

WATER RELATED IMPACTS OF SMALL SCALE MINING

Final Report to the
Water Research Commission

by

R Heath, M Moffett and S Banister

Pulles Howard & de Lange Incorporated

WRC Report No 1150/1/04
ISBN No 1-77005-119-8

MARCH 2004

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EXECUTIVE SUMMARY

Background

Small-scale mining already occurs on a sizeable scale in South Africa, and active measures are being taken by government to promote the development of this sector of the economy. It is realised that the success of this sector depends largely on providing these miners with technical assistance. The Department of Minerals and Energy (DME) has initiated the development of a National Small-Scale Mining Development Framework. This framework will ultimately be available to provide assistance to small-scale miners regarding the necessary regulatory and administrative procedures, reserve determination, business plans and mining methods.

Aims

The aims of the study were to identify and characterize the critical aspects with regard to the water-related impacts of small-scale mining. Once these impacts were identified, the aim was to develop and recommend appropriate strategies to assist small-scale miners in environmental management.

Approach Followed

The methodology that was followed in the course of this project included the following:

- A **literature review** was undertaken.
- **Project meetings** with representatives from the DME and Department of Water Affairs & Forestry (DWAF), as well as meetings between the Water Research Commission (WRC) Steering Committee and the project team were held throughout the study.
- **Stakeholder workshops** were held with regulators, small-scale mining experts and small-scale mining organisations.
- **Initial screening site** visits were undertaken throughout the country.
- Information obtained from the authorities was used to compile an **inventory** of small-scale mines.
- A limited number of sites for in depth regional site surveys were selected based on information gathered during the screening site visits.
- A **survey protocol** was developed for the researchers to use in intensive **regional site surveys**.
- A **questionnaire** was developed to interview small-scale miners and the associated community members.
- The **environmental impacts** observed during the regional survey findings were described.
- A **handbook was produced** that described the water-related impacts of small-scale mining.
- Appropriate **environmental assessment tools and management options** were described and recommended in the final report.

Findings

The 1:100 year flood line was used to delineate the area for which the impact on water quality should be considered. Where possible, both legal and illegal operations were included in the study. Small-scale mining, like the rest of the mining industry, is required to adopt measures that will promote environmental sustainability by means of the application of consistent standards and acceptance of the “polluter pays” concept. All policy principles pertaining to environmental management by larger mines are also applicable to small-scale mining

operations. However, a balance should be maintained between encouraging economic development and preserving high standards of environmental management.

There is no set **definition** of what is meant by a small-scale mine. The definition of small-scale mining varies depending on the purpose for which the term is being used. The working definition used in this study is based on the amount of material moved per annum, on the number of employees and on the level of mechanization:

A defined **upper limit** (in accordance with the DME) where the mine must not move more than 600 000 tons material/annum (50 000 tons/month) or when the total area disturbed by mining activities is restricted to approximately 10 ha at closure.

All small-scale mining types ranging from artisanal mines to small companies excluding **junior companies** (junior companies = companies employing between 50 and 200 employees). This includes companies who are classified as **micro** (< 5 employees) to **very small** (<20 employees) to **small** (<50 employees).

The **level of mechanisation** will also be used where **micro-scale** mining refers to artisanal mining that involves no mechanisation and whose prime motivation is subsistence; **medium-scale** small-scale mining where mining is not subsistence orientated and involves mechanisation on a limited scale (one truck, one front-end loader and a mechanical pan/washer); to **large-scale** small-scale mining that is not subsistence oriented and involves the use of extensive mechanical equipment (several trucks, front-end loaders and mechanical equipment for the processing of ore).

The **mining types** that were considered to be part of the study and that are known to have the greatest impact on the water environment were identified through consultation with national representatives of the DME and DWAF. The types of mining identified include diamond diggings, sand-winning (dry-pit mining, wet pit mining, bar skimming and mining of pits on adjacent floodplains or river terraces), coal mining, gold mining/panning and alluvial gold deposits, clay mining and peat extraction. Due to other parallel initiatives in the peat industry; slate mining being described as large scale; and coal mining being defined as having a large environmental impact irrespective of mine size; these forms of mining were not included in this study.

In southern Africa, the most important environmental impacts caused by small-scale miners appear to be related to:

- Accelerated erosion of areas adjacent to workings that have been de-vegetated for construction materials or fuel wood leads to increased suspended sediment loads in nearby streams and rivers.
- Excavation of flood terraces and riverbanks increases the instability of these riverbanks and enhances the likelihood of increased flood scouring.
- Alteration of river channels and flows due to mining of alluvial deposits in the river bed.
- Excavation of river sediments exposes these sediments to oxidising conditions and enhances the solubility and release of any metal ions that may previously have been previously trapped as insoluble sulphides.
- Acid mine drainage and associated water quality problems in receiving waters.
- Gold panning and operation of sluice boxes increases loads of suspended sediments in downstream reaches.
- Wash-off of mercury used to concentrate gold leads to increased risks of mercury toxicity to aquatic and terrestrial organisms, as well as to the miners.

- Wind-blown dusts from unprotected tailings and waste rock dumps enter aquatic environment.

Three different regions were identified during initial site visits for **regional site surveys**. These regions include sand-winning sites in the Umbogintwini and Umgeni Rivers near Durban in KwaZulu-Natal; diamond diggings along the Vaal River near Kimberley and Windsorton in the Northern Cape Province; and sand-winning sites along the Krokodilspruit and Boekenhoutkloofspruit north of Pretoria.

The impacts observed during the regional site visits indicate that sand-winning and gravel extraction operations impact primarily on the instream habitat and on the riparian habitat. Specific impacts on the instream habitats that were observed include:

- Riverbed degradation, *e.g.* diamond-digging along Vaal River.
- An increase in suspended sediment, *e.g.* diamond-diggings at Amendelshoogte and the sand-winning operations along the Krokodilspruit River.
- Changes in morphology and in hydraulics of river channel, *e.g.* Vaal River.
- Destruction of spawning habitat of fish and macro-invertebrates, *e.g.* Umgeni and Umbogintwini Rivers where sand-winning takes place close to the river mouth.

Impacts on the riparian habitat that were observed during the regional visits include:

- Destruction of the riparian zone (stream banks, riparian vegetation and vegetative cover) - this phenomenon was observed where gravel diggings and sand-winning operations were present along the banks of the Vaal River in Windsorton, the Umbogintwini and Umgeni Rivers in KwaZulu-Natal and the Krokodilspruit River in Gauteng. Destruction of this zone leads to stream bank destabilisation and this leads to increases in erosion, stream temperatures and sediment input.
- Reduced vegetative bank cover – this is caused by undercut banks that may be removed during sand/gravel extraction, resulting in reduced shading and increased water temperatures.

Singly, many of the effects of small- scale mining on the water environment may well be insignificant. However, when they occur simultaneously, their significance may increase by orders of magnitude. The overriding principle is that the greater the number of small-scale mines in an area, the greater the cumulative impacts are on the water environment. The major cumulative impacts observed during the regional site visits include:

- Loss of riparian habitat due to large areas of riparian vegetation being removed.
- Riverbank destabilisation after vegetation removed.
- Soil erosion of arable land adjacent to mined areas.
- Increased surface areas of discard (sand, rock and other forms of waste) that can be mobilised during rain and ultimately are deposited in the rivers.
- Increased mobilisation of sediments, which become available and clog the aquatic environment.
- Increased incidents of oils (from machinery) and chemical (if refinement takes place) spills into rivers.
- Increased potential of mobilization of metals, sulphates, acid mine drainage and other possible toxicants (such as arsenic).
- Loss of arable land due to lack of rehabilitation.
- Large tracts of land becoming a safety hazard (for people and livestock).

The duration of these impacts are mainly long term. For example, many areas along the Vaal and Orange Rivers were mined a century ago and the environmental footprints are still

prevalent. Unless appropriate rehabilitation takes place in areas that are on the riverbanks, the land largely remains unusable unless the area is naturally restored by for example, floods. The mining that takes place within the riverbed or flood plain has more chance of being restored back its original status over time due to floods.

During the regional site visits, structured interviews were conducted with small-scale miners and local communities near Kimberley (Longlands, Barkley West and Windsorton), Wolmaransstad, Cullinan and Durban (Vukani informal settlement next to the Umgeni River and Izimbokodweni settlement next to the Umbogintwini River).

The results of the questionnaire were varied but the following are the most important findings:

- the communities living in close proximity to small-scale mining operations were aware of issues such as rehabilitation and the environmental impacts associated with mining activities.
- mining was seen as a viable form of a living
- environmental issues and impacts were largely ignored by the miners
- the required mining documentation, such as EMPR's, were seen as a license to mine only and were largely not consulted any further (for example for rehabilitation and closure)
- the local communities would prefer to become employed in the mining sector rather than become employed in the rehabilitation of small-scale mines.
- the regulators had difficulty in visiting, least of all regulating, the vast number of small-scale mining operations.
- the regulators concentrated on the more formal larger scale mining operations.

The environmental assessment approach used in the current study included the application of three habitat assessment indices to each site – habitat assessment matrix (HAM), habitat quality index (HQI) and the Intermediate Habitat Integrity Assessment (IHIA). These indices are recommended by DWAF's Resource Directed Measures (RDM) office and are standard indices used by the River Health Programme. These indices evaluate each mining site on a numerical scale so that results are readily comparable.

Participation by interested and affected parties was vital in assisting the project team with the design, planning and implementation of a handbook to be used by miners to assist them in responsible mining. It was necessary to ensure that any decisions regarding content took into account the needs, interests, and values of the community, mining sector, regulators, *etc.* A stakeholder workshop was convened with the aim being to discuss possible education, implementation strategies and to engage in an understanding of the water-related issues of small-scale mining. The following groups were invited to this workshop:

Authorities, Small-scale mining associations, Sedibeng and Bakakga Mining, South African Women in Mining (SAWIMA), Minerals and Energy Policy Centre (MEPC), GEMS, Chamber of Mines, CSIR –(Environmintek and Miningtek), De Beers, University Mining Departments (University of Witwatersrand and Venda) and the WRC steering committee members.

Based on the research that was undertaken during this study and on the input gained from the **stakeholder workshop**, management issues relating to small-scale mining were identified. The stakeholder workshop also allowed delegates to give new input on the content and structure of a **handbook** that was produced to assist small-scale miners to mine responsibly. The title of this handbook is “Environmentally responsible mining: Water management guidelines for small-scale mining.”

The challenge in environmentally managing small-scale mining is to develop appropriate **implementation strategies and environmental management systems**. These strategies must be relevant, understandable, and affordable to the small-scale miner and should aim at maintaining a balance between encouraging economic development and preserving high standards of environmental management. Various strategies for managing the water-related impacts caused by small-scale mining were identified during this study. These strategies include:

- Improved and harmonized legislation
- Governmental structure and mining laws
- Education and training
- Capacity building
- Collaboration forum and co-ordination
- Working for rehabilitation
- Technical support and appropriate technology
- Best practice guidelines
- Improved stakeholder participation in decision-making
- Environmental management systems.

In order to determine the water-related impacts of small-scale mines, the following environmental assessment tools and processes are recommended:

- The small-scale miners are trained to mine in an environmental responsible manner, especially those that are applying to mine for the first time
- The legislative requirements are made more accessible and understandable prospective small-scale miners
- The water quality impacts of small-scale miners are monitored on a regional (large scale) rather than on an individual mine basis

Recommendations

The **development and success** of small-scale mining projects in South Africa is presently limited by problems associated with access to mineral rights, access to finance, a lack of appropriate structures that assist small-scale mining development, operations that are located far from major markets and lack of management, marketing and technical skills. New small-scale mine operators face technical barriers to participate in mining, including lack of skills in dealing with aspects such as complex metallurgical processes, practical mining problems and business skills. The small-scale mining sub-sector can currently offer little security, such as security of tenure. Formalization of the sub-sector and appropriate policy frameworks would mobilize small-scale mining associations.

The challenge in environmentally managing small-scale mining is to develop appropriate **implementation strategies and environmental management systems**. These strategies must be relevant, understandable, and affordable to the small-scale miner and should aim at maintaining a balance between encouraging economic development and preserving high standards of environmental management. Various strategies for managing the water-related impacts caused by small-scale mining were identified during this study.

It is very important that small-scale miners become more environmentally friendly as the results can impact both the environmental and our health and make it difficult for people nearby to get clean and safe water.

ACKNOWLEDGEMENTS

The authors would like to thank the project team for their valuable contributions especially Kerry Fairley, Mike Howard, James Lake and Erica Reynolds.

We would like to thank the steering committee, which comprises of Meiring du Plessis, Hugo Maaren, Kevin Pietersen, William Pulles, Harold van Niekerk, Rod Schwab, Elise Swart, Dr Denis Wymer, N Pienaar and Dr Eric Hammerbeck.

The regional representatives of DWAF who accompanied the project team on sites visits were Ms. Margarete van Mollendorf, Mr Jürgen Streit, Mr George van der Merwe, Mr Johan Daffue and Mr. Charles Joubert are thanked for their time.

The DME regional representatives who accompanied the project team on sites visits were Dr. Moemise “Joseph” Matjila, Mr. Zimmie Zimmerman, Echard Voight, Herman Cornelissen , Smuts du Plessis, Mr. Jay Pillay, Mr Wayne Webster, Ms Debbie Ntombela, Julius Mutyorauta, Johan Bornman, Mr Johan Lourens and Mr Pieter Venter and thanked for giving up of their time.

The social assessment survey team Mr. Obey Sichimwi, Mr. George Mokgoro (Simeka), Ms. Lulama Dumezweni (Simeka) and Mr. Vusi Mshengu are thanked for their diligent field work.

The delegates of the small scale miners workshop, who traveled long distances to share with us the current frustrations of being a small scale miner, are thanked.

Thanks to MEPC and MMDS for allowing us to use their photographs in the handbook.

And lastly thanks to all the small-scale miners who willingly shared with us their mining stories.

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1. INTRODUCTION AND BACKGROUND

The decline experienced by some sectors of the large-scale mining sector in South Africa in the last 15 years has shifted attention to smaller-scale deposits. Furthermore the political intent of the government has shifted mining into a more sociological issue with job creation being important especially in the sectors of the population that previously had limited ability to access the mineral reserves of South Africa. “Well-managed small-scale mining has the potential to take over from large-scale operations and mine economically where large-scale mining is unable to operate profitably. In this way small-scale mining can make a meaningful contribution to the total global production.” (White Paper on Mineral Development for South Africa, 1998). Small-scale mining is therefore an important development node for this country.

Although small-scale mining already takes place on a sizeable scale in South Africa, the opportunity for small-scale mining development within South Africa is currently confronted by problems associated with access to mineral rights, access to finance and the lack of knowledge and management skills. Of particular importance to this study, is the lack of knowledge and skills in environmental management. The deleterious effects of this form of mining on the environment and on safety and health elsewhere in the world dictates the necessity for research in this area. Small-scale mining is often equated with illegal operations that are characterised by a complete lack of capital, haphazard mining methods, environmental damage and health and safety risks.

The interests of the country and the community require that all forms of mining, whether large, small or artisanal (unmechanised), should be subject to the same requirements in respect of licensing, safety, health and the environment. Minimum standards in respect of the environment should be maintained for all mining operations. Small-scale mining, like the rest of the mining industry, should be required to adopt measures that will promote sustainability by means of the application of consistency standards and acceptance of the “polluter pays” concept. All policy principles of environmental management that apply to large-scale mining operations should apply to small-scale operations.

The challenge in environmentally managing small-scale mining will be to develop appropriate strategies and systems. The strategies should be relevant, understandable and affordable to the small-scale miner. These should aim at maintaining a balance between encouraging economic development and preserving high standards of environmental management. The potential for capacity building within the local communities will also need to be addressed. It is envisaged that the community as a whole should accept responsibility for management of the environment.

2. AIMS AND OBJECTIVES OF STUDY

The aims and objectives of this study were to:

- Identify and characterise the critical aspects relating to the water-related impacts of small-scale mining.
- Develop and recommend appropriate tools to assist in environmental management for small-scale miners.

The aims were divided into two main phases of work. As a first step, the typical impacts from an identified range of small-scale mines were determined. This was followed by the assessment of synergistic and cumulative impacts. Once this had been completed, an inventory of impacts were set up. This led to the identification of tools to environmentally manage small-scale mining in South Africa.

Research products from this project included an inventory/detailed description of environmental issues and a guideline document in the form of a final report. These products are aimed at small-scale mining operators, regulatory authorities, local communities, interested and affected parties, and entrepreneurs from previously disadvantaged communities.

The inventory on water-related issues related to small-scale mining include information on:

- Type of small-scale mining currently underway
- Main methods used for mining
- Constraints to mining in terms of infrastructure, skilled labour, *etc.*
- Typical environmental impacts associated with small-scale mining
- Synergistic and cumulative impacts which can be identified
- Relative importance of each of these impacts

The inventory will allow the regulators to focus attention on priority environmental issues and priority small-scale mining regions. The inventory can be used by stakeholders and role-players to determine the level of small-scale mining on a regional basis. It can also be used by interested and affected parties to identify the type of environmental impacts that could be expected from the different types of small-scale mining.

The following issues are discussed in this report:

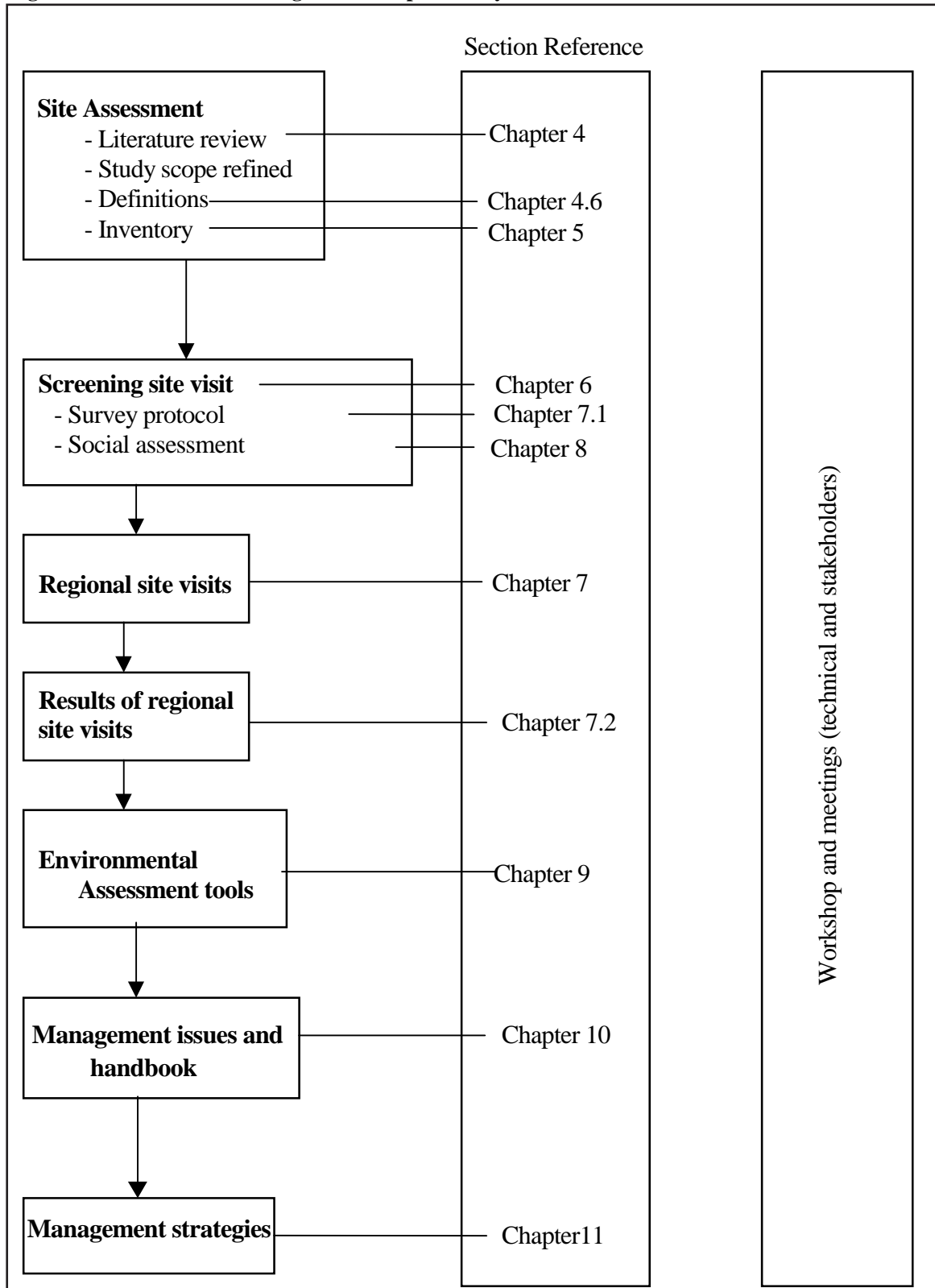
- Environmental assessment tools
- Implementation strategies
- Management options

The final report defines what systems need to be put in place to develop strategies to manage the environment, educate the miners and monitor their activities. Arising out of this are different products ranging from printed media (practical guideline) to practical suggestions for community development.

3. METHODOLOGY AND APPROACH

This section gives a brief description of the methods and approach that were used during this study. The sequence of the different steps is illustrated in Figure 1.

Figure 1. Flowchart illustrating various steps in study.



3.1 LITERATURE REVIEW

A literature review was undertaken. However, it should be noted that a detailed literature review falls beyond the scope of this study. The information contained within the review is based largely on information that was readily available.

