

## EXECUTIVE SUMMARY

**The mining industry has played a major role in the development of South Africa and has the capacity to do so for many more years.** It has had such an influence, that the urbanisation pattern of South Africa is largely influenced by the occurrence, exploitation and beneficiation of minerals. The mining industry is also the largest producer of solid waste<sup>1</sup> in the country and a major contributor to water quality degradation in many of South Africa's important catchments. The mining industry is also a large consumer of water in some of the stressed and drier catchments in South Africa and is a large consumer of electrical power.

**The survival of the industry depends on the effectiveness with which it deals with its impacts.** The social acceptability of the impacts must be sufficient for the community in which it operates to endorse and encourage its presence otherwise regulators and politicians will not support existing or new mining projects. In a number of areas where there is competition for resources such as power or water the viability of projects also depends on the ability of the mining companies to do more with less. Profitability of many mining projects can be significantly enhanced by having better resource utilisation and by minimising long term impacts, thus reducing financial liability. The effectiveness with which this is done can mean the difference between having a mining project or not. One way of doing so is to implement waste minimisation and Cleaner Production (CP) technologies.

CP is a general term that describes a preventative environmental approach, aimed at increasing resource efficiency and reducing the generation of waste at source, rather than addressing and mitigating just the symptoms by technically treating an existing waste or pollution problem.

It is generally accepted that the best long-term solution to waste management issues is to minimise waste generation at source. The mining industry is unique in that, apart from a few special cases, it is not possible to do so for the bulk of the waste produced. The **focus** for interventions rather thus shifts to the industry being required to **minimise the impacts from the waste**. Also the secondary impacts of water abstraction, water quality deterioration, effect of power usage and on land use changes needs to be dealt with in a proactive manner.

Another unique aspect of the industry is that the impacts from mines can continue to affect communities and biota for millennia after closure of these facilities from impacts such as subsidence and Acid Rock Drainage (ARD).

An analysis of the Water Research Commission's (WRC) past and present project portfolio indicates that most of the research effort to address water and waste management in the mining industry has been devoted to minimising the impact of waste on the environment and to improve the ability to predict and quantify effects as well as to develop technologies to treat polluted waters. Unlike other industrial sectors, **no projects devoted specifically to waste minimisation and CP technologies have previously been undertaken**. Although the mining industry has launched various sustainability-related initiatives such as the *Mining, Minerals and Sustainable Development* (MMSD) project, there is significant scope within the industry as a whole for greater implementation of CP practices. To address this need **the WRC solicited this project aimed at introducing CP to the South African mining industry** and entrenching CP concepts where these are already being practiced.

### Project aims and objectives

The overall objective of the project was to introduce CP technologies in the mining industry. The following tools suggested by the WRC to achieve these objectives were to be evaluated during the course of the project:

1. Conduct a scoping level situation analysis of the mining industry that identifies the present level of CP activities and awareness, both locally and internationally;

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<sup>1</sup> The largest volume is in the form of tailings material.

2. Identify existing water-related threats that could be alleviated by CP technologies and thus represent opportunities to facilitate the introduction of CP approaches in the South African mining industry;
3. Introduce the concept of Waste Minimisation Clubs (WMCs), evaluate their suitability and establish similar appropriate mechanisms and pilot clubs in the mining industry (WMCs could be used as vehicles for the training of practitioners in the mining industry in CP technologies and the implementation of CP programmes on participating mines);
4. Conduct focused high level Life Cycle Analysis (LCA) studies at an overall impact level, to determine priority areas for introducing the CP approach, acquaint service providers and industry with the technique and identify areas for the focus of WMCs;
5. Launch a campaign to raise the awareness of the mining industry concerning the benefits and need for adopting CP approaches and the possible methodologies and processes for doing so; and
6. Ensure the future viability and sustainability of initiatives to introduce CP approaches to the mining industry.

In order to address these aims, multi-faceted initiatives were undertaken to raise the awareness in the mining industry of the benefits of, and need for, adopting CP approaches.

The optimal use of resources such as water and energy does not just make a mining operation more viable but could mean the difference between a project being able to operate at all and generating benefits and rewards which are able to be shared by investors, the government and the community.

