future sustainable operations
- Water consumption and management ensuring future sustainable operations

The primary goal of this work is to determine how to shift what are currently liabilities (which inevitably arise from mining activities) into valuable assets; or at least, to minimise the costs of those liabilities. As the mechanism to do this is not yet known, the first phase of this programme will focus on defining the specific problem space, before committing to more detailed planning.

The objectives of this milestone were to:

- Define the analysis framework to be used to structure our research approach and findings
- Define the scope of documentation to be included for desktop research
- Define the universe of stakeholders to be engaged to participate and in Workshops and Key Informant Interviews

METHODOLOGY USED

A detailed synopsis of the methodology undertaken and the outcomes for each work package deliverables are provided in the relevant Milestone Reports. The milestone deliverables are provided in Milestone 1 (Appendix A), Milestone 2 (Appendix B), Milestone 3 (Appendix C) and Milestone 4 (Appendix D) reports respectively. This report is documenting and refining the outcomes of phase 1 study work conducted. The overview of the methodology followed is provided in **Figure 1**.



Figure 1: Scope Overview of Methodology

Define the problem space (Milestone 1)

The purpose of the Define the Problem Space Work Package was to develop an analysis framework intended to provide the dual purpose of structuring the research outputs based on defined areas of inquiry, and to build our research approach in alignment with these objectives. This milestone also aimed to identify key documents and literature for informing the research objectives and identify the key stakeholders from which to gather information from to inform the research objectives.

In defining an analysis framework to inform and structure research activities and outputs, we relied on leading research methodologies suited to our needs, utilizing an analytical framework matrix to capture research findings and highlight key insights and learnings.

A framework matrix is a way of summarizing and analysing qualitative data in a table of rows and columns. It allows for both cross-case as well as sorting data by theme. This methodology provided a flexible approach to develop key themes, or question areas in the columns, and match these with information on key challenge areas on the corresponding rows.

A Framework Matrix provided three important criteria for the purposes of this study:

- It provided a case and theme-based approach to qualitative data analysis which is built on the visual display of data in a matrix which is built on a hierarchy of themes and sub themes.
- It enabled data summarisation and synthesis that reduces the volume of data required to analyse yet maintained a direct link to the primary data and was fully grounded in the context, language and meanings captured in the primary data
- It ensured a systematic process for creating and populating the matrices meaning the method could be used confidently by individuals or teams who want to collaborate.

The analysis framework was utilised to structure and analyse our findings from the desktop review and interview series. The findings were structured by challenge area as well as targeted lines of inquiry under the

ecosystem and landscape, the current outlook of mining, and the future outlook of mining. Under each of these areas of inquiry a number of questions were identified to pursue information on, these include:

Mining ecosystem and landscape

- What are the existing constraints evidenced in the regulatory landscape?
- Within the mining ecosystem, what are the key challenge areas contributing towards toward sustainable mining?
- To what extent is the regulatory landscape enabling of future sustainable mining practices (including sustainable closure)?
- What challenges do mines face in their ongoing operations?
- What challenges do mines face in sustainably planning for and achieving closure?

Current outlook

Within each of the key challenge areas identified:

- What are the current challenges contributing to ensuring positive economic, social, and environmental outcomes during the life of mine and beyond closure?
- What major liabilities do mines possess that are suitable for conversion to assets?
- What is the status quo/or current state of practice in SA mines?

Future outlook

- Are there opportunities evident ensuring positive economic, social, and environmental outcomes during mine lifecycle and after closure?
- What Innovative solutions have been identified or piloted in the SA or international context and what specific challenge are they trying to solve?
- What category or usage type do these innovations consider for end of life of mine conversion?
- Are there identified regulatory changes that would enable innovation and enhance life of mines?

To support the research process, our team also defined a list of key documentation to guide our desktop review process, as well as key stakeholders for engagement through our interview and workshop series. Both of these lists were regularly updated as we uncovered new pieces of information and identified new stakeholders to engage with. The full list of literature reviewed which included key learnings, and the list of stakeholders engaged can be found in Milestone Report 1. (**Appendix A**)

Review existing information (Milestone 2)

The milestone 2 was focused on conducting desktop research and a series of interviews to gather data and information on the problem space in converting liabilities into assets in South Africa's mining sector.

In order to conduct desktop research following a series of interviews where data is collected and information being processed, the team utilised a number of practical tools and approaches to guide the identification of sources, the structured manner to collect the data and the way to analyse the outcomes. Our methodology followed is outlined below:

Interviews

Identification of interview participants – To identify suitable interview participants we relied on both our internal network as well as the Longevity of Current Mines programme Technical Steering Committee to introduce critical stakeholders. We also utilised a snowball approach by requesting interview participants to

recommend any potential candidates from their network and invited these recommended experts to participate in our interview series. We identified firstly two main groups of stakeholders, namely internal stakeholders (direct representation employed in industry) and external stakeholders (NGO's, professionals, etc who is not employed by industry). Secondly, we separated two groups of these stakeholders, namely executives and senior management. The focus areas (for each interview group) were based on:- informing the solution and understanding the ecosystem.

Co-ordination of interview scheduling – the RIIS team engaged with stakeholders utilising a prepared standardised introductory email outlining the key aspects of our works and soliciting participation in an interview series, this template can be found in Appendix 1. The invitation also included a digitally enabled scheduling tool utilising Doodle, however also provided available times for scheduling interviews in our email responses. Where stakeholders were unresponsive to emails, our team followed up regularly via email and telephonically where possible.

Conducting interviews – our team adopted a semi-structured approach to conducting interviews, including key lines of enquiry while enabling open responses. To facilitate interviews, an interview guideline (**APPENDIX B - Annexure 2**) with key questions was developed. Interviews were conducted with at least two RIIS team members, including an interview led to guide the questioning and interview support to capture the key outcomes. Where interviews were conducted over virtual platforms, the sessions were recorded for reference during reporting.

The interview series was conducted during March and April 2022, however as new stakeholders were identified and engaged, our team conducted additional interviews to address any gaps identified. The full schedule of interviews and interview participants can be found in Milestone Report 2 (**APPENDIX B**).

Desktop Research

Identification of documentation – The RIIS team adopted a dual approach to uncover relevant documentation of both searching for available online repositories and soliciting referrals from key experts and stakeholders. Repositories from leading research institutes in the mining sector, as well leading NGOs were utilised, while annual reports from the large mining companies in South Africa were readily available.

Capturing and systematising documentation – The RIIS team utilised a literature analysis framework to capture the uncovered documentation and literature to keep track of our sources and key learnings.

Analysis of data and information

To structure our approach to analysis, the RIIS team created a project scrapbook on Mural. This scrap book acted as our central repository for capturing our learning throughout the desktop research process and interview series. This scrapbook enabled us to capture insights and learnings on individual stick notes and place them within the structured framework and lines of enquiry outlined in our analysis framework. Where multiple sticky notes were evident and reoccurring from our information gathering exercise, they would be grouped together easily identifying thematic areas within our insights. This structured approach provided a central repository for our team to store and analyse information as it was uncovered throughout our data gathering activities and enabled ease of synthesis and reporting.

The digital scrapbook content I provided in Milestone Report 2 (**APPENDIX B**), and an excerpt of the analysis and synthesis process this scrapbook enabled are as follows:

- Environmental liabilities;
- Carbon footprint and future sustainable operations;
- Energy optimisation and management;
- Water consumption and management; and
- Social community and public sector engagement

The milestone is concluded through a structured approach in identifying sources of information and key informants, engaging with literature and stakeholders, and capturing insights from our desktop review and interview series. This structured approach greatly enabled the synthesis and reporting process and provide suitable themes and findings to validate with stakeholders during our workshop series.

Consolidation and verification workshops (Milestone 3)

The Consolidation and Verification Workshops milestone was focused on conducting two facilitated workshops with internal and external stakeholders to present the information gathered through the desktop review and stakeholder interview processes. The purpose of these workshops was to validate findings with a broad group of stakeholders and allow for any further input and feedback from the stakeholder group to be taken into account during the final synthesis and reporting work packages.

In order to facilitate the stakeholder workshops and drive workshop participation, RIIS relied on our already established stakeholder grouping established through the interview process and worked with MMP and the LoCM Technical Steering Committee to ensure participation from South African mining houses. This milestone was broken down into workshop planning, workshop preparation and workshop facilitation.

Workshop planning

RIIS ensured sufficient notice of the workshop and select suitable dates and times for the workshops by reaching out directly to stakeholders telephonically and through email to gauge stakeholder preferences and availability. Unfortunately, due to low initial stakeholder registration and various conflicting engagements, the workshops dates were significantly delayed, mainly due to Mining Indaba activities scheduled at the same time. Workshop dates were finalised for the 31st May for External Stakeholders and the 9th of June for Internal Stakeholders.

A full account of the workshop planning process and the list of stakeholders that were engaged and those that participated can be found in **Milestone Report 3 (APPENDIX C)**. Where stakeholders were unable to participate, the workshop material was sent to them through email asking for any feedback or input for inclusion in the final report.

Workshop preparation

The purpose of the workshop was to validate findings the RIIS team had uncovered during the desktop review and stakeholder interview process. In order to ensure that the workshop was able to crystallise the findings and cover the full breadth of insight gained, RIIS had to synthesis and distil our findings to present the most pertinent insights. RIIS utilised a Mural board to facilitate this, with key challenge areas being defined based on research inputs and key focal points being categorised within these challenge areas.

Based on the extent of anticipated stakeholder participation MMP and RIIS determined to pitch the workshop findings at a high level focusing only on the most salient challenge areas for discussion and validation. Initially

a facilitated session using Mural was envisaged, allowing time for stakeholders to directly provide input into challenge areas through an interactive session. However, with limited availability it was determined that the best use of time would be to rather facilitate a discussion for each challenge area. The RIIS team facilitated a discussion for challenge area asking the following questions:

- What are we missing or have not considered that is pertinent to this challenge area?
- How does this challenge contribute towards a knock-on effect in other challenge areas?
- What components of this challenge area are critical to address in solution building (i.e critical success factor)?