3.2 MEETINGS AND WORKSHOPS

Several internal project meetings, meetings with representatives from the DME and DWAF, as well as meetings between the WRC Steering Committee and PHD were held throughout the study. In addition, two stakeholder workshops were held with regulators, small-scale mining experts and small-scale mining organisations where valuable input was gained.

3.3 MINING TYPES TO BE INCLUDED IN STUDY

The aim of this phase of the study was to identify the mining types that need to be considered as part of the study and that are known to have the greatest impact on the water environment. These mining types were identified through consultation with national representatives of the DME (Mr. W. van Zyl, deceased) and DWAF (Ms. M. Eksteen) and include:

- **Diamond diggings** - the prospecting or mining of alluvial diamonds.
- **Sand-winning** - all sand-winning operations from a river, stream, dam or pan (upper limit of 600 000 ton of material moved per annum).
- **Coal mining** - all artisanal, *i.e.* non-mechanised, coal-mining operations are to be included in the study (see Section 4.9.5).
- **Gold mining/panning** – the prospecting and mining of magmatic reefs and alluvial gold deposits, including activities where gold is processed by means of gravitational/mechanical separation and where the chemical amalgamation of the concentrate involves the use of mercury. In this instance, mining of gold refers to at or near surface mining and not the traditional underground mining of ore on a large scale (Section 4.9.1).
- **Clay mining** - all clay mining operations (upper limit of 600 000 ton of material moved per annum) (Section 4.9.5).
- **Peat extraction** – the location of all peat mining operations were to be included in the inventory. However, research into the location, environmental impacts and the management of small-scale peat mining operations is currently being co-ordinated by the Peat Working Group (PWG) initiated by the Department of Agriculture. It was decided that this work should not be repeated and peat mining therefore falls outside the scope of this study (see Sections 4.3 and 4.9.3). DWAF suggested the impacts of the peat extraction on the water environment should be superficially investigated as part of this study and therefore peat extraction is briefly discussed in the literature review.

Slate mining is considered to be large-scale mining and was therefore not included in the study. All small-scale mining activities that have water-related impacts are covered in this study unless stated otherwise. The 1:100 year flood line was used to delineate the area for which the impact on water quality should be considered. Where possible, both legal and illegal operations were included. (The term legal is used in this study to mean with a mining permit and the term illegal to mean without a mining permit).

3.4 DEVELOP SMALL-SCALE MINES INVENTORY

Areas where current environmental problems relating to small-scale mining activities exist were identified with the assistance of the various authorities. This information was used to

compile an inventory of small-scale mines. The information provided by the Authorities included:

- A list of the small-scale mining types occurring within different provinces.
- Details regarding the areas/sites where the above mining types currently occur.
- An indication of the water-related impacts currently associated with each of these small-scale mining types.

3.5 UNDERTAKE INITIAL SCREENING SITE VISITS

Initial screening site visits were undertaken. A limited number of sites for in depth regional site surveys were selected based on information gathered during the screening site visits.

3.6 DEVELOP SURVEY PROTOCOL AND QUESTIONNAIRE ON SOCIAL ASPECTS

A survey protocol was developed for the researchers to use in the regional site surveys. Similarly, a questionnaire was developed to interview small-scale mining community members. The aim of the questionnaire was to assess the role the community could play in environmental management and rehabilitation programmes of the small-scale mines.

3.7 UNDERTAKE REGIONAL SITE SURVEYS

Three regions that were identified from the initial site surveys as severely impacting the environment were selected for undertaking in depth regional site surveys. Representatives from the DME and DWAF accompanied the researchers. The methods used to conduct the regional surveys included visual observations, matrices and rough water quality data.

3.8 COLLATE SURVEY FINDINGS

The impacts observed during the regional survey findings are described in Chapter 7.

3.9 ENVIRONMENTAL ASSESSMENT TOOLS

Appropriate environmental assessment tools are described and recommended in Chapter 9.

3.10 MANAGEMENT ISSUES AND HANDBOOK

Based on the research that was undertaken during this study and on the input gained from the stakeholder workshop, management issues relating to small-scale mining were identified. The stakeholder workshop also allowed delegates to give new input on the content and structure of a handbook that was to be produced to assist small scale miners to mine responsibly. The delegates then actively contributed to develop the handbook with feedback from a technical and user group perspective. The handbook and process followed is discussed in Chapter 10.

3.11 MANAGEMENT STRATEGIES FOR WATER-RELATED IMPACTS

Various strategies for managing the water-related impacts caused by small-scale mining were identified during this study. These strategies include existing governmental structures and mining law, best practice guidelines, education and training, capacity building and different payment options.

4. LITERATURE SURVEY

4.1 INTRODUCTION

Although the promotion of small-scale mining enterprises is seen increasingly as a way of providing employment and improving the economy throughout the developing world, there is little information available on the impacts that these operations have on the environment. All available information was reviewed and included in this literature survey.

Small-scale mining already occurs on a sizeable scale in South Africa, and active measures are being taken by government to promote the development of this sector of the economy. It is realised that the success of this sector depends largely on providing these miners with technical assistance. The DME has initiated the development of a National Small-Scale Development Framework. This framework will ultimately be available to provide assistance to small-scale miners regarding the necessary regulatory and administrative procedures, reserve determination, business plans and mining methods. The Department of Agriculture initiated the development of the Peat Working Group (PWG) in order to assist in the management of peat mining throughout South Africa. The aims of the Group are discussed in this review.

Small-scale mining operations are often associated with health, safety and environmental hazards. A balance needs to be sought that promotes the development of the small-scale mining sector while minimising the risks posed to safety, health and the environment. These measures should include the provision of technical and environmental management assistance and the simplification of procedures for complying with environmental management regulations.

Existing legislation pertinent to the regulation of small-scale mining operations has been reviewed and addressed in this review. However, due to limited manpower, as well as the remoteness of many of the small-mining sites, the implementation of these regulations and the enforcement of legislation to ensure environmental protection is not always possible. Alternatives to traditional methods of policing the compliance of mining operations methods need to be sought for small-scale mines. Methods that promote voluntary compliance and the involvement of stakeholders (including neighbouring communities) need to be sought.

There is no set definition of what is meant by a small-scale mine. The definition of small-scale mining varies depending on the purpose for which the term is being used. A further complication regarding what constitutes a small-scale mine also arises because several small-scale mining operations tend to occur in the same area, making it difficult to distinguish individual mines.

Various terminology is used when referring to the environmental impacts of small-scale mining operations and this can lead to confusion. Pertinent legislation has thus been reviewed and relevant definitions given. These definitions will be used throughout the study in order to limit confusion. These definitions are included in a glossary at the end of this report.

The draft Mineral Development Bill was reviewed and the implications of this Bill for small-scale mining and the concerns of small-scale miners forum are described. The environmental impacts of small-scale mining have generally been ignored throughout the world (Economic and Social Research Council or ESRC, 2000). Although the promotion of these enterprises is seen increasingly as a way to provide employment and incomes throughout the developing world, there is little evidence available relating to their impacts on the environment. It is often assumed that because these activities are small, they have little impact. However, since the number of small-scale mining operations in developing countries is rapidly on the increase, there is a growing need to address the problems of pollution and the health and

safety hazards that these operations may impose. Consequently, policymakers throughout the developing world, hampered by a lack of knowledge of the actual environmental impacts of small-scale miners, have only a limited understanding of how to balance employment creation with environmental protection.

This literature review is based largely on information made available by persons within the regulatory offices and other interested organisations (such as the Institute for Water Quality Studies, WQS, Mineral and Energy Policy Centre, MEPC and Mining, Minerals and Sustainable Development, Southern Africa, MMSD). These people have expressed a particular interest in the study on the water-related impacts of small-scale mines and have provided information in support of the study. However, despite these limitations it is considered that the information contained in this review serves as a good indication of the information that is currently available regarding small-scale mining.

4.2 SMALL-SCALE MINING IN SOUTH AFRICA

Small-scale mining already takes place on a sizeable scale in South Africa. According to the *White Paper for Miners Development in South Africa* (1998), opportunities for small-scale mining projects in South Africa are found mainly in gold, diamonds, coal, industrial minerals and in minerals derived from pegmatites. The development and success of these projects is currently limited by problems associated with:

- Access to mineral rights – the present South African mineral rights ownership system is seen by many as a major blockage in the development of small-scale mining.
- Access to finance – financiers are seldom willing to participate in small-scale mining ventures, which often provide limited security and financial returns.
- Incoherent structure – there is a lack of appropriate structures that assist small-scale mining development.
- Operations are located far from major markets.
- Lack of management, marketing and technical skills – new small-scale mine operators face technical barriers to participate in mining, including lack of skills in dealing with aspects such as complex metallurgical processes, practical mining problems and business skills.

The small-scale mining sub-sector can currently offer little security, such as security of tenure. Formalisation of the sub-sector and appropriate policy frameworks would mobilise small-scale mining associations.

There is a lack of associations for small-scale miners. Where these do exist, they may be handicapped by poor leadership, a lack of planning and management skills, poor communication with their members and a lack of alternative sources of funding for their activities. This means that the sub-sector has no legitimate system of representation and little collective bargaining power, either to lobby government or to access credit. A small-scale miner acting on his own, or in a small group, has little bargaining power to access credit, grants and loans, or to get affordable interest rates. He is also disadvantaged in his negotiations with mineral buyers. The individual operator finds it difficult to access training and skills development opportunities, and has little or no opportunity to participate in information exchange. In the absence of appropriate associations, small-scale miners lack the capacity to lobby for the severely disadvantaged members of the sub-sector, such as women miners and child labourers. Where such associations for marginalized groups do exist, they need special support to strengthen their role in the sub-sector.

The potential for the successful contribution of small-scale mining into the formal economic sector, as well as the upliftment of people, particularly in rural areas, has been realised by the South African government. This support has been clearly documented in the White

Paper (1998). It is also realised that the successful development of this sector depends on issues relating to health, safety and environmental protection being adequately addressed. It is also noted that small-scale mines cannot be managed in the same way as larger operations. The aim is to seek a balance that promotes the development of small-scale mines without major health, safety and environmental implications.

4.3 AVAILABILITY OF INFORMATION ON SMALL-SCALE MINING IN SOUTH AFRICA

Although the development of the small-scale mining sector is considered desirable and is already occurring in many areas throughout the country, information regarding the impacts that this sector is having or may have on the environment is currently limited. A limited number of ad hoc research projects were recently undertaken in South Africa. However, their environmental impacts are not well documented. The mobility of small-scale miners, the quasi-clandestine nature of their operations and the remote areas in which they carry out their activities make a census of the sector extremely difficult. Their activities are difficult to control and monitor and accurate and up to date data are impossible to obtain.

Research into the location, environmental impacts and the management of small-scale peat mining operations is currently being co-ordinated by the Peat Working Group (PWG) initiated by the Department of Agriculture. To avoid repetition, it was decided not to include peat mining in the scope of work for this study. However, for the sake of completeness, the objectives of this group have been stated in this literature review based on documentation that has been made available by the Department of Agriculture.

The DME has also initiated the development of a “National Small-Scale Mining Development Framework”, which is currently undertaking a number of pilot projects throughout the country. The objectives of this framework have also been discussed in this review.

In addition to limited research and available information on small-scale mining operations, there also seems to be little exchange of information between the different regulatory bodies, regional offices of the same regulatory body and between the regulators and researchers in non-government organisations. Knowledge regarding the location of small-scale mining operations is also limited, with the records kept by the regulators being incomplete and not readily accessible. This problem is further complicated by the fact that many of small-scale mines are currently illegal informal operations.

4.4 THE PROMOTION OF THE SMALL-SCALE MINING SECTOR IN SOUTH AFRICA

4.4.1 The role of small-scale mining in the South African economy

While small-scale mines currently have little impact on South Africa’s mineral industry as a combined entity, their characteristics are such that they can play a useful role in the efforts of the national and provincial governments to achieve economic goals and social upliftment (Minerals Bureau, 1996). These characteristics include the low capital investment required to begin a mining operation, the development of mining operations in rural and remote areas, the potential to relieve unemployment and socio-economic problems, as well as the potential for growth and expansion of the mining operation. However, this vast potential is limited by environmental and safety aspects as it is difficult to control these mining activities, due to their lack of funds to apply the standards set and because activities are often concealed (Minerals Bureau, 1996).

According to the White Paper (1998), well-managed small-scale mining has the potential to take over from large-scale operations and mine economically where large-scale mining is unable to operate profitably. In this way, it is predicted that small-scale mining can make a

meaningful contribution to the total global production. Although many small-scale mining operations are illegal, inefficient, and hazardous to the environment and health, they nevertheless provide a means of survival for many people and their dependants. With the new political dispensation of 1994, the previously ignored potential of the small-scale mining sector for employment creation, rural development and economic growth, was formally recognised.

The South African government aims at lowering the barriers of entry to prospective investors and seeks to optimise the earnings from minerals exploitation. Government also proposes to introduce certain measures to encourage and support mineral beneficiation. The promotion and support of small-scale mining operations coincides with this policy.

4.4.2 Support of the small-scale mining sector

The concentration of technical and financial capability in the large deep-level mines in South Africa has led to the poor development of the small and medium sections of the industry. Legal access to mineral rights is not sufficient to promote the development of the small-scale mining sector. Technical assistance and training are essential for the success of the small-scale mining sector. Institutional research and development in respect of all aspects of mineral development and exploitation, as well as the transfer of this technology to small scale miners is thus required (White Paper, 1998).

Support systems need to be set up to encourage better mining practices in terms of mining methods employed, equipment and training. Environmental management should be a consideration prior to the commencement of any operation. Therefore education and training are needed to ensure that environmental management skills are present at the start of a mining operation (MEPC, 1998).

Research conducted by the Minerals and Energy Policy Centre (MEPC, 1998) and the observation by inspectors from DME, indicate clearly that small-scale miners are not fully familiar with the licensing procedures and regulatory requirements associated with a mining operation. In order to form the enabling conditions for development, the administrative and regulatory procedures have to be adapted to an approach of guidance towards the small-scale mining sector. Consequently, the DME introduced the Small-Scale Mining Development Framework in April 1999. The objectives of the framework are to establish enabling conditions for the small-scale miners and to alleviate the technical and financial constraints in the sector. The National Small-Scale Mining Development Framework has two components, namely, the Regional Regulatory Committee and the National Steering Committee. This use of this framework by small-scale miners is summarised in Figure 2.

The White Paper (1998) recognises the dependence of the small-scale mining sector on technical, business development and financial support to achieve sustainable and orderly development. In order to form the enabling conditions for development, the administrative and regulatory procedures have to be adapted to an approach of guidance towards the small-scale mining sector. A co-operative and supportive approach towards the small-scale mining sector integrating all government departments and other agencies is thus required to promote and develop the small-scale mining sector.

Chapter 4, (Section 16) of the draft Mineral Development Bill endeavours to provide assistance to persons from historically disadvantaged groups:

- The Minister may with the concurrence of the Minister of Finance, out of moneys appropriated for that purpose by Parliament, give financial or any other assistance to persons from historically disadvantaged groups to conduct prospecting or mining activities.
- The assistance will be on a cost recovery basis.

The need for technical assistance in terms of the implementation of measures needed for successful development of the small-scale mining sector has also been recognised by government. Steps have been put in place to provide access to expertise through the National Small-Scale Mining Development Framework. However, this framework does not provide insurance that there will be compliance with the current legislation or that the environment will be protected.

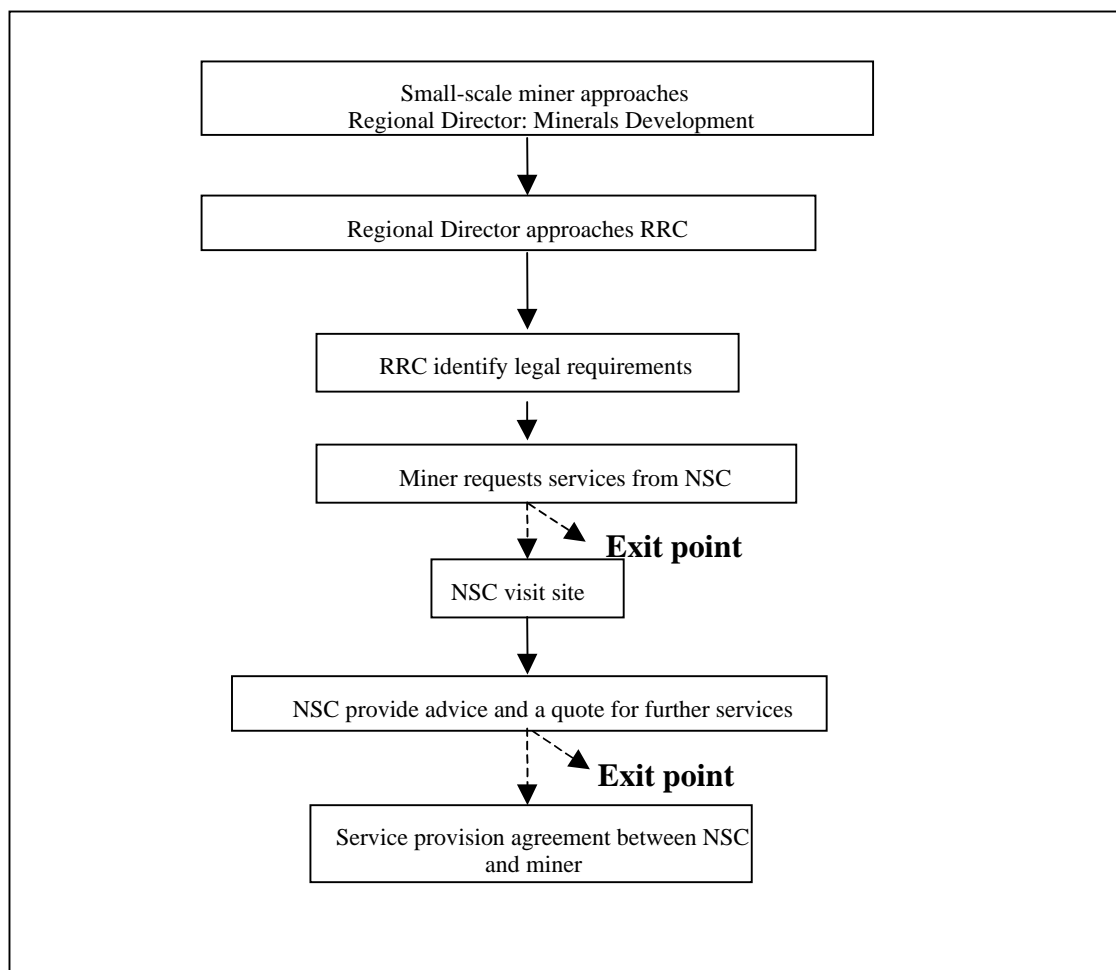
4.4.2.1 The Regional Regulatory Committee (RRC)

The RRC is the first component of the framework that comprises the regulatory authorities that have to approve and monitor a mining operation in its various aspects such as environmental control, health and safety precautions, land use, *etc.* The RRC is chaired by the Director of Mineral Development for each of the regions. The role of the RRC is to provide proactive assistance to miners that do not have the technical or financial means to initiate and conduct properly planned mining operations. Its main objective is to streamline the necessary regulatory and administrative procedures in conjunction with the other relevant government departments.

4.4.2.2 The National Steering Committee (NSC)

The NSC is chaired by the Chief Director of Minerals Promotion and consists of the Council of GeoScience, Industrial Development Corporation (IDC), Khula Enterprise Finance, the MEPC, CSIR-Miningtek, Ntsika Enterprise Promotion Agency, Mintek and the South African Diamond Board. In cases where the small-scale miner who has applied for a mining license does not have the technical and financial expertise necessary to comply with the environmental or health and safety requirements, or to compile a comprehensive business plan, the RRC refers the small-scale miner to the NSC. This process is summarised in Figure 2.

Figure 2. Summary of how small-scale miners can use the developmental framework.



The NSC consolidates the institutional support necessary for the feasibility and the planning stage of the small-scale mining project. The NSC operates in terms of the White Paper on a Minerals and Mining Policy (1998). Its policy therefore allows no compromise on the environmental, health or safety standards. Small-scale informal miners can access expert institutional services that will result in the professional evaluation of the intended mining operation. A professionally evaluated business plan reduces risk and can attract the necessary investment.

The short-term strategy of the NSC is to test the viability and the efficiency of the established assistance mechanisms by implementing pilot projects. The long-term objective is to convert itself into a self-funding small-scale mining development foundation. The NSC's aims are to uplift and legalise subsistence level mining operations, increase the efficiency of on-going sub-optimal small-scale mining operations and to ensure the development of greenfield projects. These aims will be achieved via creation of legal entities, assistance in reserve calculation, technical expertise in developing mining methods and recovery techniques and in the drawing up of business plans.

The NSC's pilot projects are centred on:

- A kaolin operation in Ndwedwe near Durban.
- A clay-mining and brick-making operation in the Osizweni township near Newcastle.
- A granite deposit to be mined by the members of the Cato Ridge community.
- A felsite aggregate quarry in GaRankuwa in the North West Province.
- An iron and manganese operation in Postmasburg in the Northern Cape.

4.5 COMMITMENT TO ENVIRONMENTAL PROTECTION

The interests of the country and the community demand that all forms of mining, whether large, small or artisanal, should be subject to the same requirements in respect of licensing, safety, health and the environment (White Paper, 1998). Minimum standards in respect of the environment should thus be maintained for all mining operations.