The following initiatives were undertaken:

### ***Scoping study***

This project began with a scoping study with the aim of determining the current status of environmental practices related to CP and to identify areas which need to be focused on to facilitate the industry's move towards more sustainable consumption and production practices. The scoping study also identified areas for conducting specialist studies and for establishing Cleaner Production Forums (CPFs).

The main findings from this study were:

1. The South African mining industry is improving its practices and taking the environmental impacts into consideration in project decisions and for operations;
2. The industry is willing to adopt CP initiatives and realise the benefits of implementing CP technologies;
3. The coal mining industry forum established in the Witbank area operating as the South African Collieries Environmental Practitioners Association (SACEPA) was an ideal place to start detailed studies and a CPF; and
4. Distinct differences in approach were noted between big and small companies. These are:
  - a. With the larger companies, the awareness is being driven mainly by the company's policies and the practices of their competitors;
  - b. Amongst the smaller companies, the awareness is driven by legislation;
  - c. The environmental policies of the larger companies contain CP principles and this was used as a route to encourage cleaner technology in these companies;
  - d. With smaller companies, cleaner technology options can be used to assist with complying with legislation and in reducing costs;
  - e. The larger firms either already have ISO 14001 certification at all operations or are striving towards ISO 14001 certification; and
  - f. The smaller companies were not keen on attaining ISO 14001, mainly due to the lack of capacity and not seeing any benefit in it.

### ***Awareness raising campaign***

This aspect of the project was implemented to improve the understanding of CP principles and techniques for the mining industry and authorities, encourage and promote CP and to ensure the effectiveness of the project. These aims were achieved through the following activities:

1. Seminars held for the mining industry;
2. Training workshops held separately for industry and for the regulators;
3. The CP guide developed for the mining sector was made public and copies provided to all participants at the seminars and to major role players; and
4. Presentations on project findings were made at different forums, seminars and conferences to cover all the stakeholders in the mining industry.

### ***Water related threats study***

A water related threats study was conducted to ensure that the project funds were directed to areas where there is really a need. Threats posed both **by** and **to** the mining industry were investigated.

It was found that water related threats posed **by the mining industry on the water resources** of South Africa are:

1. Potential contamination of surface water by spills from treatment and processing facilities;
2. The use of water in drier parts of the country increasing competition for scarce resources;
3. Long term contamination of runoff from stockpiles, rock dumps and tailings facilities;
4. ARD resulting in potentially acidic and saline leachates from tailings facilities and mine workings; and
5. Partial or total dewatering of aquifers.

### **Water related threats posed to the mining industry are:**

1. Lack of water resources to expand operations in the drier parts of the country and at existing operations;
2. Lack of legislative clarity and service delivery with respect to compulsory licensing and management requirements;
3. Potential for long term treatment costs for decanting mine water, as the option for dilution, does not generally exist in the dry South African interior; and
4. Increasing cost of water.

The introduction and use of CP principles in the South African mining industry are therefore essential to:

- Reduce energy and water consumption and improve efficiency for each unit of product produced to ensure availability of these utilities for current and future projects;
- Reduce long term water management and treatment costs;
- Reduce chances of spills and runoff contaminating surface water resources;
- Comply with water, waste, environmental and mining legislation.

### ***Cleaner Production Guide for the South African Mining Industry***

A guidance document has been compiled to assist those working in and with the mining industry, with a secondary focus on those government departments regulating the mines. The document will assist mining companies in implementing a CP programme, while at the same time, providing the regulators with suggestions on how to promote and encourage the process. It will also assist companies and regulators in identifying where they stand with respect to best practice, where opportunities exist for implementing CP options and where CP technologies have already been implemented.

Consultants to the industry will also benefit from the guidance document as it will provide necessary background information to the sector and suitable CP opportunities and business ideas.

### ***Cleaner Production Forums***

WMCs have been used in other industries and countries to assist with the implementation of waste minimisation and CP. They can be formed with companies in the same area or mining the same commodity who are facing similar environmental and economic problems. The members of these clubs share their experiences and work together to achieve improved understanding and implementation of sustainable production and consumption practices. Researchers and trained professionals provide training and other useful input at these forums.

Following discussions with members of the mining industry, a decision was made to change to terminology from Waste Minimisation Clubs (WMCs) to Cleaner Production Forums (CPF's).