Additional insights gained through discussion in both the internal and external stakeholder workshops were captured by the RIIS team for inclusion in the final report.

Workshop facilitation

With indicated, limited availability from stakeholders to participate in a lengthy half day workshop, MMP and RIIS decided to utilise a two-hour session for each workshop and streamline our presentation and discussion to maximise our time with stakeholders.

RIIS opted to use a power point presentation to support the presentation of challenge areas and findings and facilitate discussion and further stakeholder input. The below agenda was used to structure each session, ensuring ample time for introductions and project overview, discussion on key findings, and laying the path for the way forward.

Today's Agenda





12:00 – 12:15	Welcome and introductions
12:15 – 12:30	Overview of Future Sustainable Mining initiative
12:30 – 12:45	Overview of South African mining ecosystem
12:45 – 13:45	Presentation on problem space definition findings and discussion
13:45 – 13:55	Summary of needs for Future Sustainable Mining
13:55 – 14:00	Next steps and closure

Final Synthesis - (Milestone 4)

The synthesis has been an ongoing process throughout our data collection and analysis process, as we have gathered insights and structured them within our analysis framework. Our team followed an iterative process in synthesising our findings, which started through an initial analysis of data and information gathered. A thematic analysis process followed where findings were structured according to emergent themes. Lastly an internal synthesis brainstorming sessions was conducted to draw out our key findings and structure our final report. **Figure 2** provides an overview of our analysis, synthesis, and reporting approach and methodology.

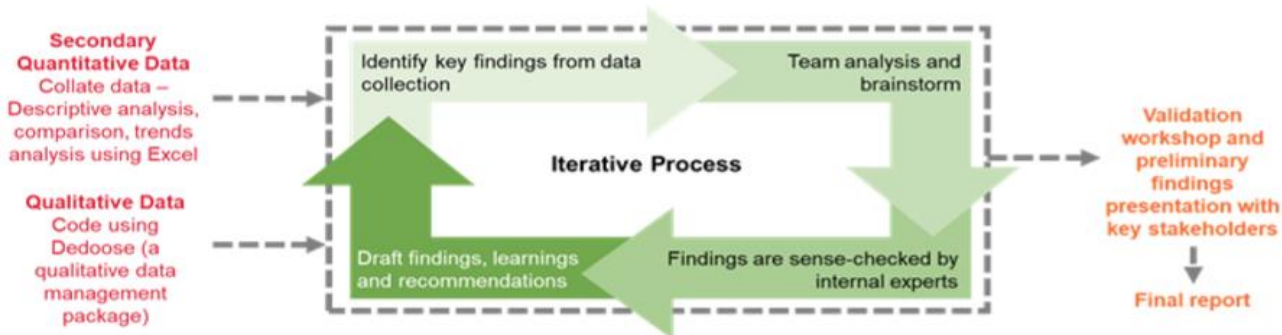


Figure 2: Interactive process overview

Data Analysis

Our team conducted inductive thematic analysis to assess the data gathered. This entails identifying themes relevant to Future Sustainable Mining, assessing the data and identifying quotations that pertain to these themes, coding them accordingly, and then interpreting the final output taking into account the frequency with which certain themes present and repeat.

Internal Synthesis

Upon conclusion of the data analysis process, our team conducted an internal synthesis session to review and interpret all findings. RIIS used evaluative reasoning along our lines of enquiry to define the key emergent themes and challenge areas as well as prominent insights associated with thematic challenge areas.

Validation Workshop

The emerging findings and recommendations were sense-checked with relevant stakeholders during a series of validation workshops to enable stakeholders to draw out implications of these findings, and brainstorm lessons learned and recommendations collaboratively.

Reporting

Once feedback had been gathered and collated through our workshop series, this input was included in our data set for further analysis, synthesis and finalisation of findings. With a full picture of our challenge areas developed our team undertook our reporting process within Mandela Mining Precinct (MMP) requirements.

The synthesis findings are drawn out comprehensively in **Milestone Report 4 (APPENDIX D)**.

Summary of Results

The summary of the result findings is provided below, followed by our exploration into the solution space.



Land

- Unregulated mining has a major **impact on the landscapes and built environment** in mining areas, characterised with stockpiles of waste material, tailings storage facilities, environmental degradation, unsecured mine voids and threatening the environmental suitability of mining regions.
- Even where rehabilitation is done effectively, this **does not fully negate the environmental impact** of mining.
- Mine closure planning often does not fully **take advantage of natural assets to drive circular economies** that improve livelihoods for communities and promote economic diversification through post mining land use.



Energy

- High reliance on **fossil fuel unsustainable energy sources** for operational and supply chain requirements.
- **Unreliable electricity provision** and blackouts reducing operational capacity and extraction.
- **Inefficient energy management** technologies and practices contributing to higher energy usage



Water

- **Water scarcity** common across many mining regions in South Africa
- Significant **costs associated with water treatment** of mine affected water for re introduction to water systems.
- Costs into **perpetuity beyond mine closure**
- **Risk of contamination** of water on which downstream users are dependent
- **Increased risk of flooding** and heavy rainfall as a result of climate change



Air pollution

- Air pollution through exposure to mine dust and potentially **toxic particulate matter** poses a serious threat to the health of communities living in close proximity to mining operations.
- Where mining waste is not effectively managed or concurrently rehabilitated in line with a closure strategy, **air pollution can impact the health of already vulnerable populations**



Communities

- Labour receiving communities in mining areas are most **threatened by environmental impact** of mining .
- They also face the most significant **threat to livelihoods** by mine closure.
- **Skills development** initiatives that focus on mining operations with limited skills to take advantage of opportunities in adjacent value chains.
- Ineffective community engagement mechanisms often result **in limited understanding and input** on mining operations and closure strategy, not fully valuing the contribution that can be made by communities



Legislative framework and implementation

- **Positive legislation advances** governing requirements during mine lifecycle.
- However, **notable loopholes and short comings** in legislation evident.
- Efforts to update mine closure policy and strategy **require a regional approach**, and establishment of a **legitimate overseeing entity**.
- Policy **implementation and enforcement is ambiguous** and inconsistent.
- Necessary **guidance and enablement** from regulator often unclear
- Reported **insufficient capacity of regulator** to effectively enforce legislative agenda.
- Current legislation focused on **primacy of protection against social and environmental degradation**, limited drive from regulator to pursue enabling future thinking approach.



- Mine houses themselves are facing increasing **pressure to move beyond environmental, social, and governance** approach of mitigating impact and move towards being **responsible corporate citizens** that have a positive impact on the environment, society, and the sustainability of the economies they operate in.
- Depletion of mineral stock and commercial viability of mining is impacting the expected life of mine for many operations in South Africa with widespread mine closure on the horizon.
- With hindrances to obtaining a closure certificate mines resort to care and maintenance and selling down operations to smaller mines with less accountability pressures for shareholders and stakeholders.

The key tenants of the findings are provided below and elaborated on in **Milestone Report 4**.

Mining activities all along the mining value chain can have both positive or negative impacts as well as direct and indirect effects on society and various environmental systems. These effects are complex, and cut across the environmental, social, economic, and political dimensions. The wide-reaching nature of these challenges makes the development of appropriate technologies and management strategies, to mitigate any possible negative impacts, of utmost importance. The following information below looks at challenge areas, and possible mitigation strategies that the mining industry should be pursuing or if they already are, then should be pursuing to a greater extent.

Rehabilitation and value generation of mining affected land

Mining significantly transforms the landscapes in which mines operate. If not properly managed and not effectively rehabilitated, then these transformations result in post mining landscapes with stripped natural areas, open pits and underground voids, loose soil piles waste rock and overburden surfaces, eroded land, tailings dams, tailings facilities altering natural landscapes and left over infrastructure that provides no economic or social value.

There are a variety of mitigation strategies available to reduce a mines impact on the surrounding land. One of these would include a focus on the reduce, reuse, recycle principle. Another mitigation strategy, contributing to sustainable development, is the effective beneficiation of mine waste within the mining value chain and in adjacent value chains. Opportunities also exists to reduce the negative impacts of mine closure, which can be mitigated by promoting opportunities for commercially viable alternative land use, post closure. It is important that all of these opportunities are identified and pursued holistically within the mine lifecycle. Following mitigation strategies such as these will generate commercial value and reducing the overall liabilities towards the end of life of mine.

Ongoing treatment and value generation of mine affecter water and water sources

Mining activities can place risk of water pollution if not actively managed. Depending on the type of mine and what the water is needed for will determine the type of water pollution. Some forms of water pollution include the following: Acid Mine Drainage (AMD), Heavy metal contamination (Leachate), Processing chemicals pollution and Sedimentation. Other waste complications include: - a decrease in ground water tables due to significant disruption and pumping of water; an increase in surface water run-off from the landscape and destruction or reduced quality of wetland areas which are integral to the ecosystem.

Mitigation strategies include rigorous treatment and recycling of polluted water to ensure that any negative environmental effects can be turned into positive ones. This is achieved through the use of different

technologies and methods, which is often most beneficial when an integrated approach using multiple mechanisms is followed. Mitigation should include a combination of both passive and active management methods. The incentive for mining companies to adopt water friendly practices is not based solely on the benefit of reducing environmental effects but will also reduce production costs.

Managing air pollution through reducing exposure to waste

Air quality in mining landscapes can be impacted during mining operations and post closure if the post mining landscape is not carefully managed, contributing to severe health impacts on surrounding communities. Mine tailings storage facilities, quarries and open pit mines, dirt roads, mine waste, dust from ongoing mining operations, degraded and eroded land and soil all contribute to the particulate matter composition affecting the surrounding air quality.