Artisanal operators are required to complete a generic EMPR at no cost to themselves at the time of application for a permit to mine (MEPC, 1998). Small and junior scale mining operators are required to produce a site and operation specific EMPR. Many felt that the cost involved was too high and represented a large portion of start-up costs. Problems were also reported regarding the slow processing and approval of EMPR's, a requirement before mining can commence. Several non-artisanal operators expressed annoyance at the preparation cost for the necessary EMPR and the length of time required for the document to be processed, which delays the commencement of mining (MEPC, 1998).

Small-scale mining, like the rest of the mining industry, is required to adopt measures that will promote environmental sustainability by means of the application of consistent standards and acceptance of the "polluter pays" concept. All policy principles pertaining to environmental management by larger mines are also applicable to small-scale mining operations. However, a balance should be maintained between encouraging economic development and preserving high standards of environmental management. According to the White Paper (1998), taxes, levies and financial guarantees in terms of rehabilitation should not be so inhibitive so as to constrain the development of small-scale operations. Rehabilitation procedures should be made affordable by devising a more flexible system for providing the necessary rehabilitation monies.

Small-scale miners have basic technical skills and geological experience, but need regular updating on appropriate technology. Inadequate and inappropriate technology inflicts severe environmental damage, including water contamination, siltation and the destruction of the landscape by alluvial mining. Many of the beneficiation techniques applied pose significant environmental and human health risks. Appropriate technology for small-scale mining has been identified in a number of cases, but the promotion and dissemination of this technology is not effective. Small-scale miners need exposure and access to technical information. They have little access to either institutions that provide training or information about appropriate technology. There is therefore little opportunity for small-scale miners to widen their technology choices.

Measures should include providing technical and environmental management assistance and simplifying the procedures for complying with the environmental management regulations (White Paper, 1998). It is suggested (White Paper, 1998) that intensive environmental guidance should be provided in areas where there is a high concentration of small-scale miners. Financial guarantees for rehabilitation should be flexible and site specific.

In many cases, the rehabilitation bond paid by miners prior to the onset of mining is insufficient to ultimately cover the cost of rehabilitation required. This has led to miners exploiting their operation fully and then leaving the site, without rehabilitating or being issued with a closure certificate, as the financial burden of rehabilitating is higher than the bond held by the government to cover rehabilitation (MEPC, 1998).

4.6 DEFINITIONS

Terminology relevant to small-scale mining is included at the back of this report. This section specifically deals with the definition of small-scale mining.

4.6.1 Definition of small-scale mining

There is no generally agreed definition of the term “small-scale mining”, although it is often defined in terms of the mine’s output, capital investment, numbers employed or managerial structure. According to the White Paper (1998), in South Africa, small-scale mining ranges from very small operations that provide subsistence living (artisanal mining), to “junior” companies for which revenue is such that subsistence living is not the prime motivator.

Artisanal mining generally refers to mining with a pick and shovel as opposed to mechanised mining. It is also defined as individual work performed by low levels of mechanisation, panners with rudimentary forms of mining using manual or portable equipment, and applied only to alluvial, colluvial and eluvial deposits (Drechsler, 2001).

Small-scale mining is often equated with illegal operations that are characterised by complete lack of capital, haphazard mining methods, environmental damage and health and safety risks. The general defining criteria for a typical small-scale mine have also been given as a mine that operates at or near the surface, would work with non-complex ore, which requires non-complex mining methods, and would operate on estimated, if not proven reserves (Franz, 2000).

According to the National Business Act of 1996, mines are classified according to the number of employees, total annual turnover, and total assets. The definition has been modified by the Minerals and Energy Policy Centre (MEPC) by the addition of proposed mining output to the definition. The definition of small-scale mining based on these criteria has resulted in many small-scale mines being divided into different classes as indicated in Table 1.

Table 1. Classification of Mining and Quarrying Operations (National Business Act, 1996), as modified by the MEPC

Category	Size of Class			
	Micro	Very small	Small	Medium (junior)
Number of Employees	<5	<20	<50	<200
Assets (property included)	<R100 000	<R1.8 mill	<R4.5 mill	<R18 million
Output (ton/annum)	<2 000	<10 000	<60 000	<150 000
Annual Revenue	>R150 000	R3 million	<R7.5 mill	<R30 million

The Minerals Bureau (1996) has also classified small-scale mining according to the number of workers operating the mine. This classification comprises the following categories:

- Artisanal mining: operations involving 1 to 5 workers.
- Micro-scale mining: activities involving 6 to 20 workers.
- Very small-scale mining: mining operations involving 21 to 49 workers.
- Small-scale mining: activities involving from 50 to 99 workers.

There must be some criteria for placing an upper limit to what should be included in the study. In assessing whether a mine is eligible for the submission of a Standard Environmental Management Programme Report (SEMP) in terms of the amount of material moved and/or the area to be disturbed, an upper limit has been placed by the DME. The same limit is considered appropriate for this study. The basis of these criteria are:

The mine must not move more than 600 000 ton of material per annum (50 000 ton per month) and/or when the total area disturbed by mining activities is restricted to approximately 10 ha at closure.

This limit should however, not be seen as a restriction that includes all mines that fit into the above category or excluding mines that could benefit from the outcomes of the project. This is simply a guideline for placing an upper limit to the size of the mine to be considered and it will be used in this study.

It is generally considered that larger mining concerns have developed considerable capability to manage their environmental impacts. The same is not true for small-scale mines. It is thus accepted that any mining type that will benefit from the outcomes of this study should be considered. However, as it is not practicable to undertake a detailed study of all classes of mines, the focus of the study will thus be on those types of small-scale mining that have the greatest impact on the water environment.

This study aims to address all small-scale mining types ranging from artisanal mines (with little or no forms of mechanisation) to small companies (most of which employ a mechanised approach). The division of small-scale mines according to the amount of mechanisation employed at the mine is also a definition that would be used in this study. The DME tend to show leniency to the environmental requirements of small-scale mines if there is no extensive mechanisation. In terms of this study, small-scale is taken to exclude junior companies (between 50 and 200 employees). For the purposes of this study, small-scale mines may be divided into three categories based on the extent of mechanisation as described below:

Micro-scale mining (unmechanised) – this refers to artisanal mining that involves no mechanisation and the prime motivation is subsistence.

Medium-scale mining (moderately mechanised) – this type of mining is not subsistence orientated and involves mechanisation on a limited scale. This may include one truck, one front-end loader and a mechanical pan/washer.

Large-scale mining (significantly mechanised) – This type of mining is not subsistence orientated and involves the use of extensive mechanical equipment. This may include several trucks, front-end loaders and mechanical equipment for the processing of ore.

Working definition used in this study

- Upper limit (in accordance with the DME) where the mine must not move more than 600 000 ton material/annum (50 000 ton/month) or when the total area disturbed by mining activities is restricted to approximately 10 ha at closure.
- All small-scale mining types ranging from artisanal mines to small companies excluding **junior companies** (junior companies = companies employing between 50 and 200 employees). This includes companies who are classified as **micro** (< 5 employees) to **very small** (<20 employees) to **small** (<50 employees).
- The **level of mechanisation** will also be used where **micro-scale** mining refers to artisanal mining that involves no mechanisation and whose prime motivation is subsistence; **medium-scale** small-scale mining where mining is not subsistence orientated and involves mechanisation on a limited scale (one truck, one front-end loader and a mechanical pan/washer); to **large-scale** small-scale mining that is not subsistence oriented and involves the use of extensive mechanical equipment (several trucks, front-end loaders and mechanical equipment for the processing of ore).

4.7 MINING METHODS

Most small-scale mining operations in South Africa may be described as artisanal relying on little more than pick and shovel operations (Drechsler, 2001). In some cases such as in diamond panning in the Northern Cape Province, simple technologies are used. A study undertaken on pan optimisation for the Northern Cape small-scale miners revealed that most were recovering little over 50 % to 60 % of the potential carats per ton (Drechsler, 2001). In the Mpumalanga region, small-scale miners searching for coal have sunk underground shafts without ventilation or prop support. They consequently mine under extremely dangerous conditions with the resultant accidents and loss of life.

The level of technology deployed by the miners is low and a substantial amount of work is required to raise them up to the level of profitable, properly managed business ventures. Where technology is used, it is usually outdated and either adapted machinery or else very old equipment. Miners also practice very unsafe mineral extraction methods. For example, mercury is commonly used in gold extraction. The coal mine operations visited relies on manual labour, which is not only economically inefficient but also dangerous. Miners frequently burrow into an overhang, and the resultant collapse of the overhang or tunnels causes injury or death.

4.8 THE IMPACT OF SMALL-SCALE MINING ON THE ENVIRONMENT – INTERNATIONAL CASE STUDIES

The environmental impacts of small-scale industries in developing countries have been ignored in the past (ESRC, 2000) and therefore information regarding the impacts of small-scale mining operations on the environment seems to be limited. This section describes several international case studies on the environmental impacts of small-scale mining. The studies were undertaken by the ESRC and by the World Bank (McMahon, *et al*, 1999). The ESRC has undertaken some research on small-scale industries in Zimbabwe and Bangladesh. These studies included brick-making and gold mining and although small-scale operations in the two countries do not necessarily have a significant environmental impact from a national or global point of view, they have detrimental effects locally. The nature of environmental effects differs between scales of production for the same product because different technologies are used.

The World Bank undertook a study that examined the environmental performance of artisanal, small and medium mines in three Latin America countries – Bolivia, Chile and Peru (McMahon, *et al*, 1999). Results from this study indicate that although artisanal and small mines (ASM) are significantly dirtier per unit of output than any other types of mining, this is not always the case. ASM is often economically viable, even when environmental costs are taken into consideration, suggesting that many of the solutions lie in areas of environmental and economic policy. In general, the results show that the environmental effects of ASM can be quite small under specific circumstances and the serious dangers that exist could be remedied without jeopardising the profitability of the enterprises.

For example, the hard rock gold miners in the Ica - Arequipa region of Peru work veins that are not economically viable for large firms, as they are too small. These operations are economically viable for the ASM sector, even when environmental costs are included. In contrast, much of the ASM sector of the Altiplano of Bolivia is involved in reworking old tailings or closed mines. In addition to the hazardous working conditions, the environmental damages are severe as old tailings are often exposed, increasing the problems of acid mine drainage.

In Bolivia, the small mining sector, consisting of co-operatives and small miners, is increasing its production of gold, zinc and silver. The exploitation methods of the co-operatives have

had severe environmental impacts, destroying not only the deposits, but also the tailings dams and the water recycling systems. Furthermore, the co-operatives work without any respect for the security of the worker or the environment. They do not have systems for disposal of tailings or water treatment.

In Chile, the small mining sector is defined as operations that own or rent facilities with an extraction capacity of less than 200 ton of mineral per day and between 0 and 10 ton a month of precipitates and concentrates. Small mining is a way of life in northern Chile, and it is an activity with an important social impact. There are two types of small miners: those whose active presence in the sector depends on the copper price and therefore produce sporadically and those for whom mining is their main activity and therefore remain active even under adverse conditions. The small mining sector faces several limitations, which are even more severe at artisanal level. As a whole, the sector is highly unstable with a large number of seasonal miners who also tend to be the smallest ones. The most formal part of this sector is found in the processing facilities.

Chilean small-scale mining exploits underground mines, open pits, buddling (washing) tanks, and tailings in very rudimentary and low-cost ways. Underground mines constitute the most widespread method of extraction. To process the minerals, small plants use flotation, leaching or amalgamation. These processes are performed with old inefficient methods without any environmental consideration. Although the use of mercury is not massive, there are identified effects over those who participate directly in the process. It can be concluded that the small mining sector in Chile, given its low levels of production, wide geographical dispersion, and very arid climatic conditions in the areas where the production takes place – does not constitute an important factor for environmental pollution. However, it may pose some local hazards associated with the operation of processing plants and tailings disposal. There are also direct risks for the miners that operate directly in contact with mercury.

Informal gold mining accounted for about 40 % of total gold production in Peru in 1995 and in 1996. The environmental effects of informal mining depend on the type and area of operation. Artisanal operations like ingenio and pushcarts have little environmental impact given that they produce small amounts of gold and remove little material, so the jungle can recuperate easily. The exploitation of beaches and riverbeds are quickly reverted when rivers swell during the rainy season. Piedmont operations have larger impacts because they remove more material and use oil and lubricants. However, because they work in flat areas, erosion after the operation is abandoned is limited, allowing the jungle to quickly recover.

The operation of front-end loaders in the Amazon foothills has by far the greatest environmental impact. This result is due to the type of operation and because, as the largest producers of gold in the area, they account for most of the mercury contamination. A typical operation using a front-end loader starts by cutting trees and burning the thicket. Then material and rocks are removed using the front-end loaders, which compacts the soil and makes the recovery of the jungle difficult. Land removal and the separation of gravel according to its size affects the water streams and pollutes them with fine particulate (lime). This affects aquatic life in the region. Finally, the excavation of terraces as well as waste disposal promotes erosion even after the operation is finished. Consequently, the ability of the jungle to recover once the operation ceases, is very limited. These operations have important additional environmental effects due to the incorrect use of mercury, petroleum and lubricants.

Underground informal mining in the Ica-Arequipa region exploits thin veins with relatively high-grade ores that are disseminated across the region. As the area of exploitation is a desert, water is scarce and there is little flora or fauna. In this context, mining has little environmental impact. Artisanal mining has much less impact than traditional mining, which uses more explosives, demands more water, and removes much more material. The main

environmental problem associated with this activity is related to mineral processing in the quimbaletes with the corresponding use of mercury and burning of amalgam. Leaching plants also have some environmental impacts, especially those that process quimbaletes tailings containing mercury. Mixed with cyanide, this process can render very toxic compounds. However, these plants are easier to monitor and environmental controls can be easily enforced.

Another potential source of pollution is tailings dust. When tailings dry, mercury contained in them quickly evaporates. The dryness of the area together with strong winds spreads mercury across vast areas. Tailings dropped along roads between quimbalete centres and leaching plants are also a source of pollution. Winds spread them quickly, and they eventually contaminate water sources.

The basin of the Mantaro River in the central highlands of Peru hosts a large number of small- and medium size underground mines that exploit polymetallic ores with high sulphur content. Mines in this area have been worked for decades and there are numerous underground open galleries, chimneys, and tunnels where acid mine drainage (AMD) is common. Acid water leaches metals contained in the rock and these mine waters end by polluting the streams in the region and AMD is an important environmental problem in the area. Tailings management and AMD are the main environmental problems resulting from mining activity in the Mantaro basin. Both have a very negative impact on water quality of the area.

The World Bank study noted that the most important environmental problems in the ASM sector are:

- Mercury disposal
- Direct dumping of tailings and effluents into rivers
- Improperly constructed tailings dams
- Acid mine drainage arising from the tailings dams or open galleries
- Improper closure
- River damage in alluvial areas
- Sand erosion damage at the edge of highland areas.

In these three countries, the ASM sector usually exhibits serious inefficiencies even when profitable. Poor creditworthiness and management capacity has led to a subsequent lack of access to formal credit markets, which often results in the use of inefficient techniques. Attempts to establish government-owned mining banks have all been unsuccessful (McMahon, *et al* 1999). The establishment of well-defined property rights would be more helpful in this regard than special credit schemes. Special attention should also be paid to the larger claim areas needed by alluvial gold miners, in particular with respect to concession fees.

In addition to these problems, there is the great difficulty in monitoring and enforcing environmental violations due to a lack of resources and the widely scattered and inaccessible nature of the sector. Occupational health and safety concerns were severe in all three countries. Given the difficulty in monitoring and enforcement of environmental violations, it seems clear that only solutions, which are of a win-win nature, are likely to have much success. The studies have shown that the ASM sector is very heterogeneous and there are likely to be many cases where effective interventions can be made. The emphasis needs to be on incentives or ways of internalising the environmental costs, rather than traditional monitoring and enforcement. There is also a need to work together with medium and large mines, especially with respect to the construction or use of shared tailings dams and processing facilities.

Education programmes have played an important role in all three countries and the study recommends that in Chile, environmental education and other programmes become a new focus of the Government. Where ASM is not economically feasible and environmentally destructive, it should not be encouraged to continue. Mining policy should not substitute for social policy.

Strategies that should be implemented for ASM sector is that government should provide technical assistance to artisanal and small mines, especially with respect to the use of more productive and environmentally benevolent technologies. However, this assistance should only be provided if:

- The mines are economically viable, including environmental costs.
- The resources cannot be profitably exploited at a larger scale. When the mine is not viable, the focus should be on poverty alleviation, not mining.

Property rights should be established for artisanal and small miners. Inefficient and environmentally unsound techniques are often directly because of inadequate property rights. Under specific circumstances, the environmental effects of ASM could be remedied without jeopardising the profitability of the enterprises. Innovation and adaptation should be encouraged in such cases. Research programmes have a critical role to play in the development and dissemination of economically profitable and environmentally sound mining practices.

Cultural considerations are increasingly important as mining may cause irreversible cultural damage due to the invasion/entry of sensitive tribal lands. Solutions should be sought that maximise the benefits of mining to indigenous groups while minimising the damage to their environment and cultures.

In general, the impacts of the small mining sector are:

- Environmental risk due to plant location in an urban zone or near rivers or natural water courses
- Soil and riverbank pollution because of liquid effluents
- Filtration and overflows from tailings dams
- Soil pollution by domestic waste.

ASM is unlikely to disappear unless there are substantial other economic opportunities. In all three countries, entry into the small mining sector was largely the result of a lack of other economic opportunities coupled with low start-up costs. While ASM is a substantial source of employment, miners seem highly mobile both within the sector and to employment outside of the sector.

4.9 THE IMPACT OF SMALL-SCALE MINING ON THE ENVIRONMENT - SOUTHERN AFRICA CASE STUDIES

Typically, the magnitude of the impact is limited to the locality of the small-scale mine as these mines are generally not deep mines and are largely related to riverine alluvial deposits (dry and wet). Small-scale mining activities, particularly the unlicensed (artisanal) type, seldom have access to appropriate technologies or mining methods. Most of the activities are not subject to proper health, safety and environmental controls, nor are they easily manageable by mining authorities. Specific concerns relate to:

- Accelerated erosion of areas adjacent to workings that have been de-vegetated for construction materials or fuel wood leads to increased suspended sediment loads in nearby streams and rivers.

- Excavation of flood terraces and riverbanks increases the instability of these riverbanks and enhances the likelihood of increased flood scouring.
- Alteration of river channels and flows due to mining of alluvial deposits in the river bed.
- Excavation of river sediments exposes these sediments to oxidising conditions and enhances the solubility and release of any metal ions that may previously have been previously trapped as insoluble sulphides.
- Acid mine drainage and associated water quality problems in receiving waters:-
 - Lower pH values – altered chemical equilibrium.
 - Increased metal concentrations – toxicity to aquatic organisms and human users.
 - Increased total dissolved salts – salinization problems for agriculture and sensitive users.
 - Unightly / toxic precipitates in streams.
 - Increased sediment loads – loss of habitat.
 - Increased water treatment costs to other users.
 - Corrosion problems in distribution systems.
- Gold panning and operation of sluice boxes increases loads of suspended sediments in downstream reaches.
- Wash-off of mercury used to concentrate gold leads to increased risks of mercury toxicity to aquatic and terrestrial organisms, as well as to the miners. Examples of this have been recorded on the Mazowe alluvial gold diggings in Zimbabwe (Ashton, *et. al.* 2001).
- Wind-blown dusts from unprotected tailings and waste rock dumps enter aquatic environment.

According to a South African study undertaken by the MEPC (1998) the environmental impact is by far the most damaging at illegal artisanal operations. Of the mining sites visited in the study, the brick-makers of KwaZulu-Natal and illegal gold mining and panning operations of Mpumalanga were identified by the research team as being the main offenders in terms of impacts on the environment. These miners did not see any need to rehabilitate the mine site, monitor or control water quality or minimise contamination and siltation (MEPC, 1998).

In contrast, legal artisanal miners questioned in the study all understood the importance of backfilling mined out areas. Most “larger” operations that employ some form of mechanised approach suggested that they did not need to improve their environmental controls. They indicated that their operations and rehabilitation practices conform to their approved Environmental Management Programme Report (EMPR) as well as to environmental legislation. Most of the respondents however, indicated that there is a need for ongoing environmental controls. Most said that this should be the responsibility of the mine itself.

According to the MEPC (1998), the mines that use chemicals in the beneficiation process do not take any precautions to prevent the contamination of soil or water. The following chemicals are listed as being used by small-scale miners, although the actual use and users of each of the chemicals were not specified by the MEPC (1998): sodium, sodium cyanide, hydrous ferric chloride, potassium iodate, fatty acids, mercury and caustic soda. No indication was given in the report how these chemicals are being used. The use of mercury by gold miners is of particular importance. The mercury is used for the extraction of gold concentrate and provides both a health and environmental risk (Table 2).

Relying solely on the enforcement of any statutory regulations and standards to control and reduce environmental damage by small-scale mining is unlikely to work. An ‘inventory approach’ measuring pollution per unit output is a potential tool for assessing environmental

impact. The specific water-related impacts of small-scale mines are discussed in detail in Chapter 7.