Two CPF's were formed during this project (one for coal mining and one for gold mining). The drive in these forums was to share ideas, fight common battles and share success stories. The member companies of the coal CPF have agreed to continue with this forum. The vehicle for implementation and the driver for the coal CPF was the SACEPA. The members have stated that they will make sure that these CPF's do not die when the project is finished. The CPF's have proved to be a good way of achieving the goals of CP and minimising the impacts of the mining industry.

### ***Graduate and Post Graduate Studies Supported***

As a means of identifying feasible CP opportunities for the coal mining industry and in particular for the CPF, an M.Sc. (Eng) dissertation entitled '*An investigation of Cleaner Production opportunities in the South African coal mining industry*' was produced by Jane Reddick through the University of Cape Town. The study identified numerous feasible CP opportunities to reduce the **amount of slurry, discards and energy wasted** at the three case study collieries. These three areas were considered to be the prime areas where changes could be made. Many of the suggested interventions, if implemented, are expected to reduce the mines' impacts on the quality of water in the region. None of the interventions proposed involved the use of unproven technologies. For the options that require high capital investments (i.e. investments in excess of R1 million), payback times were found to be less than one year, and the 10 year net present values of suggestions ranged between R10 million and R200 million.

Another M.Sc. student started on research which became an honours dissertation project which attempted to quantify the ecological footprint of gold production and its associated supply chain in South Africa, and determine major areas of impact using the LCA method. The study found that:

1. The Ecological Footprint method can be used to provide a comprehensible and relatively meaningful single indicator score for data captured in an LCA;
2. The ecological footprint of the South African gold mining industry is mainly due to its electricity use, with leachate from tailings disposal a significant second; and
3. South Africa's gold mining industry has an ecological footprint equivalent to about 9% of South Africa's ecologically productive land surface area.

Another study, *Environmental Life Cycle of Fine Coal Use for Power Generation in South Africa*, was conducted by means of two honours level research projects. It was concluded that the main source of pollution was sulphur and the system response was most sensitive to this parameter. Other major impact categories were fossil fuel depletion, gaseous emissions and climate change. The solar drying of fine coal and the subsequent use of this fine coal should be supported. This option is preferable to thermal drying of coal fines. It was thus recommended that solar drying be implemented and that coal slurry be utilised. It is noteworthy that one of the authors (Mondli Guma) has since completed a Masters degree on the development of quantified eco-efficiency indicators in the mining industry, and has now been employed as a sustainability expert by a large South African coal mining company.

In addition to the above mentioned thesis an additional two post graduate students were supported by this project but failed to complete their studies.

### ***Quick Cleaner Production Opportunity Assessments***

A practical evaluation of five different mining facilities was conducted using a quick CP assessment technique. This process looks at all inputs and outputs to a facility and has the objective of trying to

determine areas where resources can be saved to the benefit of the environment and to save the company money. Many CP opportunities were identified and recommendations were made. Worksheets originally developed by the United States Environmental Protection Agency (US-EPA) were modified to be used practically by the mines and these were used for conducting these investigations. The facilities visited included platinum smelters and concentrators, shaft complexes and gold extraction plants to ensure that as many different people as possible were exposed to the technique and to test out the worksheets for different places.

### ***Financial evaluation and opportunities***

Electrical energy has been highlighted as a major constraint for development in the mining industry in South Africa due to recent power shortages. These shortages are expected to continue. The cost of hydrocarbon based fuels has also dramatically increased over the past few years. The improvement in energy efficiency by the mining industry is thus essential, not only to maintain and improve profitability but also to ensure that sufficient energy supplies exist for new projects and developments.

**Every percentage improvement in efficiency in the mining industry could produce an additional R2 billion in sales.** This could also translate into an additional 4 500 direct jobs. Including the expected multiplier effects this could result in an additional 50 000 people benefiting from wages generated by the mining industry.

At a 7% direct contribution to the GDP and a 18.4% total effect, taking forward and backward linkages into account, the effect of a 1% increase in efficiency is equal to R1.5 billion directly and R4.0 billion in total to the South African GDP (using SA Reserve Bank figures for GDP for the first quarter 2008). It is not inconceivable that improvements in efficiency of 10-15% are achievable.

If improved efficiency is not practiced then a number of mining projects may not be initiated at all as electrical power will not be available for them neither would there be sufficient water available. The value of these projects and the implied multiplier effect on South Africa is enormous. The costs of providing alternative energy using on site generation is extremely expensive and will limit the life of the projects.