To mitigate air pollution from mining activities, the source of the particulate matter needs to be addressed. This entails the removal of exposed waste through tailings storage facilities or covering exposed waste or sources of dust. The rate of removal is an important consideration in this undertaking given that the removal process itself is likely to generate high amounts of dust. Covering erodible lands through restoration of vegetation is essential to reducing the occurrence of pollution. It is essential then that mine closure is undertaken effectively with concurrent rehabilitation of dust and particle sources. This will require coordination and alignment from different government departments to ensure effective regulation and enforcement.

Energy supply and efficiency constraints

Mine operations require substantial energy to conduct exploration, extraction and beneficiation and have historically had access to competitive pricing of coal generated electricity to meet energy requirements - providing little incentive to pursue sound energy management reduction mechanisms. This landscape has shifted considerably over recent years placing emphasis on mines to reduce their energy usage and dependence.

SA mining industry's move towards the adoption of alternative, commercially viable, energy sources, will likely entail the use of a mix of energy sources to meet the needs of the industry. Mining houses have already begun this transition, with for example the use of photovoltaic and wind energy production as well as biogasses and green hydrogen. However, mines still have a long way to go to effectively reduce their energy requirements. As technologies and solutions emerge and can demonstrate commercial viability, the incentive for adoption becomes increasingly clear. Solutions will however need to consider:

- Conduciveness of mine area to generate alternative energies.
- Commercial viability of new technologies and solutions.
- Potential for advancing community and economic benefit through pursuance of new technologies and solutions.
- Life of mine appropriateness for further investment.
- Ability to sell on energy to the municipal grid.

Ensuring sustainable opportunities for mine affected communities

During the life of mine and especially during mine closure, it is incredibly important that communities surrounding the mines have access to resources and development opportunities. Although there are currently many short-term initiatives to ensure this development, there are not many existing long-term plans and therefore, the long-term effects of mines and mine closure can be overwhelmingly negative.

These negative effects can be mitigated with careful planning, proactive stakeholder interaction, and contextually relevant strategies that benefit communities. The protection of communities will require a shift in thinking, moving from the idea of mine closure to mine transformation. This transformation planning needs to take place during the life of the mine, and not at the time of mine closure – as this will increase the viability of opportunities. It would be beneficial for mining houses if this planning mentioned above, was done through the use of an integrated Development Plan (IDP).

These are some possible considerations to enhance community beneficiation:

- Asset Based Community Development valuing the assets offered by communities from knowledge, culture, skills, resources, relationships etc.
- Emic understanding of community lived experienced.
- Participation and interaction going beyond check-box exercises to enable meaningful interaction and inputs that are taken into account.
- Qualitative understanding taking primacy in building contextual understanding and driving participation.
- Entrenched knowledge in communities to inform rehabilitation and management that compliments scientific approach.

Legislative Framework and Implementation

Legal framework advances have made notable strides and now include environmental authorisation and water use rights with the mining permit application, as well as availability of financial provisioning for remediation and rehabilitation activities for closure. However, despite these notable strides, there are still a variety of other inputs required to make the implementation of this successful. This implementation is unfortunately, curtailed by a lack of capacity within the DMRE and other departments. The current regulatory environment and the inability to obtain mine closure certificates results in mines incurring substantial ongoing costs.

To mitigate these negative effects, a regulatory landscape that promotes sustainable development is needed. This type of framework can only be achieved through significant collaboration with government, mine houses, communities and stakeholders. At its core, the legislative agenda needs to support clear objectives that promote sustainability and development in the mining industry, all of which are supported by global best practice. It is the regulators' role to create a platform where this is possible, as well as an entity who can drive all of these necessary developments and hold stakeholders accountable in this process. It is also important that government undertake more effort to provide public goods and services to mines and communities so that mining houses can avoid needing to provide basic services to mining communities. Finally, the municipal government should be capacitated to drive economic diversification, which will build off efforts on the ground to drive economic and social inclusion.

Exploring potential areas of Opportunities

Rehabilitation and value generation of mining affected land

- Waste and tailings
High volumes of waste from prospecting, extraction, treatment and storage offer significant opportunity for beneficiation and management of waste and tailing.

The historical approach is securing waste through tailings storage facilities but there are opportunities evident for reduction, re-use and recycling of mine waste that mitigates negative impact on the landscape.

Opportunities include aggregate and fill material for construction, additive and filler for cement and bricks, removed topsoil for agriculture and landscaping, backfill for sealing of mine shafts, utilisation of mine affected water for dust management separation and minerals processing, and industrial and agricultural use of mine affected water etc.

The effective beneficiation of mine waste can contribute to sustainable development within the mining value chain and in adjacent value chains while mitigating negative environmental impacts, generating commercial value, and reducing the overall liabilities towards the end of life of mine. Effective beneficiation of this mine waste also adds additional economic value by ensuring viable land for use post mining.

The current legislation in South Africa is, however, prohibitive - providing no legal definition of mine waste, and its classification as residue stockpiles and deposits, and classification of mine waste as hazardous under NEMWA. This results in a lack of clarity and misperception of liabilities and management of waste. South African legislation is focused on precautionary principles and requires a shift in thinking from minimising and mitigating environmental impacts towards encouraging development of value addition and promoting the introduction of circular economies.

- **Land Use**

Mine houses will have to identify and pursue opportunities holistically within the mine lifecycle in order to realise benefits during operations and closure. In addition, they will need to provide the driving force to bring about the enabling legislative changes.

The negative impacts of mine closure can be mitigated by promoting opportunities for commercially viable alternative land use, post closure, that diversifies economies and addresses environmental liabilities.

The potential of land use is impacted by the extent of degradation and the way land is impacted as a result of mining activities. Innovative land use requires a shift in thinking beyond just the mitigation and management of environmental impact.

These Usage strategies need to be based on the most appropriate use for socio-economic and bio-physical context, and should consider what creates value for miners, communities, the environment and economies.

The following considerations should drive strategy:

- Micro-climatic conditions – This is unique to mines and provides benefits for specific use cases.
- Location and infrastructure – The isolated nature of mines is ideal for storage, containment and testing facilities, which are all enabled through existing access and ventilation infrastructure.
- Potential for revegetation – The severity of degradation may enable restoration of landscapes for wildlife conservation, permaculture, botanical gardens.
- Location and land characteristics – This may attract leisure and recreational activities.
- Water availability – This promotes use for agriculture, aquaculture, and even extraction of drinking water.

Ongoing treatment and value generation of mine affected water and water sources

Mitigation strategies include rigorous treatment and recycling of polluted water to ensure that any negative environmental effects can be turned into positive ones. This is achieved through the use of different technologies and methods, which is often most beneficial when an integrated approach using multiple mechanisms is followed. Mitigation should include a combination of both passive and active management methods. The incentive for mining companies to adopt water friendly practices is not based solely on the benefit of reducing environmental effects but will also reduce production costs. The areas of opportunities are:

- Mines are required to treat effluent prior to releasing water back into the environment with high importance placed on the reduction of elements that exceed prescribed limits (stipulated in quality guidelines and standards). This is achieved through the use of a number of technologies and methods (neutralisation, filtration, adsorption, absorption, distillation, crystallisation etc.). Often an integrated approach using multiple mechanisms is undertaken.
- In addition, passive vs active management mechanisms can be employed. Active treatment referring to the use of reagents to remove pollutants and passive referring to the use of plant species with an affinity to pollutants or micro-organisms.
- More recently a move has been made towards minerals valorisations treatment approaches that enable the reclamation of minerals of commercial value to offset treatment costs. Involving the reclamation of drinking water and extraction of minerals.
- Valorisation and on selling of treated water offers significant opportunity for ensuring continued services to communities and generating economic opportunities that benefit communities and the regional growth of a regional economy beyond the mining value chain.

Managing air pollution through reducing exposure to waste

- In order to mitigate air pollution from mining activities the source of the particulate matter needs to be addressed.
- This entails the removal of exposed waste through tailings storage facilities or covering exposed waste or sources of dust. The rate of removal is an important consideration in this undertaking given that the removal process itself is likely to generate high amounts of dust.
- Covering erodible lands through restoration of vegetation is essential to reducing the occurrence of pollution. The Australian National Pollution inventory estimates wind emissions reductions from mining operations as:
 - 30% if primary rehabilitation occurs
 - 40% if not unself sustaining vegetation is achieved
 - 60% if secondary rehabilitation occurs
 - 90% if revegetation is undertaken
 - 100% if fully rehabilitated vegetation is undertaken.

Energy supply and efficiency constraints

- South Africa's mining industry will need to adapt to both shareholder and stakeholder expectations. It will also need to make meaningful strides towards reduced reliance on fossil fuels and increased adoption of alternative, commercially viable, energy sources. This will likely entail the use of a mix of energy sources to meet the needs of the industry.
- Mining houses have already begun this transition, towards developing the availability of alternative energy sources, through investments into the following projects:
 - Photovoltaic and wind energy production
 - Bio gasses and green hydrogen
 - Replacement of diesel operated machinery with electric or battery-operated machinery
 - Supply chain efficiency improvements
 - Carbon credit markets
- While mines have a long way to go in reducing their energy requirements, and increasing green energy sources available for operations, advances have been made. However, these are limited by the risk aversion of being the first mover to adopt untested solutions and technologies at scale.

- Vast tracks of land already being repurposed for solar energy generation by mines, ensuring benefit during mining operations. Through un-skilling communities and promoting MSME development the management and maintenance of this infrastructure can provide an opportunity for beneficiation.
- Post mining, this infrastructure can provide ongoing opportunities and income for communities through on selling of power to the municipal grid and providing for energy requirements for new industries.
- Onsite hydrogen production and storage to minimise operational energy requirements and generate economic opportunities post mining offers significant potential through unique mine characteristics.