4.9.1 Gold Mining

Much of the small-scale gold mining activity that takes place in South Africa occurs within the Barberton area of Mpumalanga and along the Swaziland border with KwaZulu-Natal (MEPC, 1998). According to the MEPC (1998), the miners are generally exploiting rich **vein deposits**, rather than panning for gold within the rivers. Small-scale gold miners extract gold by crushing or panning the ore and amalgamating the concentrate. Mercury vapour generated when the amalgam is heated to recover the gold poses a health hazard to the miners. The tailings from the process also contain large quantities of mercury, which pollute the surrounding areas and constitute a long-term threat to catchment areas.

Gold is also **panned**, illegally mostly, on quite an extensive scale and scattered over a very large area in Gauteng Province. Alluvial gold panning is dependent on the flow of water. The alluvial sands are removed and sieved. This form of small-scale gold mining does not make use of chemicals. Alluvial gold panning impacts negatively on the environment through vegetation removal. Most of the places where gold is panned in such a way correspond to the remnants of old gold mines, which have ceased operations many years ago on their old mine dumps. Some of the above mentioned areas are adjacent to or part of squatter camps. Because these illegal miners need water to pan their material, the gold containing soil is collected and carted to the closest ditch, dam or any other source of water, which is readily available. The soil is then panned out for gold to form a concentrate. Thereafter, a small amount of mercury is used to form a molten button, which is sold. Most of the known sites do not have running water or natural streams but ditches filled with water (J.P. Lourens, Gauteng DME, *pers. comm.*). The result of the above mentioned illegal mining operations is a landscape full of hollows and trenches. In one such case, the toe paddocks of one of ERGO's dumps have been destroyed due to such illegal mining.

Illegal gold operations in Mpumalanga did not see any need to rehabilitate the mine site, monitor and control water quality or minimise contamination and siltation. Studies undertaken on small-scale gold mining operations in Zimbabwe have shown that rivers and dams have become silted up at specific locations as a result of gold mining operations (ESRC, 2000). According to the ESRC (2000), it is estimated that over three ton of mercury are being discharged into Zimbabwean rivers and dams, per annum.

The MEPC (1998) suggested that water pollution and health safety concerns related to the use of mercury could be alleviated through the development of gravity-based equipment. It has also suggested that support systems need to be set up that can encourage better mining practices. These may include the development of environmentally benign processing equipment or the establishment of toll treatment facilities that would remove individuals from direct exposure to mercury.

Mintek has successfully developed an alternative to the hazardous amalgamation method (Mining Africa, 2000). This process is based on chloride leaching, using inexpensive and easily obtainable reagents. As the reducing reaction is highly selective, the gold product is very pure and thus commands a higher price. It is reported that earlier this year, about 100 miners from the mining areas near Barberton attended demonstrations of this new process.

4.9.2 Sand-winning

Little is known internationally about the environmental impacts of sand winning operations. Information on the impacts of these operations on the instream and riparian habitats have been reviewed by Hill and Kleyhans of the Institute of Water Quality Studies (1999).

4.9.2.1 Types of sand-winning operations

Hill and Kleynhans (1999) have classified sand-winning operations into four types:

- **Dry-pit mining:** mining of pits on dry ephemeral streambeds and exposed sand bars with conventional bulldozers, scrapers and loaders.
- **Wet-pit mining:** involves the use of dragline or hydraulic excavators to remove sand or gravel from below the water table. Dewatering is usually undertaken.
- **Bar skimming:** this requires scraping off the top layer from a gravel bar without excavating below the water level.
- **Mining of pits on adjacent floodplains or river terraces:** this refers to the mining of a pit that has been isolated from the main channel. Sudden changes in channel course during a flood, or in the gradual migration may breach small levees and the channel will shift into the sand or gravel pits.

4.9.2.2 Impacts of sand-winning on riverine habitats and biota

Sand-winning operations occur throughout South Africa and thus have a widespread impact on a national level. Extraction of alluvial material from within or near a streambed has a direct impact on the stream's physical habitat characteristics. These characteristics include channel geometry, bed elevation, substrate composition and stability, instream roughness elements (large woody debris, boulders, *etc.*) depth, velocity, turbidity, sediment transport, stream discharge and temperature (Hill & Kleynhans, 1999). Altering these habitat characteristics can have deleterious impacts on both instream biota and the associated riparian habitat.

The detrimental effects to biota resulting from bed material mining are caused by three main processes:

- Alteration of the flow patterns resulting from modification of the riverbed.
- An excess of suspended sediment.
- Damage to riparian vegetation and instream habitat. The disturbance activities can also disrupt the ecological continuum in many ways.

Local channel changes can propagate impacts upstream or downstream and can trigger lateral changes. Alterations of the riparian zone can result in changes in channel conditions that can have impacts on the aquatic ecosystems.

The interconnectedness of channels and riparian systems requires the simultaneous evaluation of potential disruptions of the riparian zone and channel activities. For example, aggregate mining involves the channel and boundary but requires land access and material storage that could adversely affect riparian zones, *e.g.* construction and access roads.

The following mining operations have been listed (Hill and Kleynhans, 1999) as impacting on the instream habitat:

- Extraction of bed material in excess of natural replenishment
- Changes to the morphology of the channel
- Operation of heavy equipment in the channel bed
- Altering channel hydraulics
- Removal or disturbance of instream roughness elements

The following mining operations have been listed (Hill and Kleynhans, 1999) as impacting on the riparian habitat:

- Direct destruction of the riparian vegetation and riparian zone.
- Lowered floodplain groundwater because of lowered level of channel water.
- Permanent flooding or ponded water.

- Disturbance of the natural hydraulics of the riparian zone during infrequent elevated flow levels.
- Reduced vegetative bank cover.
- Destabilisation of riverbanks.
- Increased sediment inputs.

Illegal sand-winning operations in KwaZulu-Natal raise serious concerns about management of the environment and about sustainable management of the mineral resources (MEPC, 1998). Uncontrolled sand-winning can cause water siltation, salination and instability, and leave unsightly scars. Illegal operators do not approach a resource with a long-term perspective for its exploitation. They merely pick the easy from the resource and generally discard the more difficult and lower grade aspects. Thus, a viable resource is destroyed and can no longer be mined on a cross-subsidised, sustainable basis over a long period (MEPC, 1998).

4.9.3 Peat Mining

There is currently a lack of knowledge regarding the utilisation and rehabilitation of peatlands. The Agricultural Research Council has been commissioned by the Department of Agriculture to undertake research on peatlands. The aim of this project is to develop an inventory of selected resources in the Highveld areas as well as to provide guidelines regarding the management of peatlands (Agricultural News, 2000). At this stage, a draft set of guidelines has been developed by the Peat Working Group (PWG) (Peat Working Group, 2000). Thorough research is needed to establish a basis that can support legislation and decision-making regarding the utilisation of peatlands. The PWG aims to make the relevant government departments aware of the ecological and the hydrological importance of peat, and the extent of the impact of peat extraction and other activities on the resource base. The PWG has also established a Peat Forum as a means of enhancing communication and understanding between the various role-players in the peat-industry.

4.9.4 Diamond Mining

Small-scale diamond operations in Gauteng Province occur in Cullinan, Carletonville and Vereeniging districts and are mined along river courses due to their alluvial origin. Most of these operations do not cause major water-related problems since the gravel which is mined, is screened for diamonds and is then backfilled into the holes dug. The areas where small-scale diamond mining is causing problems are the sites along rivers where the course of the river is altered by mining. Such areas include small-scale diamond mining operations along the Vaal and Orange Rivers. Diamond mining does not add chemical pollutants to the water used in the process other than silt (Loubser, DME, Gauteng, *pers. comm.*). It should be noted that sand-winning and alluvial diamond mining operations comprise the greatest proportion of small-scale mining operations in South Africa.

4.9.5 Clay and Coal Mining

Coal mining impacts are well established and the impacts on water quality include high acidity (as sulphuric acid), iron and sulphate. Sulphuric acid and ferrous iron, resulting from chemical and biological oxidation of pyrite originate from coal mine waste dumps and mined out areas that are not adequately sealed or rehabilitated.

Small-scale mining of coal in South Africa is mainly artisanal for subsistence. Most of the coal mining that takes place on a small scale is illegal. Typically, this mining takes place on waste dumps, discharge dumps, closed mines where adits have been illegally re-opened, or where coal seams have been exposed during large scale mining operations and are too thin or

unsafe to be mined viably (Plate 1). The examples of small-scale mining visited in this study were at Osizweni and Nongoma.

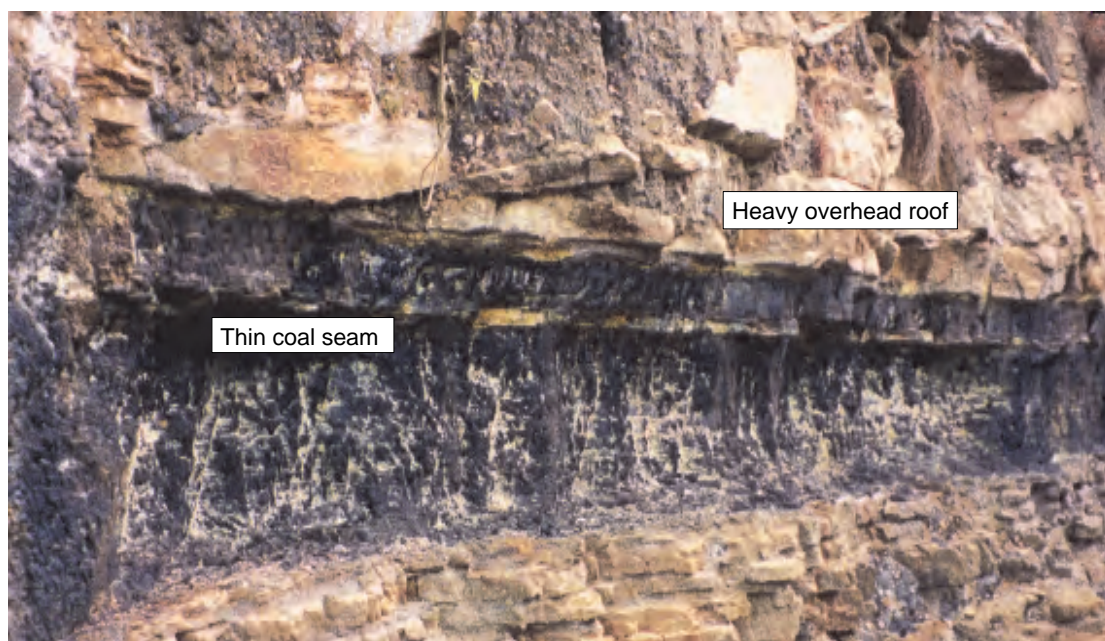


Plate 1: Exposed coal seam that is being mined by small-scale miners.

The Osizweni mining operation was a small-scale mining pilot study. In this diverse operation, coal and clay were mined. Bricks are manufactured and fired on site. The major impacts associated with this mine was that the groundwater was being contaminated by the exposure of the pyrite to air and water. This form of mining is unsafe as the miners have opened an adit of an old abandoned mine and are mining underground under existing buildings without proper mining equipment, mining techniques or safety equipment. The excavations are unstable, with no sidewall support and many incidents of wall collapse occur. Not only have large areas been excavated, which will not be rehabilitated, but they have also been filled with contaminated water.

There have been fatalities, primarily caused by the collapse of walls and pathways that run through the various operations, which are gradually being undermined and eroded. This area is not safe for any use due to the large opencast mining areas not being rehabilitated or landscaped. The accessibility to the water in the open pits can result in animals and humans drowning. In addition, none of the brickmakers wear any form of protective clothing or footwear and many women and children are involved in the operation (MEPC, 1998). The miners wade through decant water that is contaminated by pyrite exposure. The effects of the miner's skin being exposed to this type of water were evident during the site visit.

In Gauteng Province, clay mining occurs mostly in the Bronkhorstspuit and Magaliesberg Moot areas. The extractive nature of clay mining results in a big hole in the ground remaining, which is left to fill with rainwater. Pollution of groundwater can occur if toxic material such as dove coal is allowed into such a water-filled mine pit.

4.9.6 Other types of mining

Minerals exploited on a small to junior scale (defined as operations employing up to 200 employees) include gold, diamonds, semi-precious stones, industrial minerals (including feldspar, mica, fluor spar, andalusite, sillimanite, barytes and pigment materials) (MEPC, 1998). There is significant small-scale mining activity, much of it being illegal, in the gold,

diamonds, clay, sand and coal sectors. Ashton *et al.* (2001) has indicated that there are over 1 900 “active” mines identified in the Limpopo and Olifants River basins in southern Africa and over 1,700 abandoned mines.

Other types of small-scale mining operations include a verdite mine near White River in Mpumalanga. One person is employed in this pick and shovel operation (MEPC, 1998). Similarly, pegmatite is mined in Namaqualand in a pick and shovel operation that only employs one person.

4.10 MANAGEMENT OF SMALL-SCALE MINING OPERATIONS

Environmental legislation is governed by the National Environmental Management Act of 1998, the Minerals Act of 1991, the EIA guidelines of 1997, the Environment Conservation Act of 1989, and the Aide Memoire requirements of 1992. Many of these regulations are unintelligible to small and artisanal miners who rarely adhere to the standard guidelines nor do they engage in any rehabilitation programmes.

Since the drafting of the Minerals Act of 1991, all small-scale mining operations applying for prospecting or mining permits are forced to pay a deposit for rehabilitation. Many of them find this a burden and this leads to non-registration or alternatively to illegal mining (Drechsler, 2001). Similarly, the requirements of the environmental impact assessments are beyond the capacity of the small-scale miners who have neither the resources nor the capacity to carry out such an assessment.

In cases where small-scale miners are receiving state assistance in the form of the National Steering Committee, the deposit and environmental impact assessment requirements are adhered to and agreements are reached between the project and the DME. In some instances, the DME has waived the environmental requirements and requested a deposit for post mining rehabilitation. The reality is that such deposits are too low to conduct post mining rehabilitation and the problem therefore remains (Drechsler, 2001).

Table 2: Typical impacts associated with small scale mining of coal, gold, diamonds and sand.

Mining type	Typical water quality problems	River diversion	Riparian vegetation	Human health impacts	Aesthetics	AQUATIC LIFE
Coal recovery from waste dumps	Low pH, high sulphates, iron, manganese, metals	None	Limited to re-habilitated areas	Potential for collapse of waste dumps	Limited, can cause scouring and erosion	Toxic, increased salinity (TSS)
Coal recovery from closed mines – adits re-opened	Low pH, high sulphates, iron, manganese, metals	Minimal except if flow too high	None	High due to hazardous mining in closed, abandoned areas	Minimal	Minimal except if adit decants into a river
Gold panning	Turbidity(sedimentation) Mercury (if beneficiation), metals	Only when flow is too high to work in river bed	Removal of vegetation	Limited except if using mercury for beneficiation	Removal of riparian vegetation	Smothering of riverine habitat by silt, fish gill clogging
Gold alluvial sand pumping and sorting	Turbidity (sedimentation), mercury (if beneficiation), metals	Only when flow is too high to work in river bed	Removal of vegetation	Adverse if mercury used	Discard sand and rock dumps	Toxic
Gold magmatic reef	Localised pH, high sulphates, arseno-pyrites, cyanide, metals (Zn, Cu, Mn, Fe)	None	Minimal	Adverse if drinking contaminated water	Discard sand and rock dumps	Toxic
Diamonds - alluvial	Turbidity (TSS)	Frequent occurrence	Removal of vegetation	Minimal	Discard sand and rock dumps, unrehabilitated holes	Smothering of riverine habitat by silt, fish gill clogging
Sand dragline (wet pit mining)	Turbidity (TSS)	Berms built into river for greater access	Removal of vegetation	Minimal	Discard sand and rock dumps	Smothering of riverine habitat by silt, fish gill clogging, removal of benthic organisms and habitat
Sand deposited adjacent flood plain	Turbidity (TSS)	Minimal	Removal of vegetation	Minimal	Discard sand and rock dumps	Smothering of riverine habitat by silt, fish gill clogging
Sand bar skimming	Turbidity (TSS)	Frequent occurrence, stop flow of river	Removal of vegetation	Minimal	Discard sand and rock dumps	Smothering of riverine habitat by silt, fish gill clogging

4.10.1 Environmental Management Programmes and Mining Authorisation

In terms of Section 39(1) of the Minerals Act, 1991, an Environmental Management Programme (EMP) in respect of the surface of land concerned in any prospecting or mining operations, shall be submitted by the holder of a prospecting permit or mining authorisation to the regional director concerned for his approval. Also, subject to Section 39 (4), no such operations shall commence before obtaining such an approval. The regional DME offices issue three types of mining authorisations in respect of all minerals (Figure 3):

- A mining permit is granted for smaller operations and shorter periods (costs R50).
- A mining license is granted for larger operations and longer periods (costs R100).
- A prospecting permit is issued for one year only (can be renewed) at a cost of R50.

The permits and licenses are issued following the approval of the EMPR. A series of Standard Environmental Management Programme Reports (SEMPR's) have been developed by the DME for the management of the small-scale mining sector. These dedicated SEMP's are based on the same principals as the Aide Memoire for the Development of EMPR's (DME, 1998). The rationale behind the development of SEMP's is the need for a different approach to certain types of mining motivated by the nature of the activity and the magnitude of the impacts to be addressed. The approach is based on the

provision of specific and detailed management requirements in the SEMP that aims at the prevention and pro-active minimisation of the risks. Thus, a common standard in environmental management that acknowledges activity specific circumstances is ensured.

In general, these documents may be used in the following instances:

- Where the exploitation of minerals is by means of the open-cast mining method; and
- In circumstances where not more than 600 000 ton of ore are removed per annum (including overburden) and/or
- When the total area disturbed by mining activities is restricted to approximately 10 hectares at closure.

These documents may not be used in the following instances:

- In the case of coal mining or the exploitation of any mineral containing sulphide; and
- The exploitation of any mineral, metal or rock in a sensitive area or environment.

According to this definition, a sensitive area or environment can be described as an area or environment where an unique ecosystem, habitat for plant and animal life, wetlands or conservation activity exists, or where there is a high potential for ecotourism. Specific limitations for the use of each of the dedicated SEMP's are also given. The following SEMP's have been developed by the DME:

- Standard Environmental Management Programme for the Slate Industry (1997).
- Standard Environmental Management Programme for prospecting (1996).
- Environmental Management Programme for the mining of sand from a River, Stream, Dam or Pan (1995).
- Standard Environmental Management Programme for the mining of land-based precious stones (1999).
- Standard Environmental Management Programme for Crusher Operations at Waste Rock Dumps (1997).
- Standard Environmental Management Programme for Prospecting/Mining of Precious Stones in the Concession Area and Surf Zone (1997).
- Standard Environmental Management Programme for small-scale Prospecting/Mining of Gold Deposits in Magmatic Reefs or of Alluvial/Colluvial Nature (1995).
- Abridged Aide Memoire (1994).
- Standard Environmental Management Programme for Provincial Administrations and the South African Roads Board with regard to Gravel, Sand, Soil and Clay Quarries for Road Building Purposes: Section 39 of the Minerals Act, 1991 (Act 50 of 1991).
- Guideline Document for the Sorting of Bantams and the Recovery of Precious Stones by small-Scale operators making use of non-mechanical equipment (unknown).
- Guidelines for the Preparation of an Environmental Management Programme Report for the Mining of Offshore Semi-Precious Stones (1997).

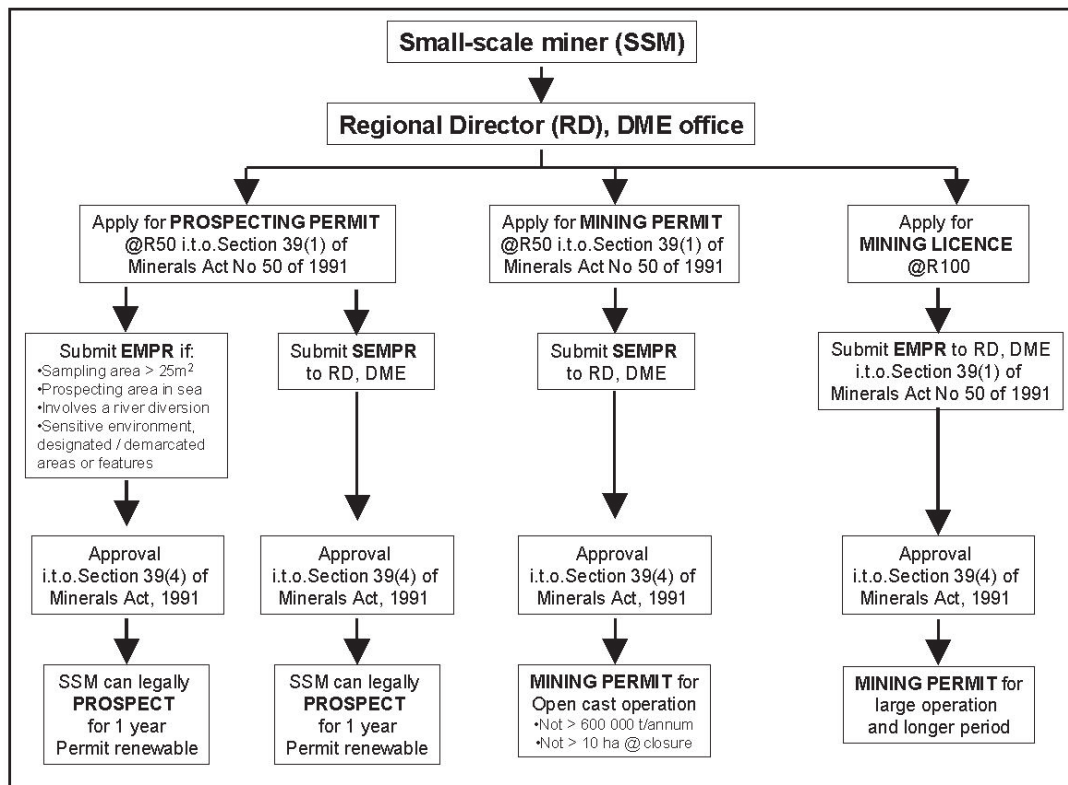


Figure 3. Structure for authorisation of mining and prospecting (2001).