Economic development in South Africa is currently severely constrained by the availability of electrical power. Even though new productive facilities are being built rapidly it is likely that it will be many decades before a comfortable reserve margin is built up given current growth rates. Whilst it is possible that additional generation capacity can be constructed for electricity it is highly likely that this will represent a constraint to development for the next few decades. It is thus essential that available resources be used more efficiently.

South Africa is a dry country and the availability of water for consumptive use is finite. In order to meet the expected growth rates of the economy and the expectations of the people for a better life it is imperative that this scarce resource is used in an efficient and effective manner.

More effective use of this country's mineral resources will ensure that they can continue to be exploited for a longer period of time and provide income to the government and communities to enable them to develop a sustainable society through the exploitation of minerals, as mining is by definition an unsustainable activity. The full utilisation of current mine wastes will ensure that environmental liabilities are reduced and the benefits to society are enhanced.

The potential return on investments is plain to see and thus all state institutions and businesses should be encouraging the development of technologies which will allow for the more efficient exploitation of our mineral resources and the optimal utilisation of these resources in the development of sustainable communities.

### **Discussion and conclusions**

The project has succeeded in meeting all its aims and objectives except for possibly ensuring the sustainability and viability of initiatives to introduce CP approaches to the industry. The introduction of CP will have to be pursued by many organisations providing services to the mining industry and by all role players in the industry.

Thousands of people working in the mining industry, or providing services to it, have been exposed to the principles of CP and the tools available to assist with its implementation. The initiatives were generally very well received and this project has provided the basis for many more initiatives to be implemented in the coming years.

***Recommendations for implementation:***

1. The public and the regulators need to find a way to challenge the mining industry to reduce coal fine wastes and to optimise electricity consumption, particularly in the gold mining sector;
2. The design and implementation of training programmes for regulators in respect of CP needs to be encouraged;
3. The guideline document needs to be widely distributed to the industry, consultants and regulators. Its availability should be advertised in the press and at conferences. Training programmes should be conducted with people who would find it useful;
4. Service providers/consultants interested in the implementation of CPFs should be trained. Managing CPFs is an ideal environmental product as it will provide income for the service providers while aiding the industry in becoming more competitive and sustainable;
5. The WRC needs to continue support for all CP initiatives as the cost saving and ability of these interventions to make a marked difference to the way industry conducts its business is remarkable;
6. There needs to be support for all initiatives to lower the power consumption of SA mines per unit of product;
7. The use of fine coal and initiatives to enhance its calorific value by air drying it should be promoted; and
8. The benefits of utilising various tools such as LCAs, CPFs, etc. needs to be publicised in order to get them implemented.

***Recommendations for research:***

1. Bursaries should be provided to students for LCA investigations, CP and consumption studies, CPFs and water and energy efficiency studies;
2. There needs to be support for all research initiatives into preventing ARD from occurring from all residue or discard facilities, waste rock dumps and mine workings;
3. Research into the deportment and eventual fate of all sulphur in a coal mine needs to be supported;
4. There should be targeted training programmes and awareness campaigns. A WRC project could include lectures to all local, provincial and national authorities tasked with implementing CP. Awareness campaigns should be developed for the mining industry which can be used at all levels in organisations;
5. There should be sponsorship available for organisations to establish and run CPFs in different areas;
6. Support needs to be given to industrial symbiosis projects whereby different industries co-operate and that CPFs do not just become a mining industry initiative;
7. There needs to be support projects which look at ways of getting water to the drier parts of the country in the eastern and western limbs of the Bushveld Igneous Complex (BIC), particularly if that water comes from mine water and costs may be saved if it is used rather than water which is not saline. This will also save expensive water treatment costs;
8. All work on energy efficiency projects should be encouraged;
9. The WRC needs to continue supporting projects which seek to minimise the water quality impacts from mine waste and mine workings; and
10. The WRC needs to find ways to assist the Department of Water Affairs and Forestry (DWAF) in implementing the law such that give security and assurance to water users.

The Department of Water Affairs and Forestry produced a series of guideline documents for water management in the mining industry which promote the concept of Cleaner Production. These are described in more detail in the Appendix to this report and can be found on [www.dwaf.gov.za](http://www.dwaf.gov.za).