Ensuring sustainable access to economic opportunities for mine affected communities

- Negative impacts associated with mine closure can be mitigated through the creation of positive outcomes. This can be achieved with careful planning, proactive stakeholder interaction, and contextually relevant strategies that benefit communities.
- This will require a shift in thinking from mine closure to mine transformation that contributes to the securing of livelihoods and sustained well-being of communities.
- It also requires early consideration and planning within the mine lifecycle to identifying and develop opportunities. This pro-active approach is useful as the viability of opportunities diminishes over the mine-lifecycle. These Identified opportunities need to be socially and culturally sensitive; contextually relevant and based on inputs from a multitude of stakeholders.
- Mining houses would benefit from using an Integrated Development Plan (IDP) framework. This would be useful as it co-ordinates and provides a good understanding of all of the development opportunities and solutions available. It takes into consideration local and government spheres, to produce the most coherent plan (The Practice Group, 2017). Screening, Identification, Assessment and Support Policies (SIAs) also provide insight into contextual socio-economic issues and should inform SLPs in further elaborating on opportunities.
- Communities and the development of requisite skills and promotion of MSMEs is central to sustainable ongoing operations for mines and the successful generation of post mining opportunities.
- This needs to be informed by a meaningful understanding of community needs and capabilities that informs a suitable approach to realising post mining sustainable economies and landscapes.
- limited economic opportunities, lack of basic service provision, and unhealthy living conditions will lead to social unrest and the adoption of illegal activity that severely impacts mine liabilities.

Legislative Framework and Implementation

- The regulatory landscape around mine closure needs to promote sustainable development principles and move beyond its current limited scope in mitigating environmental and social impact. This, however, can't be achieved through the regulator alone but rather requires significant collaboration within government itself, mine houses, communities, and stakeholders. This will require a process of redressing entrenched mistrust amongst stakeholders and will need buy in and input from all stakeholders.
- At its core, the legislative agenda needs to promote clear objectives and mechanisms for driving sustainable economic development, enhanced livelihoods of communities, environmental sustainability interventions, and rely on global best practice.
- It is the role of the regulator to provide a clear framework and platform in which this can take place, it is also the role of the regulator to ensure that there is a legitimate entity established that is able to take on the responsibility of conducting the orchestra with the mandate and authority to hold stakeholders accountable.

- The regulatory landscape and the lack of clarity provided poses the most significant challenge to reducing mine liabilities while ensuring sustainable outcomes. Inability to achieve closure results in liabilities into perpetuity for mines.
- Despite being the 'only thing that exist' Integrated Development Plans (IDPs) often do not offer an effective framework for mines to integrate their closure plans and SLPs with. Shortcomings with IDPS include:
 - Focus on short term gains over longer term sustained impact, driven by the politicised 5-year cycle.
 - Not designed to maximise economies of scale through mine contributions
- Mines have significant value to offer in contributing to the development of regional IDPs that adopt a strategic long-term view but can't be the primary driver of this.

Exploring potential areas for solutioning

Rehabilitation and value generation of mining affected land

Land use strategy development needs to be undertaken through a sustainable development framework that recognises the interdependencies between economic growth, social equity, and environmental integrity. It requires long term planning and coordination across sectors and actors from local to global level.

- Innovative land management strategies are very useful in producing opportunities regarding ways in which to effectively close a mine. Some of examples of these opportunities include the following:
- Utilising the vast amount of land, a mining operation exists on, for community led agricultures initiatives (funded by mining companies) (Nengovhela, 2022).
- Utilising effected mine water that has been treated, as an alternative water source for various activities like agriculture. This option would be incredibly useful in any country, but specifically a country that struggles considerably with water shortages (Nengovhela, 2022).
- Transforming the vast amounts of mining land into infrastructure that is able to harness renewable energy sources. This will be incredibly helpful as South Africa, along with the rest of the world, transitions to clean energy (Nengovhela, 2022).
- Embracing more immediate, smaller scale, often community lead initiatives. This could include a collaboration with communities and local SMEs to perform activities such as reclaiming old waste rock dumps and repurposing parts of old mines into tourism hot spots (Nengovhela, 2022). Further on in this report, we touch on some examples of global initiatives that have successfully converted old mines into new facilities, like amusement parks and research hubs, resulting in vibrant, new economic development zones.
- Current move towards utilising mine waste as backfill to replace underground voids can significantly reduce post liabilities and improve post mining landscapes – however still a risk of acid mine drainage (AMD) and needs regulatory enablement.
- Through capacitation of micro, small and medium enterprises (MSMEs) in the mining value chain, waste management can provide an important opportunity for generating economic value form waste while reducing mine liabilities – this requires up front planning in closure plans and social and labour plans (SLPs).
- Illegal mining poses a significant risk for mines and health and safety concerns for communities. This needs to be addressed through a push and pull perspective through a demand and supply perspective by lessening the need for communities to engage in illegal activities while formalising the establishment of artisanal mining that is regulated and safe.
- Repurposing of infrastructure efforts often curtailed by the municipality's capacity to operate and maintain infrastructure – resulting in vandalism and health and safety risks.

- Special Economic Zones (SEZs) offer an alternative for donating unutilised infrastructure, but maintenance and safety costs an ongoing concern.
- Recent advances in agricultural output potential of repurposed mine land demonstrate the need for active soil renewal and regeneration and the importance of agricultural as a post mine land use.

Land rehabilitation for agricultural use

Lucerne hay production by Coal & Allied, Australia

Project description:

After using the alluvial land in Hunter Valley for coal mining, Coal & Allied was required to restore about two-fifths of the land to a state where it would be suitable for irrigated agriculture, which was the pre-mining use of the land.

Before mining commenced the topsoil and subsoil were stockpiled and these were replaced to a depth of 1.5 metres to accommodate crops and in 2013 a hybrid of wheat and rye, was planted on the land, the first to be grown at a commercial level since the mine trial in 2007.

Envisaged impact:

By 2007 the trial area demonstrated hay production yields above the district average for three consecutive years after which the land was deemed fit for commercial crop production.

Impact areas:



Land



Communities



Land rehabilitation for agricultural use

Winter Wheat pilot project at Wonderfontein coal mine, Mpumalanga

Project description:

The Mpumalanga Winter Wheat Pilot is exploring the viability of using old coal mining sites and mine water to irrigate and grow crops.

First pilot project began in April 2021 and continued till January 2022 testing a range of winter wheat

The research particularly focused on Winter wheat due to the interest of a cereal company in South Africa highlighting the potential opportunities of its grains to be used in the manufacturing of cereals.

Envisaged impact:

The pilot proved the success of growing winter wheat in Mpumalanga using remediated coal mine land and mine affected-water.



Impact Areas:



Land



Communities



Water

Source: Glencore (2022)

Data Processing/server sites

Bluebird Network- Underground data center

Project description:

Bluebird Network is located approximately 25m underground a limestone mine in Springfield Missouri

Advantages

- Protected from manmade or natural disasters
- Stable environment and consistent temperature
- **Closed loop cooling system** thereby saving 150 million gallons of water each year

Envisaged impact:

- Repurposing of land
- Economic benefits: Revenue generated from sale of storage space

Impact areas:



Land



Water



Building food farms underground

'Growing Underground'-Clapham London: WWII Underground bomb shelter converted into a hydroponic farm

Project description:

- Located 33 meters below Clapham, AgTech Company Zero Carbon Farms built a hydroponic farm named 'Growing Underground' farming salad mixes and micro herbs
- Academics and scientists argue that a variety of crops could be grown using hydroponic planters; with plant roots fed with nutrient-rich water. Hydroponic technology uses water systems to grow plants as opposed to soil
- "Water can be sourced from groundwater or water that is condensed from ambient air"
- Coloured LED units will permit photosynthesis
- Industrial CO2 emissions can be captured and stored underground for plants to breathe
- "Hydroponic systems use 60-70% water less than traditional outdoor agriculture" - Dickson Despommier
- Sources of revenue generated by farm include selling products directly to consumers and supplying retail stores & supermarkets; as well as sale of tickets for farm tours

Envisaged impact:

- Farms are protected from irregular weather conditions, increasing food security
- Reduced carbon footprint
- Underground setting provides a steady temperature for plants to flourish in

Impact areas:



Land



Communities



Water



Source: Growing Underground (2022); Zero Carbon Farms (2022)

Transforming old mines to underground scientific/research facilities

Sanford Underground Research Facility (SURF)- Old Gold Mine in South Dakota, USA

Project description:

Sanford Underground Research Facility is an underground physics lab hosting ground-breaking research and experimentation in fields such as biology, engineering, and geology; and has conducted studies about subatomic particles and dark matter.

The lab is 1.6km underground. Being located underground makes it an ideal location for sensitive physics experiments as it is protected from the sun and any potential interfering cosmic rays.

Impact:

- Job creation- either directly by SURF or through large on-site science projects
- Income generation
- SURF creates new opportunities in higher education through offering research programs for students to participate in as well as learning facilities for individuals to conduct ground-breaking research at

Impact areas:



Land



Figure 26: Sanford Underground Research Facility



Figure 27: Dark matter detector experimented at SURF

Source: Sanford Underground Research Facility (2021); Tyson (2020)

Repurposing the land for tourist attraction sites

Salina Turda- old Salt Mine in Western Romania

Project description:

- Salina Turda was the first major experiment in turning a disused mine into a non-traditional tourist attraction when it opened to the public in 1992.
- Visitors descend 120 meters underground along the same elevator shafts that once hauled salt to the surface
- At the bottom sits an underground theme park with a miniature golf course, Ferris wheel, bowling alley and underground boating lake. Salina Turda also has a spa and wellness centre capitalizing on the healing properties of the cave's naturally occurring salts and 80% humidity

Impact:

The repurposing of a disused mine to create a tourist attraction site has an impact on local economies through:

- Job creation
- Income generation

Impact areas:



Land



Figure 28: Salina Turda Underground Boating Lake



Figure 29: Salina Turda

Source: CNN (2015); Johanson (2015); Salina Turda (2020)

Treatment and value generation of mine affecter water and water sources

Despite a regulatory push for zero-liquid discharge and valorisation, current technologies and methods are not yet sufficiently developed or available at a large commercial scale. Future treatment approaches should consider:

- Opportunities for deployment of integrated systems that utilise technologies enabling value extraction and beneficiation of minerals.
- Offsetting of operating costs through the resale of by-products.
- Improvement of crystallisation techniques that acquire clean salts of commercial value.