4.10.2 Regulations on the use of water

The use of water for mining activities is controlled by the National Water Act, No. 36 of 1998. Water use includes, amongst others, the storing of water, activities that reduce stream flow, waste discharges and disposals, alteration of the watercourse and the removal of groundwater. In general, a water use must be licensed by the Minister of DWAF.

Section 26(1) of the National Water Act provides for the development of regulations. The regulations on use of water for mining and related activities aimed at the protection of water resources were published in Government Notice No. 704 (1999). Operational guideline M6.0 details these regulations and gives guidelines as to how they should be implemented. This guideline M6.0 is currently a consultative publication and the final guideline is still to be published. Some of the regulations having specific implications for the management of small-scale miners are detailed below. Note that a water use licence has higher authority than the regulations. Exemption from any of these regulations does not negate the need for a water use licence. The exemptions are to be listed in the water use licence.

4.10.3 Restrictions on locality of mine operations and mine facilities

In terms of the regulations any residue deposit, reservoir or any other facility may not be located within the 1:100 year flood-line or within a horizontal distance of 100 metres from the watercourse. With the exception of the mining of alluvial materials or sand winning operations, no mining operations may take place within the 1:50 year flood-line or within a horizontal distance of the 100 metres from the watercourse (whichever is greatest). No sanitary convenience, fuel depots, reservoir, or depots for any substance that is likely to cause pollution of the water resource, may be located within the 1:50 year flood-line.

4.10.3.1 Specific Regulations referring to the extraction of alluvial materials

No person may extract sand, alluvial minerals or other materials from the channel of a watercourse or estuary unless reasonable precautions are taken to:

- Ensure that the stability of the watercourse is not affected.
- Prevent scouring and erosion of the watercourse or estuary which may result from such operations.
- Prevent damage to in-stream or riparian habitat through erosion, sedimentation, alteration of vegetation or structure of the watercourse, or alteration of the flow characteristics of the watercourse.

Slimes dams or settling ponds may not be constructed within the 1:50 year flood-line or within a horizontal distance of 100 metres from any watercourse.

Every person winning sand or alluvial materials, must:

- Construct water treatment facilities to treat water to the prescribed standard.
- Construct stockpiles outside of the 1:50 year flood-line or a horizontal distance of 100 metres from the watercourse.
- Implement control measures that will prevent the pollution of any water resource.

4.10.3.2 Capacity requirements of clean and dirty water systems

In terms of Regulation 6, all unpolluted water is to be kept away from any dirty area. All dirty water control systems must have a minimum freeboard of 0.8 metres above the full supply level. Effective measures must be taken to minimise the flow of any surface water into mine workings.

4.10.3.3 Protection of Water Resources

In terms of Regulation 7, reasonable measures need to be taken to prevent any substance that can cause pollution from entering any water resource. The mine must also ensure that the water system is kept free from any matter or obstruction that may affect the efficiency thereof.

4.10.4 The Regulation of Peat Extraction

In terms of the Minerals Act, No. 50 of 1991, “a mineral means any substance having being formed by or subjected to a geological process”. As such, peat does not fall into this definition and is not regulated by the Minerals Act. Peat mining is thus not regulated by the DME. A permit for the extraction of peat is issued by the Department of Agriculture in terms of Section 6 of the Conservation of Agricultural Resources Act, No. 43 of 1983. On an international level, wetlands (many of which contain peat) are protected under the Ramsar Convention to which South Africa is a signatory.

The Department of Agriculture chairs the Peat Working Group, which is composed of other government departments with an interest in the regulation of peat. These departments are DWAF, the Department of Environmental Affairs and Tourism (DEAT), DME and relevant provincial authorities. These departments advise and support the Department of Agriculture in evaluating applications to extract peat (Peat Working Group, 1999). The PWG is responsible for regulating the commercial utilisation of peat resources in South Africa.

In making decisions, the PWG is guided by principles contained in the National Environment Management Act, No. 107 of 1998. In order for the PWG to make these decisions, it requires information on proposed peat extraction operations. The PWG has suggested (1999) that most this information to be generated is through the environmental impact assessment (EIA)

procedure. The Peat Working Group has thus developed a draft set of guidelines for the contents of the EIA report. These reports are to follow the EIA guidelines published by the DEAT in 1998. In the draft guidelines the PWG have however, listed additional information that should be included in the EIA report, specifically relating to peat extraction. Generally, these include:

- A detailed project description.
- Hydrological information.
- Conservation status of the watercourse.
- A description of the “wetland benefits” (*e.g.* water supply, flow regulation, erosion control, nutrient removal and retention, *etc*).
- A description of the cumulative effects of the peat removal.
- An environmental management plan.

4.10.5 Mineral Development Draft Bill

The South African Mineral Development Draft Bill was released for public comment at the end of 2000. The draft Bill is a radical departure from previous Bills particularly with respect to the ownership of mineral rights. One of the principles of this Bill states that the development of mineral resources will take place within the framework of sustainable development and environmental management and will be regulated in accordance with national environmental management policy, norms and standards. Key aspects of the Bill which affect the small scale mining sector are:

4.10.5.1 Mineral rights

The Bill intends reverting all mineral rights to the State. On commencement of the new legislation, prospecting rights, mining rights, retention permits and permission to remove minerals will only be granted by the State. Small-scale miners require clarity on a number of issues, in particular:

- How the provisions of the Bill will deal with compensation for mineral rights under the existing regime?
- The position of land claimants, which is subject to new or existing mineral lease or mine developments .
- The position of traditional communities regarding land and mineral rights.

4.10.5.2 Small-scale mining sector

There is a lack of policy and guidelines for the small-scale mining sector in the Bill. Small-scale miners expressed the need for the following (Drechsler, 2001):

- Access to finance.
- Availability of geological data
- The creation of one-stop shops to make application procedures easier.
- A “Mineral’s Bank”, similar to the Land Bank, to be set up to assist in the raising of finance.

4.10.5.3 Minerals and Mining Development Board

The Bill proposes to establish a Minerals and Mining Development Board to advise the Minister on policy matters relating to the subject matter of the Bill. Any recommendation by the Board shall be of an advisory nature only. The small-scale miner’s wanted to ensure that this board would also consider their recommendations (Drechsler, 2001).

4.10.5.4 Ministerial Discretion

Small-scale miners wanted to see more checks and balances as far as ministerial discretion is concerned (Drechsler, 2001).

4.11 ALTERNATIVE METHODS OF REGULATING SMALL-SCALE MINING OPERATIONS

As the implementation of regulations and the enforcement of legislation are not always possible to ensure protection of the environment, alternatives need to be considered. Regulatory control of small-scale mining operations is limited by lack of manpower as well as the remoteness of several of the mining sites. According to the ESRC (2000), based on studies undertaken in Bangladesh and Zimbabwe, a direct incentive or financial return to the entrepreneur could be more effective. The use of cleaner and better technology that can actually save the miner money is more likely to be successful.

Another potentially effective tool is the use of voluntary compliance methods to encourage improved environmental performance (ESRC, 2000). The involvement of stakeholders, *e.g.* neighbouring communities, consumers, should be promoted. For a stakeholder approach to enforcement to be successful, there is a need for training and the introduction of awareness-raising programmes.

5. NATIONAL INVENTORY

The aim of the inventory was to provide DME, DWAF and DEAT with an information database that will catalogue the most significantly degraded areas. This will allow these departments to prepare a priority list of areas to be rehabilitated, and thus to implement strategies to prevent, minimise and redress environmental impacts. However, it was realised early on in the project that the development of a full scale national inventory of small scale mining was unrealistic as part of this project (see Section 5.3).

In the meeting held with representatives of the DME and DWAF during the initial stages of the project (9 February 2000), it was suggested that the national representatives could assist in the co-ordination of the information required for the development of an inventory of small-scale mining sites within the different regions. Contact details of regional representatives were provided and the following events subsequently occurred as described in a flow diagram (Figure 4).

5.1 INVENTORY DATA COLLECTION PROCESS

The regional representatives of the DME and DWAF were contacted telephonically and forwarded a letter announcing the project. The following information was requested from the Authorities:

- A list of small-scale mining types occurring within different provinces.
- Details regarding the areas/sites where the above mining types currently occur.
- An indication of the water-related impacts currently associated with each of these small-scale mining types.

Very little response was received from the initial contact made. Thus the regional representatives were contacted again with the intention of collecting information on the location of small-scale mines, the scale at which mining operations occur (micro, medium or large) and the number of mining operations that occur.

A map and a data collection table were forwarded together with a letter requesting information. This map forms part of a Geographical Information System (GIS), (Figure 5) an example of which is included in the CD Rom available from the WRC. Information was received from the Northern Province (NP) DME and the Western Cape Province DME. Several representatives responded telephonically indicating that they are unable to assist and gave contact details of the relevant persons.

Representatives of the regions that did not respond to the data request indicated above were contacted again. In most cases, the representatives referred PHD to other representatives in the departments that deal directly with mining. The individuals were contacted and requested to send any available information to PHD. In general, the representatives have indicated that the information is not readily available and would need to be collated before forwarding it to PHD. The DWAF representatives have largely indicated that the DME is the lead agent with respect to the location of mines within the region.

Data were formally requested from the Minerals Bureau in Pretoria. Although no electronic information was provided, PHD was provided with reports published by the Minerals Bureau. Relevant information contained within these reports has been incorporated in the database. However, several of these reports are outdated and the status of mines listed will need to be confirmed. The Minerals Bureau indicated that they were reluctant to provide PHD with additional information as it is considered confidential. A GIS database was compiled based on all information received (Figure 5). The different mining types are expressed as a percentage in Figure 6.

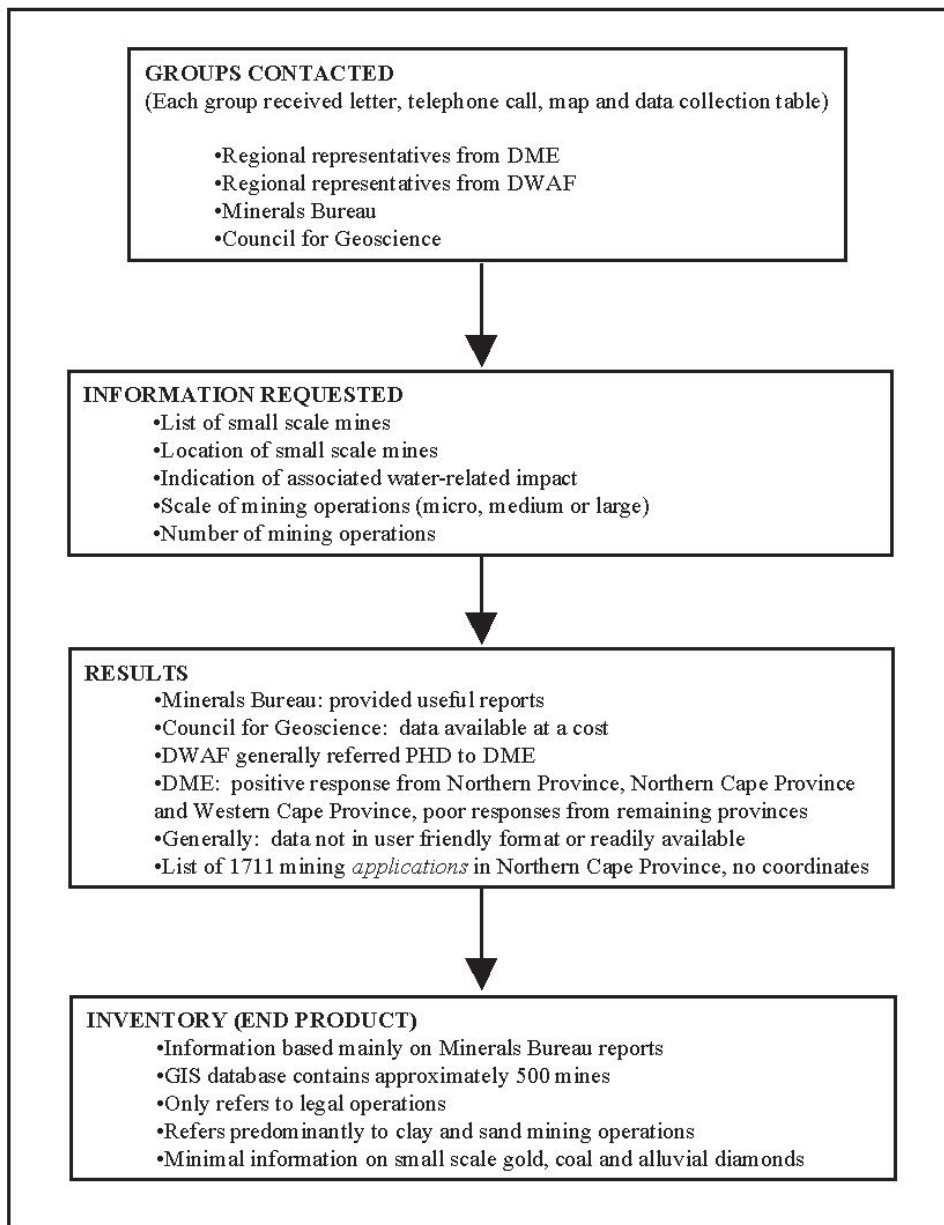


Figure 4. Flow diagram illustrating inventory compilation.

5.2 FEEDBACK AND RESULTS OF SMALL-SCALE MINE INVENTORY

The Council for Geoscience has developed a database of mineral deposits in South Africa. Information on the status of mined or not of clay, sand and alluvial diamond mining operations can be provided by this database. The Council has indicated that they are willing to provide this information at a reduced cost (50 % reduction). The contact web site for the Council of Geoscience is <http://www.geoscience.org.za>

Authorities in the different provinces identified areas where small-scale mining operations existed. The provinces and associated mining areas are listed in Table 3. The responses received from the authorities in each province in terms of the data requests is tabulated (Tables 3 and 4) and included in the CD Rom available from the WRC.

Table 3. Locality of mining operations based on information received from provincial authorities

Diamond Digging	
<i>Northern Cape:</i>	Along Vaal River between Barkley West and Delpportshoop (Sydney-on-Vaal)
	Gong-Gong
	Confluence of the Orange and Vaal Rivers (near Douglas)
<i>North West:</i>	Vaal River between Bloemhof and Wolmaransstad
	Bamboesspruit near Wolmaransstad
	Makwassie
	Mooi River between Boskop and Klerkskraal Dams
	Bakerville/Delareyville area
	Vaal River at weir in Orkney
<i>Gauteng:</i>	Pienaars River downstream from Cullinan Mine
Sand winning	
<i>KwaZulu-Natal:</i>	Port Shepstone
	Amanzimtoti
	Natal Midlands
	Hazelmere Dam
<i>Free State:</i>	Modder River upstream from Maselspoort
	Qwa-Qwa
<i>Mpumalanga:</i>	Wilge River near Bronkhorstspuit
<i>Northern Cape:</i>	St Helena Bay
<i>Eastern Cape:</i>	Swartkops River near Port Elizabeth
	Rivers in former Transkei (e.g. Umtata River)
Coal Mining	
<i>KwaZulu-Natal:</i>	Allandale Colliery (north of Dundee and west of Ballangeich)
Gold Panning	
<i>Mpumalanga:</i>	Kaap River near Barberton
	Treur River in vicinity of Pilgrim's Rest and Sabie.
<i>KwaZulu-Natal:</i>	Klipvaal Gold Mine
Peat Extraction	
<i>North West:</i>	Mooi River
<i>Gauteng:</i>	Wilge River near Bapsfontein/Delmas
Clay Mining	
<i>KwaZulu-Natal:</i>	Osizweni

5.3 INVENTORY SYNOPSIS

Approximately 500 mines have been included in the current inventory database (Table 4). The database is included in the CD Rom available from the WRC. Most of the mines listed in the inventory are based on information given by documents published by the Minerals Bureau in 1994, 1997 and 2000 and refer only to legal operations. Thus illegal operations are not included and some of the information may be outdated. The existence and locality of some of the mines needs to be confirmed. Most information refers to clay and sand mining operations and all records of the mining of these minerals have been included. Information on small-scale gold, coal and alluvial diamond operations is minimal. Information on the scale (micro, medium or large) of the small-scale mining operation is lacking. Information on illegal operations is also scarce. Information relating to applications for mining permits received by the DME in the Northern Cape is included in CD Rom available from the WRC. This database contains over 1700 applicant entries and contains a description of the type of minerals for which mining permits are being applied for. It does not however state how many

of these applications have been granted. Of the 1 748 applications received, 1 561 (89.3 %) were applications for diamond mining.

Based on correspondence with DME representatives and on a visit to the DME offices in Gauteng, indications are that the regional departments do not have an electronic database of permitted and licensed mines in their regions. Experience of the database in the DME permit office in Gauteng has indicated that the information is contained in cross-referenced files. The location of mines is given as pins on a wall map consisting of combined 1: 50 000 topographical maps.

Relevant data (including the name of the mine, the mineral mined, the name of the farm and the co-ordinates) for the north-western section of the province (approximately 100 mines) were collected in only 6 hours by a single researcher. It should be noted that the scale of small-scale mining taking place could not be determined. All clay, sand and alluvial diamond mining (if indicated as such) operations were included. No coal and gold mining operations were included, as the scale of the mining operations could not be determined. Records of prospecting permits, mining permits and mining licenses issued by the Department were used in the development of the database.

Due to the difficulties in sourcing information and the number of hours spent on this task, it was decided not to pursue this issue any longer. As the development of a complete inventory was not originally included in the scope of work and not budgeted for, no additional time was spent on it as the sites necessary for detailed studies were already selected. It is therefore proposed that the DME be approached to fund the finalisation of a national database of small-scale mines throughout South Africa.

Table 4. Mining types identified during inventory for each province

Mine Type	Total SA	Provinces								
		EP	FS	GP	KZN	MP	NC	NP	NW	WP
Clay	106	14	5	27	0	9	1	16	7	27
Sand	380	22	12	111	33	6	2	45	14	135
Diamonds	19	0	0	6	0	0	9	0	0	4
Coal	2	0	0	0	0	1	0	1	0	0
Gold	1	0	0	0	0	0	0	1	0	0
Total	508	36	17	144	33	16	12	63	21	166

SEE FIGURE 5 ON CD

Figure 5. A GIS inventory of the small-scale mines in South Africa based on readily available information

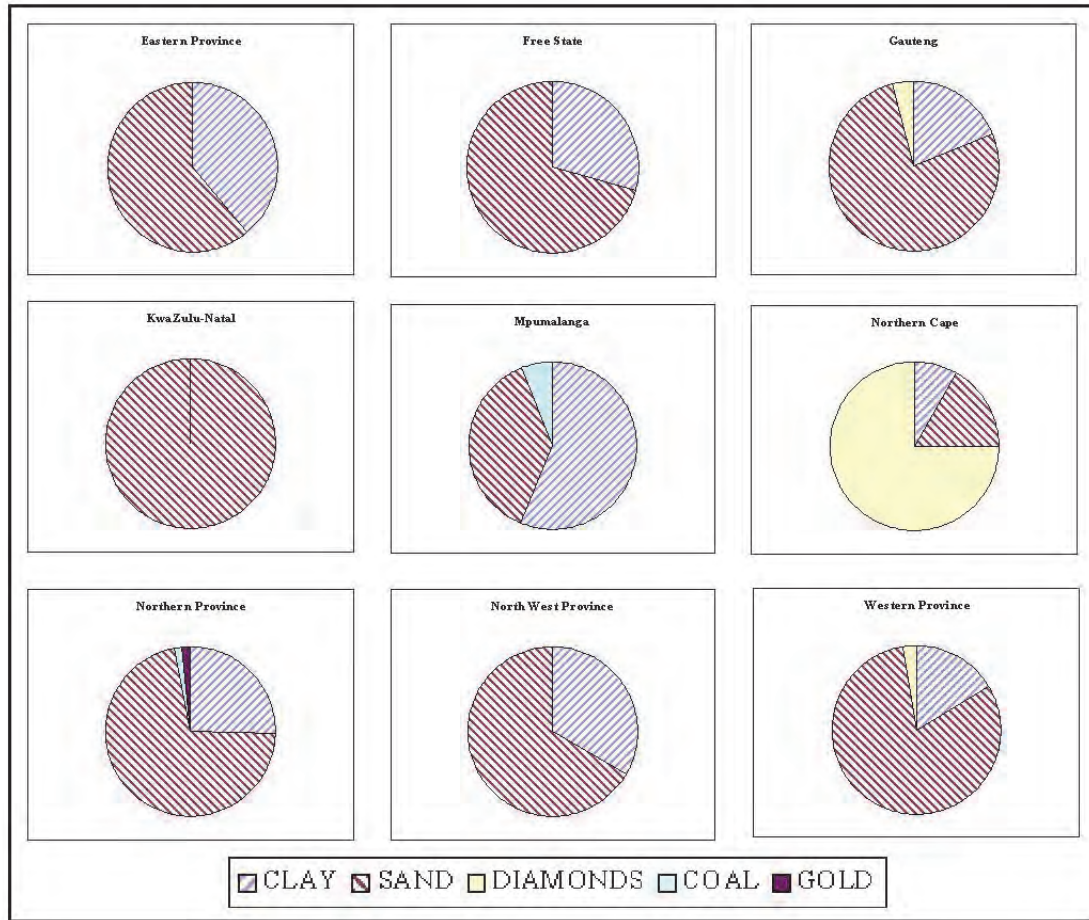


Figure 6. Percentage of commodity mined identified during inventory for each province

6. SCREENING LEVEL SITE VISITS

The initial site visits were used as an impact scoping exercise to assist in the development of a survey protocol and of an on-site matrix evaluation that could be used by the researchers for the regional site surveys. Areas identified as small-scale mining areas were included in the inventory using GIS. The inventory and an example of a GIS map are included in the CD Rom available from the WRC. The aim of these screening level visits was also to try to identify regions that should be visited during the regional site visits. The study was delineated to define what should be included in the survey protocol and only activities immediately associated with the small-scale mining activities and the water environment were considered. It was decided at a workshop held on 11 May 2000 that the zone of impact that was to be considered in this study should be limited to the 1: 100 year flood line. No secondary activities or activities not in the river or riverbed would be considered. Biomonitoring was not feasible within the scope of this study.