Valorisation and on selling of treated water offer significant opportunity for ensuring continued services to communities and generating economic opportunities that benefit communities and the regional growth of a regional economy beyond the mining value chain.

Repurposing for agricultural and industrial use needs to balance with meeting ecosystem requirements of ensuring sustainability of water supply.

Commercialisation and feasibility of new technologies is still a major barrier to adoption by mine houses.

Beneficiation of mine affected water: drinking water for community use

Anglo American- eMalahleni Water Reclamation Plant

Project description:

Located in the Witbank Coalfield, Anglo American has found innovative ways to reuse mine water through the eMalahleni Water Reclamation Plant

1. This is made possible through the process of reverse osmosis, using reactors and clarifiers to desalinate and neutralise mine water and produce millions of tons of potable water per day. Acid Mine Drainage is treated to produce potable water.
2. Additionally, Anglo found an innovative way to utilise two of the by-products of reverse osmosis: brine and gypsum – which were converted into bricks, enabling the construction of hundreds of employee homes

Envisaged impact:

First initiative: this has enabled Anglo to provide the surrounding community with clean water

Second initiative: this has enabled the creation of 700 temporary jobs and 57 permanent jobs

Impact areas:



Communities



Water



Figure 9: eMalahleni Water Reclamation Plant

Source: Anglo American (2017);

Beneficiation of mine affected water: drinking water for municipal/community use

Reverse Osmosis Technology- Anglo American Aquila, Australia

Project description:

- The use of reverse osmosis (RO) systems has been identified to be better equipped to deal with "tough mining process wastewaters and acid mine drainage".
- Reverse osmosis is the "pressure-driven separation of contaminants through a semi-permeable membrane that allows water to pass through while retaining contaminants" and "is a proven method to demineralize acid mine drainage"; RO can be used to remove "metals, total dissolved solids and solids" from mine affected water
- Anglo American's Metallurgical Coal Business has recently begun operation of a reverse osmosis water treatment plant at its Aquila Metallurgical Coal project with the aim of reducing its freshwater consumption.

Impact:

- Part of Anglo's global Sustainable Mining Plan involves the reduction of Anglo's fresh water consumption by 50% by 2030.
- RO treatment produces high quality water that can be reused for operational use, or drinking water
- The water treatment system is currently treating two megalitres of mine affected water a day

Impact areas:



Communities



Water

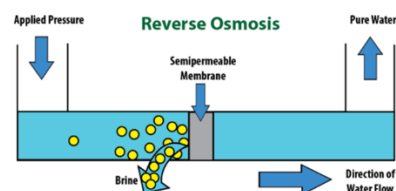


Figure 11: Diagram of Simplified Reverse Osmosis process

Beneficiation of mine affected water: recycling and reusage for mine operations

Rio Tinto, Argyle Diamond Mine Western Australia

Project description:

- Argyle Mine set a target to reduce its water usage from Lake Argyle in its operations to zero. The main concerns with water included:
 - limited supply,
 - negative impact on groundwater
- Main usage of water is at the processing plant, in place of discharging the water to the environment, the water is recycled
- How was this achieved?
 - Recycling and reusing water used by the processing plant
 - "capturing seepage from tailings which get recycled"
 - Dewatering of the surface pit operations and underground mines are also collected and stored in two dams for drinking and operational use

Envisaged impact:

In 2005, Argyle Diamond mine used more than 3 500 megalitres of water from the lake for mine operations. By 2009, they managed to reduce their lake water consumption to 300 megalitres- 95% drop (see graph)

Impact Areas:



Water

Lake Argyle water consumption

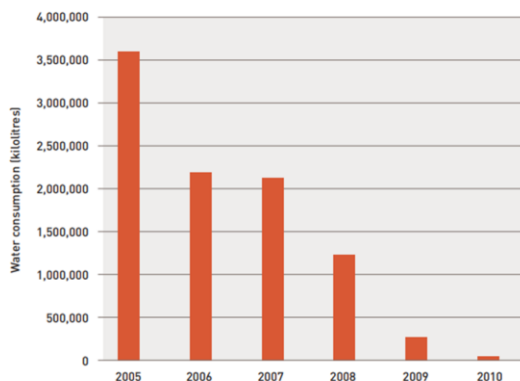


Figure 12: Record of Argyle Mine's Lake Argyle water consumption from 2005-2010

Source: International Council on Mining and Metals (2012)

Solutions in action: Anglo American, eMalahleni Water Reclamation Plant

The World Coal Association's Leadership and Excellence Awards, which were presented at the Worldwide Coal and Climate Summit, have awarded Anglo American's eMalahleni Water Reclamation Plant, an international honour (Anglo American, 2013).

The award recognises exceptional accomplishment and innovation in the international coal industry and its value chain (Anglo American, 2013). The eMalahleni plant, won the award for excellent conduct with regards to reducing environmental impacts of coal (Anglo American, 2013). "The eMalahleni Water Reclamation Plant is a shining example of how an environmental liability – mine water – can be transformed into an asset with extensive benefits for the local community, the

environment and our own operations,” said CEO (previous) of Anglo American’s thermal coal business, Godfrey Gomwe (Anglo American, 2013).

The eMalahleni Water Reclamation Plant is possible through the process of reverse osmosis, using reactors and clarifiers to desalinate and neutralise mine water and produce millions of tons of potable water per day. This process has enabled Anglo American to provide the surrounding community with clean water. The benefits of this project didn’t stop at creating community water stability, but Anglo American went a step further and found an innovative way to utilise two of the by-products of reverse osmosis, brine and gypsum – which were converted into bricks, enabling the construction of hundreds of employee homes. Another community benefit as a result of this initiative is the creation of 700 temporary jobs and 57 permanent jobs (Anglo American, 2017). “This partnership demonstrates what can be achieved when government and the private sector work together,” Gomwe said (Anglo American, 2013).

“eMalahleni has been identified as a growth node for the region, and we are strategically positioned to provide the area with access to a clean and reliable source of water. Water is directly related to growth and development and without it neither industry nor communities can grow,” says the company’s head of safety and sustainable development, Philip Fourie (Anglo American, 2013).

Solutions in action: Landau Colliery Kromdraai Opencast – Crop irrigation using lime-treated acid mine drainage

Landau Colliery Kromdraai Opencast Section, located in Witbank Mpumalanga, has recently gone through a field screening trial of 20 agronomic and pasture crops, including maize, soybean, rye, wheat, lucerne, and kikuyu testing the possibility of irrigating these crops using lime-treated MIW on a sandy acidic soil. The results were very successful, illustrating that a massive yield increase occurs on crops that are irrigated with lime-treated MIW, as opposed to normal rain-fed crops (Jovanovic, Barnard, Rethman & Annandale, 1998) in (Grewar, 2018). The revolutionary results produced in this study, could potentially mean such vast opportunities for the mining industry (Grewar, 2018).

Solutions in action: Anglo American’s FutureSmart™ Mining Programme

The FutureSmart™ Mining programme at Anglo American was implemented with the objective of introducing step-change innovations into the mining sector to work towards creating a mining environment that is integrated, uses automation, is carbon neutral and uses far less water (Anglo American, 2022).

Through technologies and digitalisation, Anglo American envisages four concepts for the future of mining: Concentrating the Mine, the Water-less Mine, the Modern Mine, and the Intelligent Mine (Anglo American, 2022).

The Water-Less Mine concept is working towards reducing dependence on water and associated tailings facilities. Anglo American acknowledge that they will always need water but they plan to get closer to full recovery recycling. This will be achieved through the use of an integrated system of technologies, such as: Coarse Particle Recovery, Novel Leaching and Hydraulic Dry Stack. This programme will reduce fresh water usage and initiate the move to a closed loop system and ultimately dry-processing in their operations, thereby eliminating the need for wet tailings and instead creating stable, dry, economically viable land (Anglo American, 2022).

Managing air pollution through reducing exposure to waste

It is essential that mine closure is undertaken effectively with concurrent rehabilitation of dust and particle sources. This will require coordination and alignment from different government departments to ensure effective regulation and enforcement.

Air pollution needs to be addressed through a coordinated regulatory response that placed primacy on reduction of particle matter in the atmosphere. This can only be achieved through promoting the reduction of atmospheric exposure to waste, ensuring efficiency in operations, and regenerating and repurposing degraded land as a priority. This requires future thinking in planning in developing closure plans and ensuring ongoing rehabilitation.

Using drone technology to map air quality

qAIRA, Peru

Project description:

qAIRa makes use of big data analytics and robotics to digitize and map air quality information on global map

This is done using drones that fly over large areas and at high altitudes to gather data on air quality allowing them to create a global contamination map

Envisaged impact:

qAIRa's technology has developed a mechanism to monitor the impact of a company's operations on air quality, thereby being able to their environmental footprint



Impact areas:



Air



Communities



Figure 37: qAIRa drone technology

Source: World Intellectual Property Organization (ND)

Solutions in action: Sibanye-Stillwater's commitment to tailings management

Sibanye-Stillwater has pursued a variety of different programs to enhance their approach and their management processes with regards to tailings management, in order to align themselves with the new Global Industry Standard on Tailings Management (GISTM) (Sibanye-Stillwater, 2020). The company currently has 35 tailings storage facilities in South Africa, all of which are under strict management and committed to continual improvement to ensure the safe and environmentally responsible management of tailings (Sibanye-Stillwater, 2020).

Sibanye-Stillwater has recently embarked on a new initiative to improve their capabilities especially related to effective tailings management. This initiative was the purchase of 50.1% shareholding in DRDGOLD, a world leader in retreating surface gold tailings. This partnership will allow Sibanye-Stillwater to acquire knowledge and gain experience from DRDGOLD's proven capabilities in the area of managing tailings (Sibanye-Stillwater, 2020).

In particular, Sibanye-Stillwater will benefit from learning more about:

- How to manage and execute the implementation of any new infrastructure development that is needed, with regards to tailings management (Sibanye-Stillwater, 2020).
- How to optimise innovative and technology driven processing (Sibanye-Stillwater, 2020).

Solutions in action: Implats, increasing their use of technology to monitor tailings dams

Implats believe that increasing their use of innovative technology will help them better manage their tailings facilities (Implats, 2022). They are particularly focused on increasing their amount of drone usage, to monitor environmental controls and keep accurate records of these inspections – through photographs and videos (Implats, 2022).

At Impala Rustenburg they regularly conduct monitoring (CCTV) inspections and volumetric surveys via drones (Implats, 2022). There are a variety of advantages that come with the use of drone inspections as opposed to visual helicopter flights. These advantages include:

- Lowering operating costs (Implats, 2022).
- Higher resolution images (Implats, 2022).
- Lower labour intensity (Implats, 2022).
- Measurements can now be taken in areas that were previously restricted (Implats, 2022).
- Faster volume calculation (Implats, 2022).
- Thermal imaging is possible (Implats, 2022).
- Drone imaging can be carried out at any given time, which allows a more live monitoring (Implats, 2022).

Solutions in action: Impala Rustenburg is implementing an air quality offset programme

Impala Rustenburg discovered certain offset opportunities in the vicinity of their Rustenburg facility as part of an impact evaluation report, governed by the Air Quality Offsets Guideline and the Waterberg-Bojanala Priority Area Air Quality Management Plan (Implats, 2022).

This plan will involve constructing sports facilities and enhancing existing schools' structures and grounds. In addition to enhancing the general air quality in the vicinity of the mines, these projects are a part of Implats' larger socioeconomic development initiative in collaboration with the Royal Bafokeng Nation. The concentrations of PM10 and PM2.5, as well as the amounts of dust fall, in and near the project areas, are anticipated to improve over the long term as a result of these efforts (Implats, 2022).

An expansion and continuation of Impala's collection of non-hazardous domestic waste from Bafokeng communities and delivery to their landfill site, is also included in this initiative. This will result in better air quality as there will be less informal burning of waste and so less pollutants released into the air. This initiative will be underpinned by air quality education campaigns in surrounding areas and schools (Implats, 2022).

The effectiveness of these initiatives will be determined through the use of Impala's monitoring network. This will help them understand where additional interventions are needed. Once the monitoring process collects sufficient amounts of data, Impala will then be able to set more concrete offset targets (Implats, 2022).

Energy supply and efficiency transition to alternative sustainable solutions

- As technologies and solutions emerge and can demonstrate commercial viability, the incentive for adoption becomes increasingly clear. Solutions will however need to consider:
 - Conduciveness of mine area to generate alternative energies.
 - Commercial viability of new technologies and solutions.
 - Potential for advancing community and economic benefit through pursuance of new technologies and solutions.
 - Life of mine appropriateness for further investment.
 - Ability to sell on energy to the municipal grid.

Shifting to alternative sources of energy: hydrogen

Anglo American, Mogalakwena PGM mine, South Africa- Hydrogen powered truck

Project description:

Anglo America has recently unveiled the world's biggest hydrogen truck which aim to replace their ultra class haul trucks, which usually consumes around 3 500 liters of diesel per day

'Green' hydrogen is generally produced by splitting water into hydrogen and oxygen in electrolyzers that use platinum catalysts; and is produced by the mine site.

Envisaged impact:

By converting these trucks to a hydrogen power source, Anglo will reduce 80% of its emissions associated with diesel on each mine site

Impact areas:



Energy Communities



Figure 30: Anglo American's Hydrogen Powered truck

Shifting to alternative sources of energy: Biomass

Uhuru Green Energy- Green energy supplier and solution provider located in Johannesburg South Africa

Project description:

Uhuru Green Energy specializes in developing integrated renewable energy solutions assisting clients decarbonize their business operations. One key component of Uhuru's solutions involve the conversion of biomass to energy resulting in the production of forms of Renewable Energy such as:

- BioFuels (for generating electricity and green diesel):
 - BioGas
 - BioMethane
 - BioSynGas
 - BioCrude
- Green hydrogen/BioHydrogen which can act as fuel source for mining vehicles.

The source of Uhuru's Biomass feedstock comes from energy crops and agricultural waste. Alternative sources for biomass include animal waste, sewage, industrial and municipal waste

The development process of Uhuru's biomass-to-energy involves the growing, processing of biomass and production of forms of R.E

Envisaged impact:

- Decarbonization of mining operations: reduced greenhouse gas emissions
- Reduction in air and water pollution

Impact areas:



Energy Communities



UHURU ENERGY



Figure 31: Uhuru Energy's Biomass Feedstock

Source: Arnoldi (2021); Uhuru Green Energy (2022); Zafar (2021)

Shifting to alternative sources of energy: Solar Power

Gold Field-South Deep Mine, South Africa

Project description:

Gold Field is constructing a solar plant of with a capacity of 40MW at the South Deep Mine, with a potential to expand to 70MW. The power plant will consist of 116 000 panels, occupying an area equivalent to roughly 200 soccer fields.

Envisaged impact:

- The 40MW solar plant is expected to generate 20% of the mine's average electricity consumption
- Carbon footprint is expected to reduce by 100 000 tonnes of CO₂ a year
- Mitigatedisruption from load shedding
- While the expected cost of the solar plant is R660 million, Gold Fields expects to save approximately R120 million a year on electricity cost

Impact areas:



Energy Communities



Figure 32: Gold Fields' Solar Plant

Source: Gold Fields (2021); Phillips (2021)

Shifting to alternative sources of energy: Solar and wind power

Pilanesburg Platinum Mine, Sedibelo Resources Limited

Project description:

Pilanesburg Platinum Mine (PPM) appointed Sturdee Energy and Juwi South Africa-companies focused on renewable energy projects- to supply renewable energy to the mine. A memorandum of understanding has been signed by the various parties and negotiations towards a Power Purchase Agreement have started.

One part of the project is to purchase a combination of "solar PV and wind systems to power the 40MW mine load". A project that is expected to "supply 55-60% of the mine's energy needs" and is set to commence in 2024

Envisaged impact:

- The project is expected to:
- Reduce Pilanesburg Mine's carbon emissions by approximately 45%.
 - Reduce pressure and reliance on Eskom's grid.
 - Result in significant savings.

Impact areas:



Energy Communities



Figure 33: Solar PV and Wind System for Pilanesburg Platinum Mine

Conversion to electric vehicles

Epiroc- Electrification of underground mining

Project description:

The wide-scale adoption of electric vehicles has significant potential to decrease carbon emissions in the mining industry. Electric vehicles make use of electricity to charge their batteries, as opposed to the traditional use of fossil fuels such as diesel or petrol which release harmful gases to the environment.

The cost of electricity to charge these electric vehicles can further be reduced through installations of renewable energy sources.

Epiroc is a Swedish manufacturer of infrastructure and mining equipment with a global footprint that provides innovative sustainable solutions in a range of sectors. Epiroc is taking charge towards the electrification of underground mining and is developing solutions for sustainable mining through "battery-electric zero-emissions equipment".

Impact:

- Reduced carbon footprint due to significant decrease of tailpipe emissions
- Improved air quality
- Reduced cost of ventilation underground which is normally associated with the use of diesel thereby lowering operational costs

Impact areas:



Energy



Communities



Air



Figure 34: Electric mining vehicle built by Epiroc



Figure 35: Epiroc Charging product

Source: Engineering and Mining Journal (2020); Epiroc (2019); Epiroc (2022)

Solutions in action: Anglo American, partners with EDF Renewables to secure 100% renewable energy supply for South African operations

Anglo American has partnered with EDF Renewables, a global leader in renewable energy, with the purpose in mind of creating a South African, regional renewable energy ecosystem ("RREE"). Once this development is completed, hopefully by 2030, Anglo American will be able to run their operations on 100% renewable electricity (Anglo American, 2022). This initiative will benefit Anglo American, strengthen of the local electricity supply and assist on the journey towards decarbonising the energy of this country (Anglo American, 2022).

Anglo American already has 100% of its South American operations working off of renewable electricity supply. Anglo American is expecting 56% of their global grid supply to be sourced from renewables by 2023. South Africa has an abundance of renewable energy sources such as wind and solar, but there is currently limited renewables infrastructure to harness it. Currently, Anglo American's single largest source of Scope 2 emissions is generated from its grid in South Africa. This will be largely reduced by the EDR partnership, and assist Anglo American on their journey towards their 2040 carbon neutral target. The RREE aims to support South Africa's decarbonisation ambitions and the country's Just Energy Transition, creating a sustainable and inclusive future (Anglo American, 2022).

The partnership is expected to bring a host of benefits to South Africa and the region, including:

- Implementing 3-5 GW of renewable electricity (solar and wind) and storage over the next decade. This will increase total grid supply resilience (Anglo American, 2022);
- Supporting the decarbonisation initiatives of governments across Southern Africa (Anglo American, 2022); and
- Stimulating the development of new economic sectors, local production and supply chains (Anglo American, 2022).

Solutions in action: World's biggest hydrogen truck starts work at Anglo American

Anglo American recently introduced the world's biggest green-hydrogen powered truck at a platinum mine in northeast South Africa. This initiative was introduced with the aim of replacing a fleet of 40 diesel-fuelled vehicles each of which use about a million litres of the fossil fuel every year (BusinessTech, 2022).

The NuGen project at the Mogalakwena mine, owned by Anglo American subsidiary Anglo-American Platinum Ltd., will use power from a solar plant to supply a hydrogen electrolyzer to split water and provide the trucks, which can carry up 315 tons of ore each, with hydrogen fuel (BusinessTech, 2022).

The project, which is expected to be fully implemented by 2026, "is a first step in making eight of the company's mines carbon neutral by 2030", says Julian Soles, Head of Technology Development, Mining & Sustainability at Anglo American (BusinessTech, 2022).