A further aim of the initial site visits was to identify typical water-related environmental impacts that are associated with small-scale mining. Once completed, the synergistic and cumulative impacts could be assessed.

6.1 SITES VISITED

An investigation of the impacts associated with the small-scale diamond operations along the Vaal River, near Kimberley, was identified as a priority by the national representatives of the DME and DWAF. This area was therefore considered a suitable candidate for an initial site visit. Several sites were visited along the Vaal River from Windsorton to Barkley West. Mining operations along the Riet River near Douglas were visited, as well as operations along the Makwassiespruit and the Bamboesspruit near Wolmaransstad.

Other areas visited included gold panning operations on the Noord Kaap River near Barberton, sand-winning operations near Durban on the Umgeni and Umbogintwini Rivers, as well as sand-winning operations north of Pretoria along the Boekenhoutspruit and Krokodilspruit Rivers. Coal operations and clay and anthracite operations in Northern KwaZulu-Natal (Osizweni and Nongoma) were selected for the initial site visits. Regional representatives of the DME and DWAF accompanied the research team on these screening level site visits. The details of the initial screening site visits are included in the CD Rom available from the WRC.

6.2 RESULTS OF SCREENING LEVEL SITE VISITS

6.2.1 Alluvial diamond mines

The alluvial diamond mining operations north of Kimberley are regarded as small-scale by definition. They can however be divided into three distinct groups - pick and shovel type of mining (characteristic of most miners in this region), mechanised mining with limited machinery (a truck and front-end loader), and larger operations with more machinery (several trucks and front end loaders and mechanised wash pans).

Observations during the screening site visits indicate that these alluvial operations impact on the water environment by altering the physical characteristics of the river. These impacts include the:

- Alteration of flow patterns
- Creation of islands due to the modification of the riverbed
- Ponding of water in excavations along the riverbanks
- Temporary damming of water (Plate 2),

- An increase in the concentration of suspended solids and sedimentation due to disturbance of the riverbed and surrounding habitat and the washing of alluvial sands.

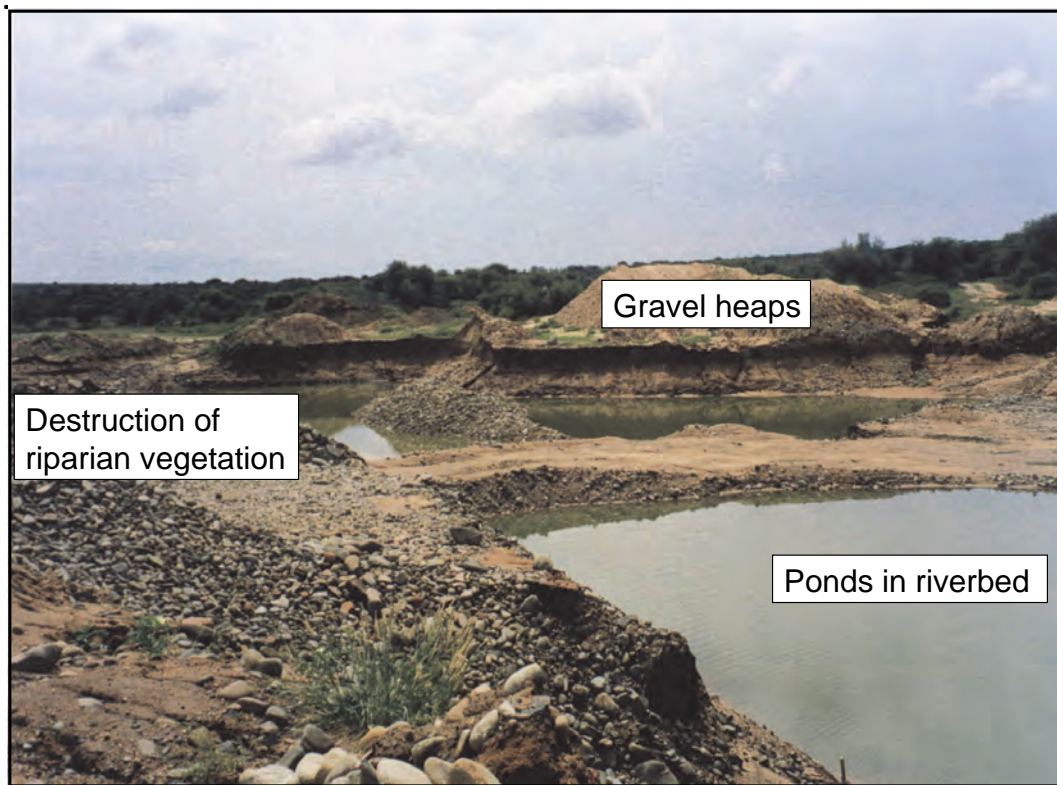


Plate 2. Alluvial diamond operation along Vaal River result in ponding of water along the riverbanks and temporary damming of water in the riverbed.

Significant impacts on the riverine environment were also observed. All riparian vegetation is removed during mining operations, excavations are not backfilled and topsoil is not replaced (Plate 2). In some cases, backfilling occurs with the placement of topsoil first. Little vegetation is thus able to establish in areas that have been mined (Plate 2).

6.2.2 Sand-winning operations north of Pretoria

The initial site visit to the sand-winning operations in the Krokodilspruit area north of Pretoria revealed that the water environment is significantly impacted by this form of mining. All sand-winning operations are mechanised but they differ in terms of the number and type of machinery used.

As was the case with the alluvial diamond diggings visited north of Kimberley, these small-scale mining operations impact on the water environment by altering the physical characteristics of the river. This includes changes in flow rates, flow paths and sediment loads within the river. The river catchment area is also physically altered, largely because of changes to the topography and vegetation cover (Plate 3). These physical changes are expected to lead to changes in the biota found both within the river and along the riverbank itself. The change in the biota present, *e.g.* the removal of riparian vegetation and wetlands, is also expected to lead to a change in the physical characteristics of the river.

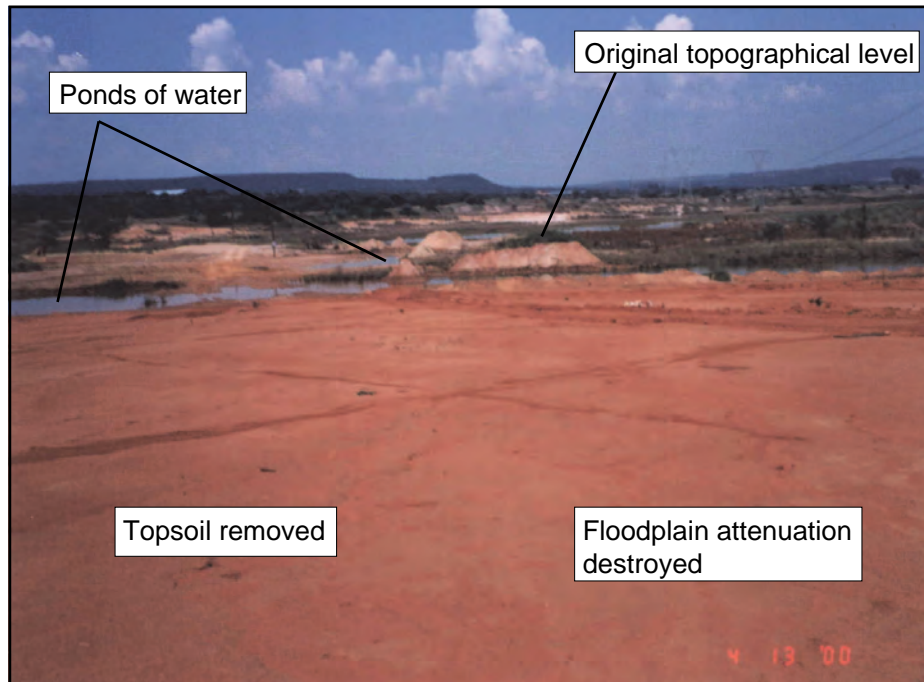


Plate 3. Sand-winning in the Krokodilspruit area has impacted on the catchment area by causing changes to topography and to the vegetation cover. Ponding of water also occurs along the sides of the river

The approach of sand miners to the rehabilitation process was found to differ between operations. Some operators rehabilitate the mined area as mining progresses while others plan to rehabilitate once all mining operations have ceased. The rehabilitation process adopted largely involves levelling of the landscape. Generally, no stockpiling of topsoil takes place and in some instances, it is sold as product. Lack of education regarding the need for water management and the maintenance of existing biota was evident.

Sand-winning operations are prominent in the KwaZulu-Natal rivers, especially in coastal rivers close to estuaries such as the Umbogintwini and Umgeni Rivers. The initial site visit revealed that sand-winning operations impact on the water environment by altering the physical characteristics of the environment. These impacts include the:

- Alteration of flow patterns
- Creation of islands due to the modification of the riverbed (Plate 4),
- Ponding of water in excavations along the riverbanks
- Temporary damming of water
- An increase in the concentration of suspended solids and sedimentation due to disturbance of the riverbed and surrounding habitat
- Loss of sand from the river, estuary and coastal dune system.

Significant impacts on the riverine environment were also observed. All vegetation is removed during mining operations, excavations are not backfilled, and topsoil is not replaced. In some instances, backfilling occurs with the placement of topsoil first. Little vegetation is thus able to establish in mined areas.

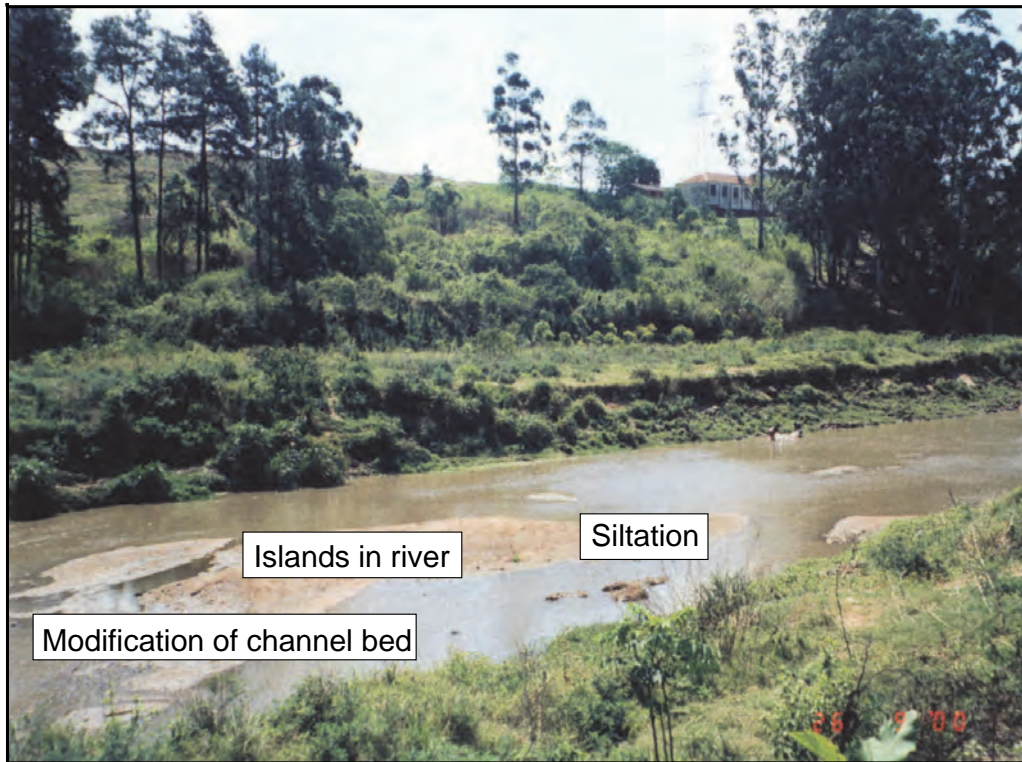


Plate 4. Umbogintwini River in KwaZulu-Natal. Sand-winning has resulted in sediment movement, which has led to islands in the riverbed at low flow, physically altering the nature of the riverbed and causing removal of marginal (buffer) vegetation.

6.2.3 Alluvial gold mining operations

Alluvial gold mining operations are prominent along the Noord Kaap River near Barberton in Mpumalanga. The initial site visit revealed that alluvial gold mining operations significantly impact on the water environment. Impacts include the removal of riparian vegetation (Plate 5) in order to gain access to the alluvial gold deposits. Front-end loaders are used to move mounds of gravel that are left in random heaps and not rehabilitated (Plate 5). The overall pattern of rehabilitation was that backfilling took place as mining operations progressed but no other forms of rehabilitation took place. Floods were responsible for most of the “rehabilitation” that occurs.

The cumulative impacts from legal and illegal alluvial gold mining on the Noord Kaap River are not known but may lead to an increased silt load, riverbank instability, increased encroachment of macrophytes, possible reduction of fish breeding habitats and a loss of biodiversity. At this site, impacts caused by pollutants, *e.g.* sewage, oils and diesel, are likely but are considered limited in comparison to the impacts on the physical characteristics of the river and on the riverine environment.

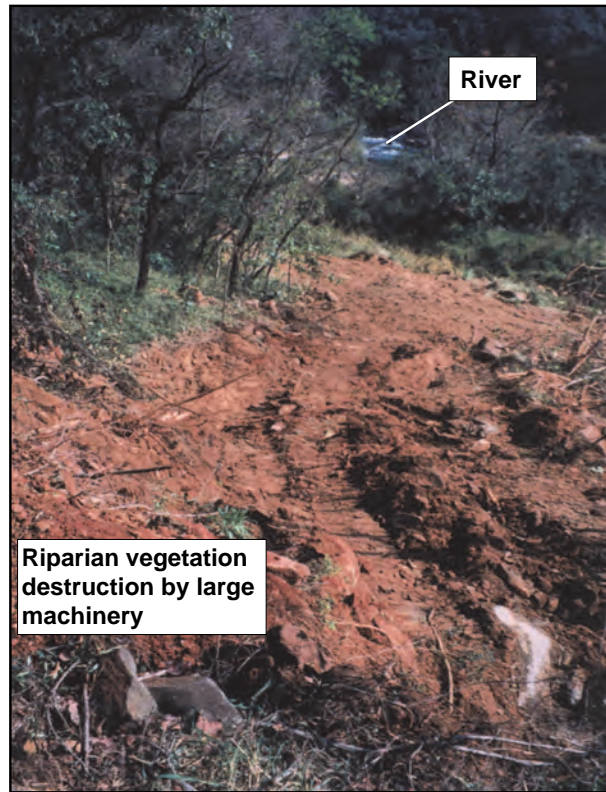


Plate 5. Alluvial gold mining in the Noord Kaap River in Mpumalanga results in mounds of gravel being moved and left in heaps and in riverine vegetation destruction.

Chemical pollutants are minimal, even in gold panning operations where mercury has previously been thought to pose a problem. DME and DWAF indicated that the gold miners no longer use mercury as the gold bearing ore is taken to a central point (Middelburg Refinery) for gold extraction. The chloride leaching technique developed by Mintek had been demonstrated to gold miners within the Mpumalanga region but not to miners in the Noord Kaap River area. As this was the main concern regarding water quality in this area, it was deemed not necessary to include mines of this area in the current study.

6.2.4 Coal and clay mines in KwaZulu-Natal

Initial sites visits were undertaken to an illegally re-opened old underground coal mine in Nongoma and to Osizweni township with large areas of open cast coal and clay mining used for brick making. The issues arising from mining in an old underground mine are related mainly to human health and safety. The long term acid mine drainage decants into the groundwater. No surface water bodies such as rivers were observed close to Nongoma.

The main environmental impacts of the open cast coal and clay mining in Osizweni are related to aesthetics (large holes left with no rehabilitation at all), large pools of water that are a safety hazard, odours and groundwater contamination. It should be noted that the Osizweni site is not near a surface water body. Small-scale coal-mining operations may give rise to chemical pollutants such as Fe, Al, Mn and SO_4 . These pollutants are generated by the exposure of pyrite and the associated acid-mine drainage. As these issues are well documented, it was decided that they do not require further investigation in this study.

6.3 IMPACTS IDENTIFIED DURING SCOPING SITE VISITS

The scale and extent of the water-related impacts differ for different minerals/products, with the greatest scale and extent of impacts being associated with alluvial diamond mining and the sand-winning operations. The various mining methods also cause a variation in the extent and scale of the water-related impacts observed. This variation in scale was particularly obvious in the different types of sand-winning (dry pit mining with bulldozers and scrapers versus wet-pit mining with a dragline). The small-scale mining impacts observed during the initial site visits are summarised in Table 5.

Table 5. List of water-related impacts observed during initial site visits.

Environmental impact	Alluvial diamonds	Coal and Clay	Alluvial gold panning	Sand-winning
Aesthetics	X	X	X	X
Riparian vegetation loss	X	-	X	X
Bank destabilisation	X	-	X	X
Chemical contamination	-	X	X	-
Increase in sedimentation	X	-	X	X
River diversion	X	-	X	X
Water abstraction	X	X	X	X
River bed and fauna disturbance	X	-	X	X
Alteration in channel hydraulics	X	-	X	X
Lowering of floodplain groundwater	-	-	-	X
Disturbance of flood attenuation	-	-	-	X
Ponding in floodplain	X	X	X	X
Loss of river sediments	X	-	-	X
Acid mine drainage	-	X	-	-

The specific type of impacts that were associated with a particular type of small-scale mining is discussed in more detail in Chapter 7.

7. REGIONAL SITE SURVEYS

Three different regions where small-scale mining was identified during initial site visits (CD Rom available from WRC) as severely impacting the environment were selected for regional site surveys. These regions include sand-winning sites in the Umbogintwini and Umgeni Rivers near Durban in KwaZulu-Natal; diamond diggings along the Vaal River near Kimberley and Windsorton in the Northern Cape Province; and sand-winning sites along the Krokodilspruit and Boekenhoutkloofspruit north of Pretoria.

7.1 DEVELOP SURVEY PROTOCOL

The aim of these regional site surveys was to objectively assess water-related impacts in the different regions affected by typical small-scale mining operations. The survey protocol included visual observations in the field, application of various assessment matrices and taking rough water quality data from the affected areas. In addition, aerial photos were used to quantify impacted areas. Members of the local communities and miners were interviewed by means of questionnaires in order to assess their potential role in being responsible for environmental management and rehabilitation programmes of the small-scale mines. The social questionnaire survey and the questionnaire results are included in the CD Rom available from the WRC.

The regional site survey consisted of two components:

- A brief meeting with representatives of the DME and DWAF to discuss the purpose of the regional surveys.
- Visits to several of the sites identified by the regional representatives as being of importance where the habitat was assessed.

The PHD and Simeka research teams were accompanied by representatives from DME and DWAF during these regional site surveys. The role of the regulatory bodies was to assist the researchers in identifying areas where small-scale mining operations currently occur and the water-related impacts associated with this the type of mining. They could also provide information regarding access to the sites that were to be studied.

Water quality and flow data were obtained from Umgeni Water and DWAF for each site. These data were of limited use as the sample points were not in close proximity to the actual sites and the water quality parameters measured did not give an indication of the impacts caused by small-scale mining.

The DWAF River Health Programme matrices were used so that the results would be congruent with those of DWAF's current status of biomonitoring. The matrices allowed the extent of the impact to be rated on a numerical scale so that the different sites could be compared to each other. Three assessment indices were applied to each site – habitat assessment matrix (HAM), habitat quality index (HQI) and the Intermediate Habitat Integrity Assessment (IHIA) of the resource directed matrix (RDM). These indices evaluate each mining site on a numerical scale so that results are readily comparable. The three habitat indices that were used are discussed in more detail in the sections that follow.

7.1.1 Habitat Assessment Matrix

The aim of this matrix is to assess the conservation status of a stream and the impact of physical habitat degradation using a scoring system. A HAM was completed for each site. Where possible, a matrix was completed for a point upstream of the mining activity, a point within the mining activity area and at a point downstream of the mining activity. The

following biotopes are defined by the HAM and if present, they were noted on the scoring sheet:

- Stones in current
- Stones out of current
- Sand
- Gravel
- Mud
- Marginal vegetation (MV) (mesic sedges and grasses)
- Aquatic vegetation (AV)

HAM has a range of scores from 1 – 135 and this value is shown as a percentage in Table 7. The higher the value, the healthier the habitat and the lower the value, the poorer the habitat. An example of a HAM field data sheet is given in the CD Rom.