Solutions in action: Anglo American Completes first biofuel trial to reduce shipping emissions

Anglo American used biofuel mixed with very low sulphur fuel oil (VLSFO) in a sea trial with the aim of cutting carbon emissions and managed to successfully decrease emissions by about 10%. The trial also illustrates the possibility that sustainable biofuel could be used as a 'drop-in' fuel – renewable fuels which can be blended with petroleum products – improving the chances that it is able to help reduce emissions in the shipping sector (Henning, 2022).

'Connecting our customers with the metals and minerals they need in a way that is safe, efficient and sustainable is a key priority for us.' said Peter Whitcutt, CEO of Anglo American's Marketing business. 'Last year, we outlined our ambition for carbon-neutral controlled ocean freight – a natural extension of our commitment to decarbonising our mining operations by 2040' (Henning, 2022).

This is Anglo American's second biofuel marine trial. The first trial, conducted in June 2021, used a biodiesel blend produced by converting waste cooking oil from Singapore's food and beverage industry and reduced carbon emissions by around 5% (Henning, 2022).

Solutions in action: Anglo American's FutureSmart Mining™ Programme

As discussed in a previous FutureSmart Mining™ Programme example, Anglo American envisages four concepts for the future of mining: Concentrating the Mine, the Water-less Mine, the Modern Mine, and the Intelligent Mine (Anglo American, 2022).

Concentrating the Mine, will have a very direct impact on energy. This programme is working on increasing precision in mining, with minimal energy, water and capital intensity. This will be achieved by utilising technologies that more precisely target the desired metals or minerals, delivering greater than 30% reductions in the use of water, energy and capital intensity, and producing less waste in the process, in line with Anglo American's overall trajectory towards carbon neutral mining. This includes coarse particle recovery, bulk sorting and ultrafine recovery (Anglo American, 2022).

Solutions in action: Exxaro – The Cennergi Project

The Exxaro Climate Change Response Strategy is dedicated to ensuring that they assist in the development of the low-carbon environment of the future (Exxaro, 2022).

One of the initiatives put in place to achieve this response strategy is the formation of Cennergi. Cennergi is a renewable energy subsidiary that runs wind farms in the Eastern Cape and is also developing a Solar Project to supply renewable energy to the Grooteegeluk Complex in Limpopo (Exxaro, 2022).

The transition at Exxaro, towards a low carbon environment is built on the "Just Transition" principle, which seeks to balance business financial performance, economic development, environmental considerations and the ability of society to adapt to changing climate (Exxaro, 2022).

Ensuring sustainable access to economic opportunities for mine affected communities

Here are some possible considerations to enhance community beneficiation:

- Asset Based Community Development valuing the assets offered by communities from knowledge, culture, skills, resources, relationships etc.
- Emic understanding of community lived experienced.
- Participation and interaction going beyond check-box exercises to enable meaningful interaction and inputs that are taken into account.
- Qualitative understanding taking primacy in building contextual understanding and driving participation.
- Entrenched knowledge in communities to inform rehabilitation and management that compliments scientific approach.

Solutions in action: Bauba Resources – Committed to caring for the community

The development of community relations is an integral part of Bauba's stakeholder engagement plan. Bauba chooses to invest in projects that allow the whole community to benefit and not just certain individuals. To ensure that these sustainability projects are built on strong community relations, Bauba promotes open dialogue with community members and facilitates this through the selection of community-based liaison officers who keep all community members well informed about all of the activities at Bauba (Bauba Integrated Annual Report, 2021).

Two highlights from Bauba's community lead initiatives include the following:

1. The provision of a stable water supply to surrounding communities, this was achieved through Bauba's borehole project which sunk and equipped 12 boreholes (Bauba Integrated Annual Report, 2021).
2. Bauba is also committed to the creation of a greener and cleaner environment for individuals in the surrounding communities. For this cause Bauba has planted a variety of indigenous trees, firstly to act as an environmental awareness campaign, and secondly to control dust and noise levels in the community (Bauba Integrated Annual Report, 2021).

Solutions in action: Implats – Commitment to the community

Implats is a South African holding company, a leading producer of platinum, platinum group metals as well as nickel, copper and cobalt (Implats, 2022), who is committed to growing and uplifting the community in which they operate (Implats, 2022).

Some examples of Implats community development include the following:

- Implats has recently renovated Qumbu Public library in the Eastern Cape (Implats, 2022).
- Implats has created the Marula school project. This project was initiated with the purpose in mind of reducing overcrowding in classrooms. This project recently built more classroom blocks at four local schools: Manyaka and Ntoshang Primary schools and Mosedi and Dihlabakela Secondary schools (Implats, 2022).
- Impala Rustenberg has also recently collaborated with Royal Bafokeng to support the Metshameko Programme, which is a one year sports, skills development initiative (Implats, 2022).

Solutions in action: Anglo American – Educational development programmes

Part of the Anglo American responsibility is to develop projects that create long-term benefit for the communities where mining operations exist. This is an example of why the development of prosperous communities is one of the three pillars in their Sustainable Mining Plan approach. These pillars all consist of different stretch goals to 2030 in the areas of health, education and enterprise development (Anglo American, 2019).

Under the pillars mentioned above, Anglo American is committed to creating long term jobs by ensuring that the community receive proper education and promoting the participation of the youth in various development programmes to ensure that they are equipped with the right skills to become successful (Anglo American, 2019). To this end, Anglo American has introduced the South Africa Education Programme, a partnership with the Department of Basic Education. This programme targets 100 early childhood-development sites and 100 schools, which are close to the mine site. Its aim is to address a number of underlying problems that exists in the education system in order to improve reading, writing and numeracy skills of South African students. The programme proposes to do this by supporting school management teams, governing bodies, principals and teaching staff. (Anglo American, 2019).

Solutions in action: Anglo American – The Musina Water Supply Project

Musina, the local community surrounding one of De Beers Group's Venetia mine in South Africa has been experiencing a variety of water challenges due to issues such as increased need for water, reduced supply, and ageing infrastructure (Anglo American, 2020). Anglo American has subsequently embarked on the Musina Water Supply Project to upgrade the water supply of the Musina Local Municipality. 2019 was the start of Anglo American's Phase One of the Musina Water Supply Project - with the support of the Musina Local Municipality (Anglo American, 2020). The project work included drilling of eight extra boreholes and the installation of related piping and infrastructure that was needed to connect the new boreholes to the main Municipality feed (Anglo American, 2020).

Legislative Framework and Implementation

- Government should undertake efforts (collaboratively where feasible) to enhance their capability on the delivery of public goods and provide services to mines and communities. This will avoid the situation of mines having to play a pseudo-government role in basic service provision to mining communities.
- The municipal government should be capacitated to drive economic diversification. This should be performed from a localised contextual understanding that is informed by national strategic objectives. It should also be an approach that builds off of efforts on the ground to drive economic and social inclusion.
- Draft mine closure legislation is well intended but requires a regional approach to consolidation and closure and a 'conductor of the orchestra' to drive action and ensure compliance – it can't be the responsibility of a single mine.

Learning from international examples

The challenges faced in South Africa's mining sector do not occur in isolation, and while the South Africa's socio-economic context is unique there are valuable lessons that can be derived from approaches adopted outside of South Africa. We have included some compelling cases below that have applicability to the South African mining sector.

qAIRa, a Peruvian start-up tackling air pollution

Air pollution is a huge environmental concern, on a global scale. It has terrible effects on human health, causing millions of deaths per year. Deaths caused from air pollution are experienced world-wide, but our most prevalent in middle income countries like Peru (WIPO, n.d.).

qAIRa was started in 2015, by research students from Peru's Pontifical Catholic University, with the main aim of dealing with the air pollution problem in Peru, including that caused by the mining industry (WIPO, n.d.).

How qAIRa works:

- qAIRa works by mapping out air quality, on global maps, with the use of big data analytics, robotics and digitize (WIPO, n.d.).
- Its utilises drone technology to survey vast areas, at high altitudes, gathering data on the air quality. Once this data is collected, a contamination map can be created allowing mining companies to better monitor and control their environmental impact (WIPO, n.d.).
- qAIRa has also implemented low-cost static air quality modules, which are able to track pollution in urban areas (WIPO, n.d.).

qAIRa has sparked great interest in the mining industry in Peru, as a successful way of tracking air quality and being able to adjust their operations accordingly to ensure minimal environmental impacts. The technology at qAIRa can also be relevant to other sectors that are dealing with air pollution challenges. These other sectors include; oil, gas, agriculture, electricity and many others (WIPO, n.d.).

Anglo American: Photovoltaic plant built over mining tailings (first in the world)

The project, at Las Tortolas pond at the Los Bronces copper mine in Chile, is made up of of 256 solar panels with a combined output of 86 kW (330 watts each). This project has been set up over a floating island that is connected to a service room that is able to monitor how much energy is produced each day. This initiative will be successful in reducing CO2 emissions, generating renewable electric power and reducing water evaporation over the area is covers (Anglo American, 2019).

At the launch event, Chilean Mining Minister, Baldo Prokurica emphasised that "mining has diverse challenges regarding many areas and one of them is caring for the environment. This type of initiative positions Chile at the global forefront of mining innovation for a sustainable industry – an excellent idea for mining traceability and for the efficient use of water" (Anglo American, 2019).

By reducing water evaporation from Las Tortolas' surface, this endeavor will enhance the amount of water that is available for recirculation during the mining operation. Currently, between 70 and 80 percent of Los Bronces' process water is recirculated (Anglo American, 2019).

"This initiative reinforces Anglo American's commitment to develop new mining practices that adapts and connects with the interests of neighbouring communities and that has made innovation a fundamental axis of its activity. We believe that it should be a priority to re-imagine mining, challenging the way things have always been done. By actively developing new solutions and

stimulating new ways of thinking and working, we move towards increasingly sustainable mining,” explained Patricio Chacana, Los Bronces Operations Vice-President (Anglo American, 2019).