7.1.2 Habitat Quality Index

The habitat quality index (HQI) is very similar to the HAM. HQI also has a range of scores from 0 – 135 and the scores obtained by using these two indices are very similar. No habitat sampling took place during this survey and the maximum score total is therefore 115. The value obtained is expressed as a percentage in order to compare the sites.

7.1.3 Intermediate Habitat Integrity Assessment

The Intermediate Habitat Integrity Assessment (IHIA) is one of the RDM indices used for the protection of water resources in river ecosystems (Figures 11 to 16). This simplified procedure was formulated based on the Habitat Integrity (HI) approach (Kleynhans, 1996).

The table in the CD Rom available from the WRC details the criteria used in the assessment of the intermediate habitat integrity. The criteria considered indicative of the habitat integrity of the river were selected on the basis that anthropogenic modification of their characteristics could generally be regarded as the primary causes of degradation in the integrity of the river. The severity of certain modifications will therefore have a detrimental impact on the habitat integrity of a river. The assessment of the severity of impact of modifications is based on six descriptive categories with ratings:

- 0 (no impact),
- 1 to 5 (small impact),
- 6 to 10 (moderate impact),
- 11 to 15 (large impact),
- 16 to 20 (serious impact) and
- 1 to 25 (critical impact).

7.2 RESULTS OF DETAILED REGIONAL SITE VISITS

Table 6 indicates the locality of the sites visited and gives an indication of the aerial extent of the mining activities.

Table 6. Locality of sites visited and the aerial extent of mining activities

Site Name	Description of activity	Latitude	Longitude	Approximate length (km) x width (km) of affected area	Estimate of area affected by mining activity
Winter's Rush, Gong Gong, Delportshoop, Longlands.	Alluvial diamond mining	28°24' to 28°28'	24°15' to 24°24'	23 km x 1.5 km	34.5 km ²
Windsorton	Alluvial diamond mining	28°18' to 28°22'	24°41'30" to 24°44'30"	9 km x 1 km	9 km ²
Umgeni River	Sand Mining	29°47'45" to 29°48'30"	30°57' to 31°00'	5 km x 0.3 km	1.5 km ²
Umbogintwini River	Sand Mining	30°00' to 30°00'30"	30°52'30" to 30°54'30"	5 km x 0.2 km	1 km ²
Krokodilspruit River	Sand Mining	25°22'25" to 25°35'	28°26' to 28°26'45"	4.5 km x 1.6 km	7.2 km ²
Boekenhouts-kloofspruit	Sand Mining	25°33'	28°27'30"	1 km x 0.36 km	0.36 km ²

7.2.1 Kimberley Region

A representative from DWAF accompanied the research team on the site survey on 18 September, 2000. The two sites surveyed extended along the Vaal River from Sydney-On-Vaal, in an easterly direction towards Gong-Gong.

Alluvial diamond operations on the Vaal River in and surrounding the town of Windsorton were surveyed on 19 September, 2000. Specific areas that were surveyed are listed below and are shown in Figure 7:

- Site 1: Winters Rush (Sydney-On-Vaal Bridge) (Plate 6).
- Site 2: Old Island in Vaal River.
- Site 3: Waldeck's Plant.
- Site 4: Island near Amandelshoogte mining on outskirts of Windsorton.
- Site 5: Mining site within the town of Windsorton.

The HAM indicated that the ranges were from the middle of the 'poor' scale to the lower end of the "good" scale. The HQI mirrored these observations in only about 50 % of the surveys (Table 7).

Table 7. Habitat assessment matrices and quality indices for sites visited.

Locality	River	Product and type of mine	Ave. HQI (%)	Ave. HAM (%)	pH	EC (mS/m)	T (°C)	Date
Winters Rush (Sydney-On-Vaal Bridge)	Vaal	Diamonds	41	56	8.59	49	15.3	18/9/00
Winters Rush Old Island	Vaal	Diamonds	49	29	8.59	49	16.0	18/9/00
Waldeck's Plant	Vaal	Diamonds	39	75	8.7	47.1	18.7	18/9/00
Island opposite Amandelshoogte	Vaal	Diamonds	31	34	8.1	81	15.7	19/9/00
Windsorton Town	Vaal	Diamonds	38	69	8.7	36.4	16.2	19/9/00
Lafarge Upstream	Umgeni	Sand	34	29	7.45	20.9	22.1	26/9/00
Lafarge downstream	Umgeni	Sand	36	19	7.19	21.1	22.3	26/9/00
Channels/floodplain operation	Umbogintwini	Sand	29	27	7.55	32.5	25.4	26/9/00
Downstream end of channel/floodplain.	Umbogintwini	Sand	32	13	7.38	32.3	22.7	26/9/00
River Channel	Umbogintwini	Sand	20	16	7.45	31.7	24.3	26/9/00
World-Wide Sand	Krokodilspruit	Sand	32	22	-	-	-	21/9/00
Mooi Uitsig	Krokodilspruit	Sand	54	53	-	-	-	21/9/00
Boekenhout Sand Mine	Boekenhoutkloof-spruit	Sand	43	27	-	-	-	21/9/00

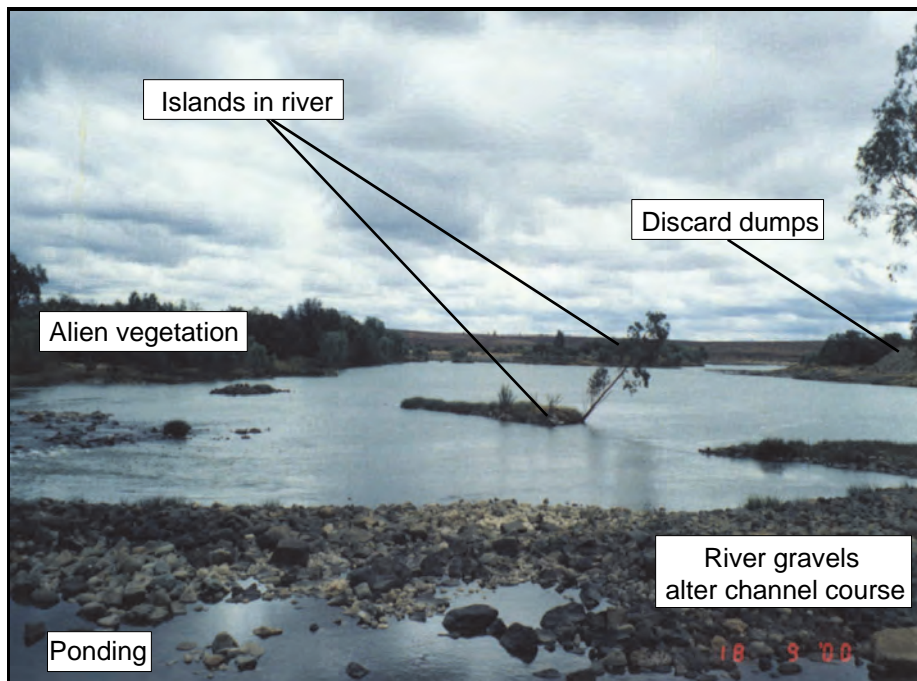


Plate 6. Diamond digging along the Vaal River near Sydney-On-Vaal illustrating impacts such as islands in the river and ponds adjacent to the river.

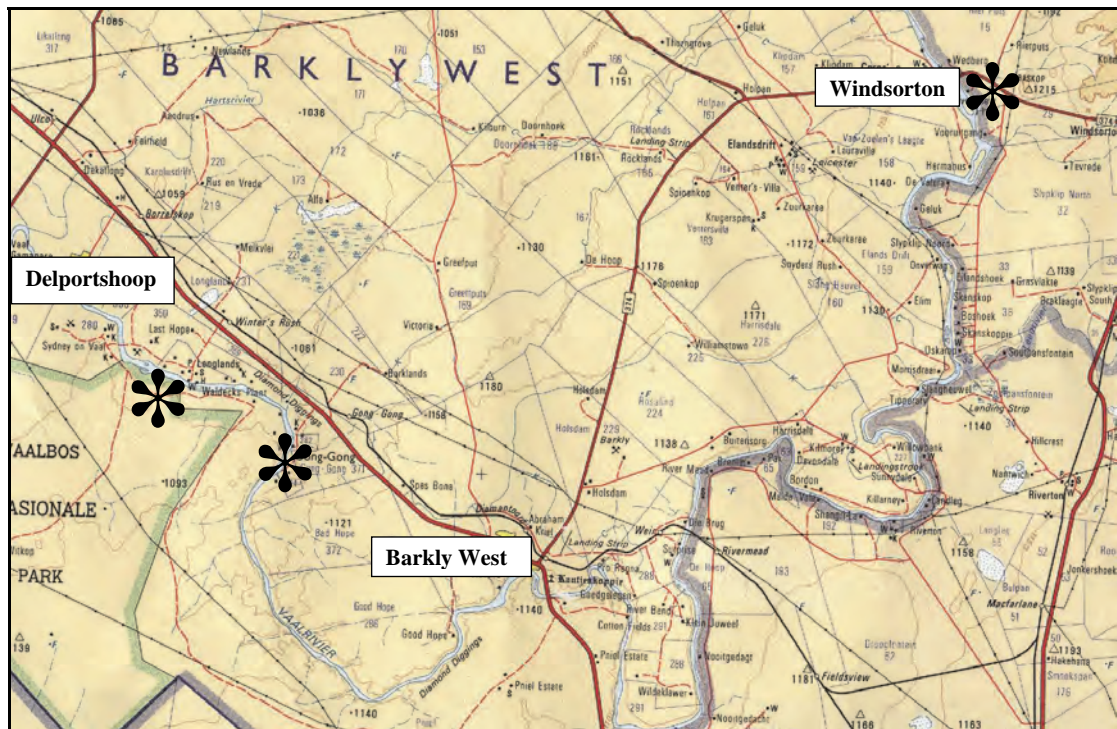


Figure 7. Locality of alluvial diamond mining sites visited along the Vaal River

7.2.2 Krokodilspruit and Boekenhoutskloofspruit region

Small-scale sand-winning operations in the Krokodilspruit and Boekenhoutskloofspruit were visited on September 21, 2000 (Plate 7). Representatives from DWAf and DME in Gauteng accompanied the PHD team on the site survey. Specific areas that were surveyed are listed below and shown in Figure 8:

- Site 1: World-Wide Sand Mine on the Krokodilspruit.
- Site 2: Mooi Uitsig excavation on Krokodilspruit.
- Site 3: Boekenhout Sand Mine on Boekenhoutkloofspruit.

The matrices for the Krokodilspruit area yielded similar results to the Kimberley survey. The World Wide Sand Mine and the Boekenhout Sand Mine indicated poor habitats, while the Mooi Uitsig excavation reflected the lower end of the “fair” range (see Table 7).

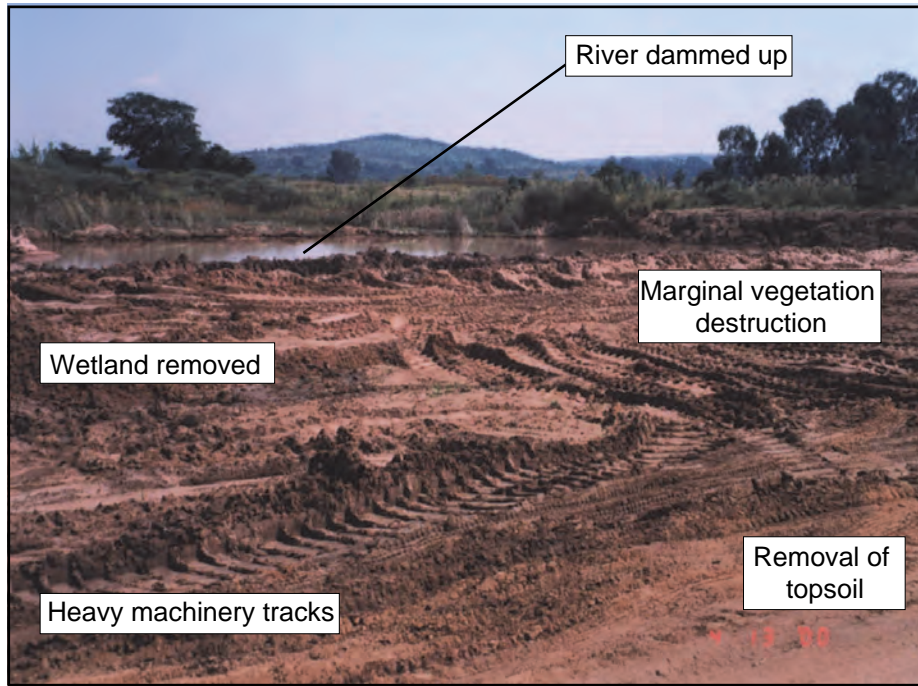


Plate 7. Sand-winning operation in Krokodilspruit area north of Pretoria.

7.2.3 Umgeni and Umbogintwini Rivers near Durban

Small-scale sand winning operations in the Umgeni and Umbogintwini Rivers near Durban in KwaZulu-Natal were visited on September 26, 2000. A representative from DME in Dundee accompanied the PHD team on the site survey. Specific areas that were surveyed are listed below and illustrated in Figure 9 and Figure 10:

- Site 1: Upstream of Lafarge Sand operation on Umgeni River.
- Site 2: Downstream of Lafarge Sand operation on Umgeni River.
- Site 3: Upstream of channel and floodplain operation on Umbogintwini River.
- Site 4: Downstream of channel and floodplain operation on Umbogintwini River.
- Site 5: Sand-winning operation upstream in channel on Umbogintwini River.

Both the assessment matrices (HAM and HQI) that were used to survey the two sites on the Umgeni River indicated poor habitat conditions. The three sites that were surveyed on the Umbogintwini River also reflected poor habitat conditions with all three sites scoring less than 30 % in the HAM and less than 33 % using the HQI matrix (Table 7).

The form of sand-winning that occurs along the Umgeni River is known as wet-pit mining. This involves the use of a dragline or hydraulic excavator to remove sand or gravel from below the water table or from a perennial stream channel, as in the case of the Umgeni River. The impacts caused by wet-pit mining include an excess of suspended sediment, damage to riparian vegetation, modification to the river bed that results in changes in the flow pattern, and disturbance of aquatic organisms such as juvenile crabs, mussels and fish that use the estuary as a nursery. The sand extraction also causes a diversion of flow through the sand removal site.

Areas where mining has occurred show decreased depth of river flow that could result in migration blockages for fish and other fauna during low flows. When water does not cover much of the streambed, the amount of viable substrate for aquatic organisms is limited. The

operation of heavy equipment in the channel bed can also destroy spawning habitat for fish and macro-invertebrate habitat, and cause increased turbidity and suspended sediment downstream (Hill and Kleynhans, 1999).

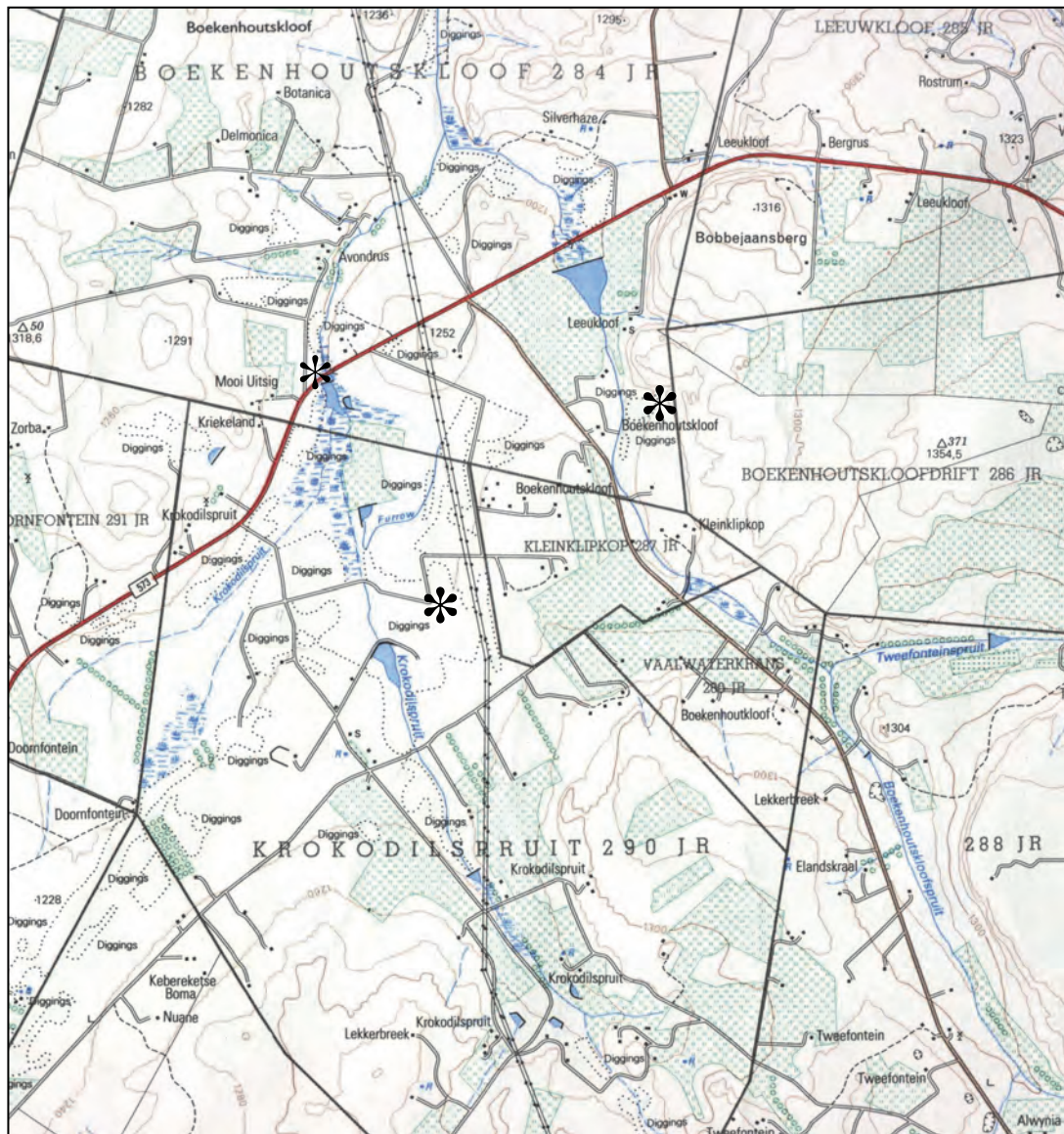


Figure 8. Locality (*) of sand-winning operations along the Krokodilspruit and Boekenhoutskloofspruit Rivers north of Pretoria.

SEE FIGURE 9 ON CD

Figure 9. Location of small-scale mining along the Umgeni River.

SEE FIGURE 10 ON CD

Figure 10. Locality of small-scale mining along the Umbogintwini River.

7.3 WATER QUALITY DATA

Physico- chemical water quality data were measured at all the sites visited (Table 8). Water quality data from sampling points upstream and downstream of the sites visited were obtained from DWAF and Umgeni Water and statistically analysed.

Table 8. Locality of DWAF and Umgeni water sampling points.

Sampling point and number	Location with reference to site visited
De Hoop (C9H009Q01)	Upstream of Windsorton and Winter's Rush
Vaalharts (C9H008Q01)	Upstream of Windsorton and Winter's Rush
Schmidtsdrift (C9H024Q01)	Downstream of Windsorton and Winter's Rush
R-Bokodweni_01	Umbogintwini River at golf course (mouth). Downstream of sand-winning operation.
R-Bokodweni_02	Umbogintwini River below sewage works. Downstream of sand-winning operation.
R-Bokodweni_03	Umbogintwini River above sewage works and upstream of sand-winning operation.
R-Mgeni_08	Umgeni River at Kennedy Road
R-Mgeni_08	Umgeni River at Riverdene – upstream of Lafarge operation.

The water quality data analysed did not indicate any water quality impacts that were as a result of small-scale mining. This is because these water quality sampling points are not in close proximity to the small-scale mining operations. For example, the Schmidtsdrift sampling site (C9H024Q001) is located approximately 55 km downstream of the Winter's Rush diamond digging area and the resultant water quality measured at Schmidtsdrift may have been influenced by other land use activities.

The water quality variables of concern related to small-scale mining include turbidity, TDS and suspended solids. In most instances, these parameters were not measured or analysed by DWAF or Umgeni Water. In the Vaal, Umbogintwini and Umgeni Rivers, the background values of these variables are usually high and consequently the impacts of small-scale mining would not be easily detected. The localised impacts would only be detected after a heavy rainstorm.

It should be noted that no upstream or downstream water quality data were available for the sites visited in the Boekenhoutskloofspruit River and Krokodilspruit River areas. The sites that are regularly sampled by DWAF were located too far upstream or too far downstream of the mining activities to be of value.

7.4 INSTREAM MODIFICATIONS

Figure 11 illustrates the major instream modifications that exist as a result of sand-winning in the Umbogintwini and Umgeni Rivers. This figure also indicates the major difference between different sand-winning techniques in these two rivers. The Umbogintwini sites are typical of sand mining that takes place within the riverbed as well as in the flood plain. The Umgeni sites are typical of sand-winning using a dragline (Plate 8). The major instream modification caused by the different techniques is flow modification. The Umbogintwini

River downstream site causes major flow modification in the winter months by damming up the river in order to mine the alluvial sands downstream (Plate 9).