Old coal mines in Glasgow to host geothermal research lab

The Glasgow Geothermal Energy Research Field Site, an approximately \$11.7 million project which was initiated by the Natural Environment Research Council and the British Geological Survey, has been approved for building by Glasgow City Council and South Lanarkshire Council in Scotland (Leotaud, 2018).

The eastern side of Scotland’s largest city, where various coal mines historically worked, will be the location for the new research hub. The main mission for this new initiative is to work on understanding if carbon mines can generate harnessable low-carbon heat which can be used in domestic settings (Leotaud, 2018).

Scientists working at the research hub need to investigate temperature, water flow and seismic activity in mine tunnels that are currently not in use. This will be conducted using “state-of-the-art sensors,” and will measure the temperature, water flow and seismic activity in the disused mine tunnels. The data collected from these activities will be stored in an open-access data base, that scientists will analysis to find out if renewable heat can be produced from warm water (Leotaud, 2018).

It is anticipated that investigation will last for at least 15 years (Leotaud, 2018). Scotland has pledged to reduce emissions by 80% by 2050, and this project is a part of Scotland's attempts to transition to a low carbon economy (Leotaud, 2018).

Salina Turda



When Salina Turda, an old salt mine in Transylvania western Romania, opened to the public in 1992, it represented the first significant attempt to transform a closed mine into a unique tourist destination. Guests travel the 120 meters underground, using the old elevator shafts, that the workers used to use. Once underground, the guests can explore and utilise the amusement park, miniature golf course, bowling alley and underground

boating lake. Guests can also opt for an exciting spa experience, where the natural salts and 80% humidity in the cave are utilised for spa treatments (Johanson, 2015).

Wales: Bounce below



Bounce Below, is a massive trampoline with multiple levels, lighted in Technicolor and hanging within a Victorian era slate mine in Gwynedd, Wales. It is essentially made using the method of combining an abandoned cavern, 930 square meters of bounce nets and the well-known childhood game Shutes and Ladders. Bounce Below is known as the world's largest underground trampoline. The different

net levels are all connected with ramps and slides, and the walls are covered in mesh to ensure the safety of the guests (Johanson, 2015).

CGG Paris launches TailingsPulse Monitoring

TailingsPulse is a multi-method monitoring system that provides you with actionable intelligence for the duration of your mine, building on the popular MineScope™ Earth observation intelligence service and merging CGG's top multi-physics, instrumentation, and real-time measurement capabilities (CGG, n.d.).

TailingsPulse has the following functions:

- Ability to provide expert provision, processing and analysis of Earth observation data for remote, wide area monitoring of surface characteristics and TSF behaviour (CGG, n.d.).
- Ability to create comprehensive 3D multi-physics imaging for subsurface attributes related to structure, seepage and ground water contamination (CGG, n.d.).
- Ability to enhance monitoring capabilities, through utilising Sercel S-scan passive seismic technologies (CGG, n.d.).
 - Ability to predict and warn against possible hazards within the tailings storage facility, this is possible through the use of real-time measurements of strain and temperature (CGG, n.d.).

Towards a future outlook for the mining ecosystem in South Africa

In collaboration with stakeholders a high-level future view of the mining ecosystem was defined. This future view is intended to provide an ideal state of the South African mining ecosystem which as stakeholders are working towards.



Land

A natural and built environment that is concurrently rehabilitated during mining operations and able to **sustain life and economic opportunities beyond mine closure.**



Energy

A **just transition** towards reliance on a mix of sustainable and reliable cost-effective energy and effective energy management that reduces the need for excess energy and provides economic inclusion opportunities for communities.



Water

Effective water stewardship practices entrenched in mining operations that beneficiates water resources and reduces negative impact on shared water sources and ensures safe access to water for downstream users.



Air pollution

Effective management of waste and exposure to hazardous toxins at risk of contributing to air pollution in line with a comprehensive closure strategy.



Communities

Well informed and engaged communities that are skilled and able to **benefit from growth** in the mining sector and emergence of diversified economic opportunities beyond mining, while ensuring access to public and social goods



Legislative framework and implementation

A well **defined policy and legislative framework** that enables mines to seamlessly operate throughout the mine life-cycle while upholding the interests of communities, the economy, and the natural environment and resources that are impacted

A **collaborative and productive working relationship** between government and all stakeholders in the mining industry that strengthens governments capacity at the national, provincial and local government levels to support growth in the mining sector while protecting the interests of communities, the economy, and the natural environment and resources affected by mining.



. A **well coordinated regional approach** to ongoing mine operations and beyond with mine houses as the **driver of sustainable circular economies** that utilise existing assets to increase the longevity of mines, while impacting the environment,, society, and post mining economies positively.

In order to make meaningful strides towards this future state, a number of key action items have been identified:

- Meaningful planning and conceptualisation for mine closure and post mining economic diversification from necessary from initial planning phases of mine life cycle while allowing for adaptation over time to meet contextual need at closure.
- Continual monitoring and adjustment to strategy and financial provisioning to meet post closure needs.
- Concurrent rehabilitation and future state management to avoid unnecessary accumulation and spiraling of rehabilitation costs.
- Consultation with all relevant stakeholders during mine closure process from the outset and collaboratively developed strategy for future land use.
- Ensuring that communities are educated on their rights and responsibilities from mining application stage.

- Capacitation of relevant skills and expertise to effectively plan, manage and execute closure both within the DMRE and mining houses themselves (socio-economic development thinking and sustainability framework implementation).
- Shift in industry and regulator thinking of cradle to grave in favour of a cradle to cradle and beyond understanding.
- Promotion of circular economies that are driven by, and mutually beneficial to, mining operations.
- Improved cooperation and accountability between different government departments and various pieces of legislation.
- Improved cooperation and coordination between mine houses themselves and other stakeholders towards a regional approach.

CONCLUSIONS

The objectives of this milestone were to provide a brief summary of the findings outlined in the Final Synthesis report and explore solution areas to be fully developed in Phase 2 of this assignment. This report provides a solid basis for the commencement of activities in our next Phase.

RECOMMENDATIONS

Following the successful completion of this milestone, RIIS will turn to Phase 2 of this assignment and begin to define the solution space.

WAY FORWARD

Building off the work conducted in Phase 1 to define the problem space, RIIS intends to support the Longevity of Current Mines programme to implement Phase two of the future sustainable mining project. The delivery of Phase 2 has been conceptualised through five interdependent work packages. The deliverables are illustrated in **Figure 3**.

WP1 - Inception: The Inception Work Package is intended to establish a Community of Practice (CoP) of interested stakeholders from academia, NGOs, the Public Sector, and the mining industry that will be consulted for input throughout various points of project delivery. During this package RIIS will also coordinate and develop a partnership agreement with the University of Pretoria Enterprise team as well as mobilise our internal resources for project kick-off.

WP2 - Solutioning: During the Solutioning Work Package we will define and prioritise solution areas and interventions for development and validate these with the CoP.

WP3 - Design: During the Design Work Package we will identify implementation partners and co-design high potential interventions which will be verified and refined through the CoP.

WP4 - Implementation planning: During the Implementation Planning Work Package we will develop an implementation road map and plan, with timelines, roles and responsibilities, governance structures, and a Monitoring and Evaluation framework

WP5 - Next phase preparation: The final Work Package will focus on planning and preparation for the implementation phase and RIIS will support the MMP in securing funding for interventions and building stakeholder buy-in through a series of road shows.

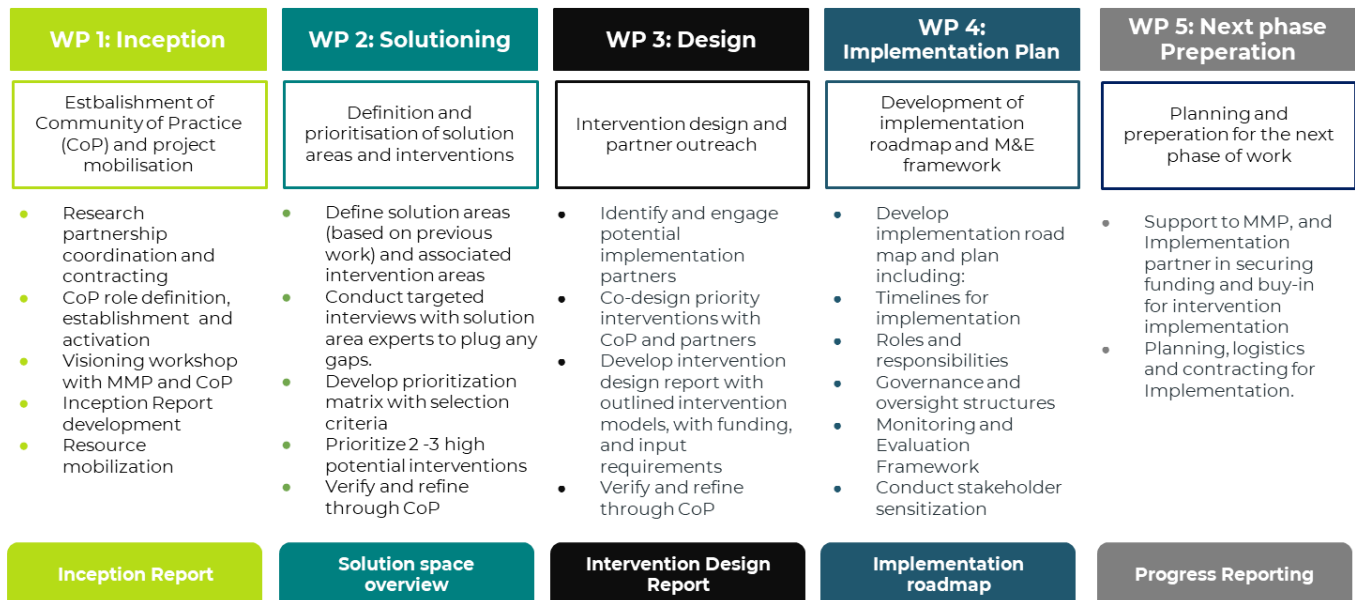


Figure 3: Phase 2 Deliverables