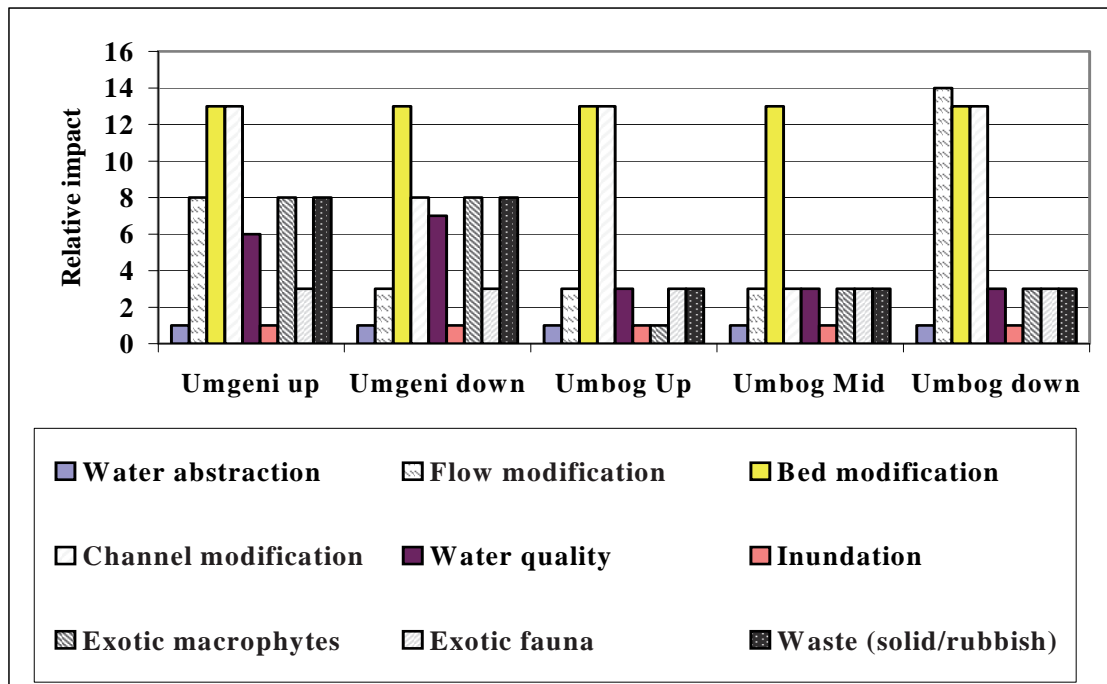


Figure 11: Comparison of instream modifications in two KwaZulu-Natal rivers because of different types of sand-winning operations.

Plate 8 indicates the type of sand-winning that currently occurs along the Umgeni River. This form of sand-winning causes flow modification, bed modification and channel modification, the impacts of which are discussed in Section 7.2.

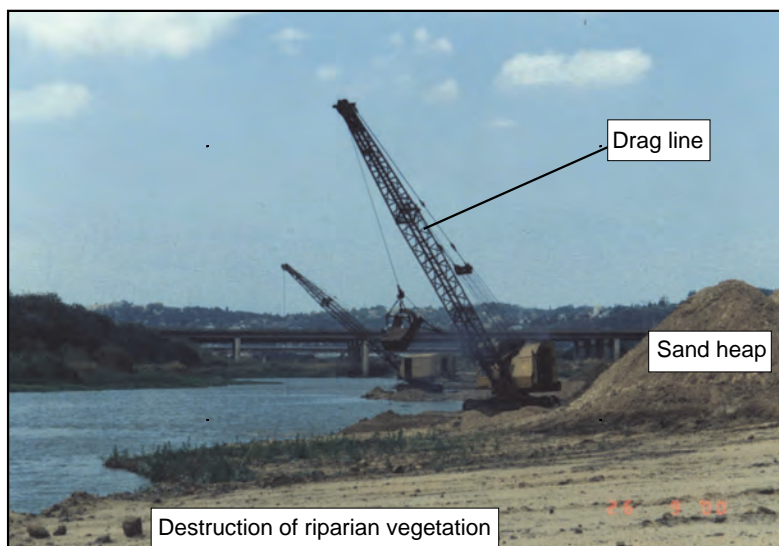


Plate 8. Drag-line sand-winning operation along the banks of the Umgeni River.

Plate 9 indicates the type of sand-winning occurring along the Umbogintwini River.

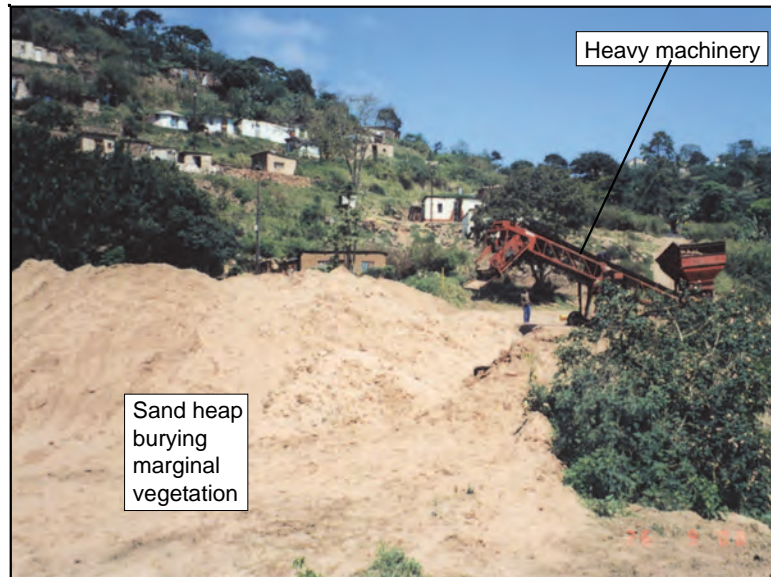


Plate 9. Sand-winning operation along the banks of the Umbogintwini River.

Figure 12 indicates the different instream impacts as result of alluvial diamond mining in the Vaal River. The major instream impacts are solid waste dumps and riverbed modification. If the different sites are compared then it is clear that Amandelshoogte site upstream of Windsorton has the greatest impact on the Vaal River (Figure 12). This was because mining takes place directly into a braided channel in order to mine a sandy island in the river. This resulted in the flow of the Vaal River being forced into the main channel. This has severely impacted the riverbed and channel and waste dumps are left without any attempt being made by the small-scale miners to rehabilitate the area. The gravel and sand that is removed from the riverbed armours the bed, stabilising banks and bars. Removing this gravel causes excessive scour and sediment movement. Gravel removal not only impacts the extraction site, but may reduce gravel delivery to downstream fish spawning sites (Hill and Kleynhans, 1999).

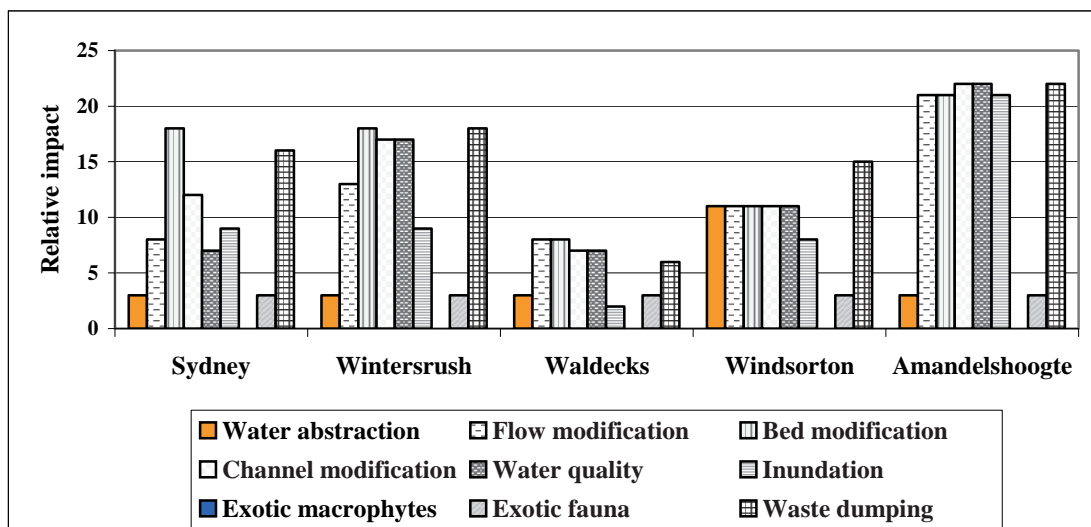


Figure 12: Comparison of different instream impacts on the Vaal River at different diamond digging operations.

The relative impacts of sand-winning in the Krokodilspruit River (Figure 13) are indicative of the different magnitudes and localities of these mines with respect to the river. World-Wide mining takes place with the flood plain and over several square kilometres. Uitsig is a one man and a front-end loader operation that takes place within the river, which results in sediments being released into the river.

High levels of sediment deposition create an unstable and continually changing environment that becomes unsuitable for many aquatic organisms (Plate 9). The most likely effects of suspended sediments on fish and other fauna such as crabs include a reduction in light penetration and of photosynthesis in micro-and macrophytes. This results in reduced food availability and plant biomass, reduced visibility of pelagic food, reduced availability of benthic food due to smothering and clogging of gillrakers and gill filaments.

Mining in the Boekenhoutskloofspruit River takes place approximately 100 m from the river and sand is transported to the washing site. Water quality is the main issue due to washing water being partially settled in a slimes dam and the decant being released back to the river. These activities cause an increased sediment load (Plate 10).

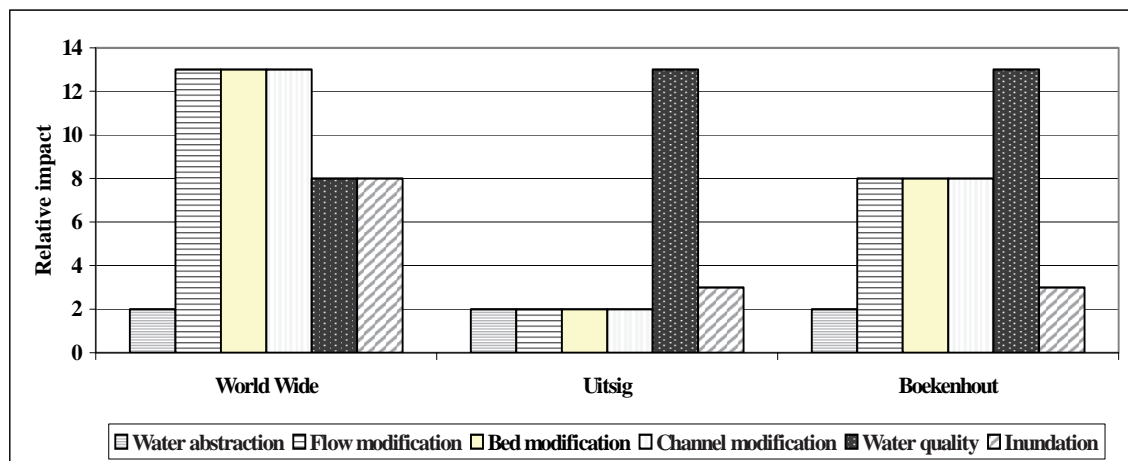


Figure 13. Comparison of instream modifications in the Krokodilspruit because of different sand mining operations.

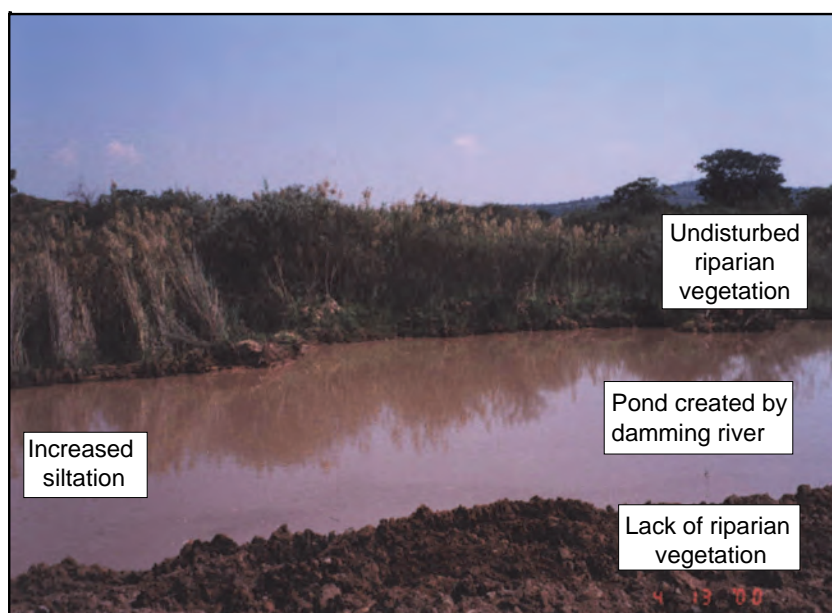


Plate 10. Sand-winning operations along the Krokodilspruit River cause an increase in the sediment load of the water. Riparian vegetation is also removed.

7.5 RIPARIAN ZONE MODIFICATION

Figure 14 indicates the major riparian zone modifications that are due to sand mining in the Umbogintwini and Umgeni Rivers. The major impacts are vegetation removal, bank erosion and channel modification. The difference between sites and mining techniques are indicated in Figure 14. The riparian zone includes stream banks, riparian vegetation and vegetative cover. It serves as a buffer to pollutants entering the stream from runoff, controls erosion, and provides habitat and nutrient input into the streams.

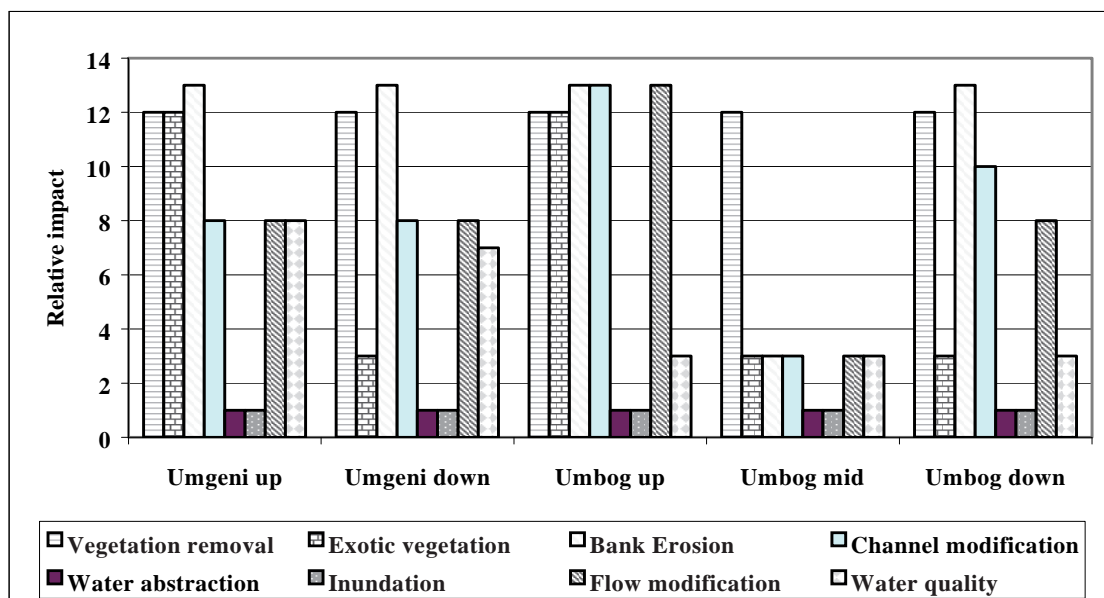


Figure 14: Comparison of riparian zone modifications in two KwaZulu-Natal rivers because of different sand mining operations.

Figure 15 indicates the different riparian zone impacts as result of alluvial diamond mining in the Vaal River. The major impacts include riparian marginal vegetation removal, bank erosion, channel modification and inundation of land. The riparian zone vegetation at

Amandelshoogte is the most significantly impacted when compared to the vegetation at the other sites (Plate 11). Permanent flooding or ponded water occurs when sand/gravel is removed to certain depths, which will result in long-term loss of riparian vegetation. Sand/gravel removal results in a significant shift of the river channel that subsequently causes annual or frequent flooding into the disturbed site. This will also cause a loss of vegetation.

Destruction of the riparian zone during sand or gravel (diamond diggings) extraction operations can have many negative effects on the instream habitat. Damaging any one of these elements can cause stream bank destabilisation, resulting in increased erosion, sediment and nutrient inputs, and reduced shading and bank cover leading to increased stream temperatures. If the level of channel water is lowered, the floodplain groundwater level is also lowered. Riparian vegetation reliant on the groundwater will subsequently be stressed and may consequently die off.

The riparian vegetation may also be destroyed by heavy equipment, processing plants and gravel stockpiles at or near the site (Hill and Kleynhans, 1999). Vegetation destruction was specifically noted at the Amandelshoogte operation where large soil stockpiles were present (Plate 11).

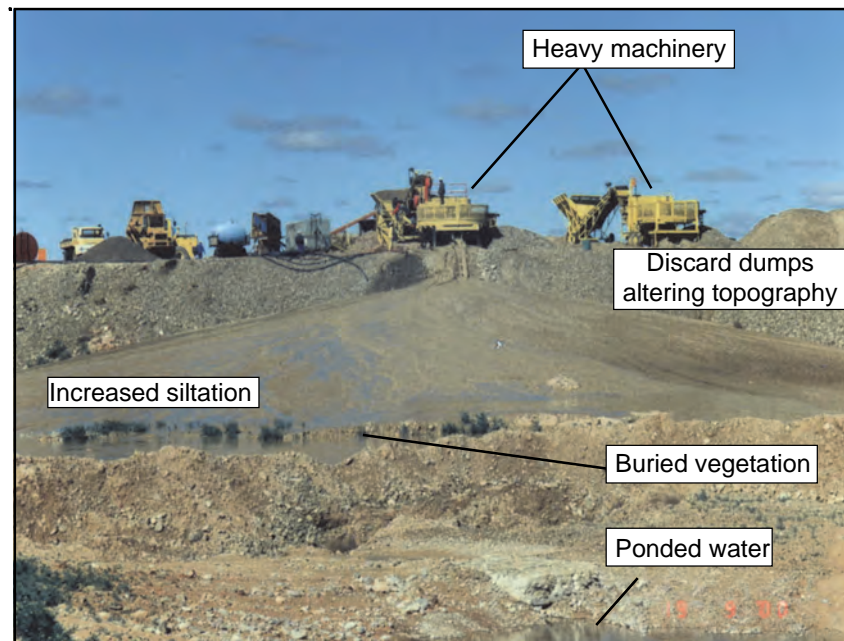


Plate 11. Amandelshoogte diamond diggings in and along the banks of the Vaal River near Windsorton. Riparian vegetation is smothered by large gravel stockpiles and heavy machinery.

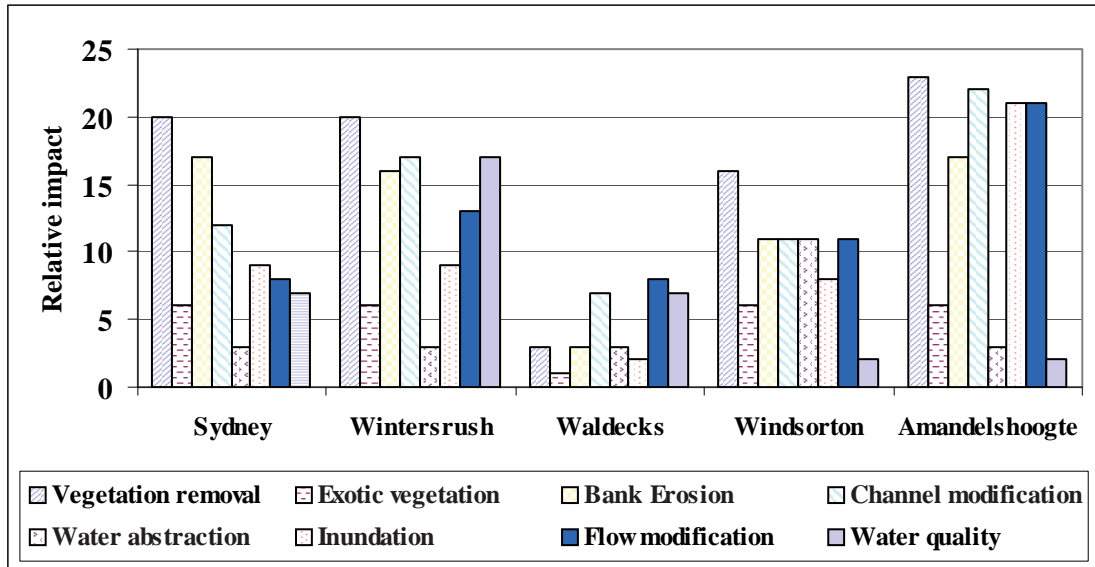


Figure 15: Comparison of riparian zone modifications in the Vaal River because of different alluvial diamond mining operations.

The impacts of sand-winning in the Krokodilspruit (Figure 16) on the riparian vegetation indicate that marginal vegetation removal and bank erosion are the major impacts. This phenomenon is illustrated in Plate 11 where riverine vegetation is present on the far side of the river and absent on the near side due to removal by sand-winning operators. Reduced vegetative bank cover results in reduced shading and increased water temperatures. Reduced vegetative bank cover can also result in rapid bed degradation that may induce bank collapse and erosion by increasing the heights of the bank.

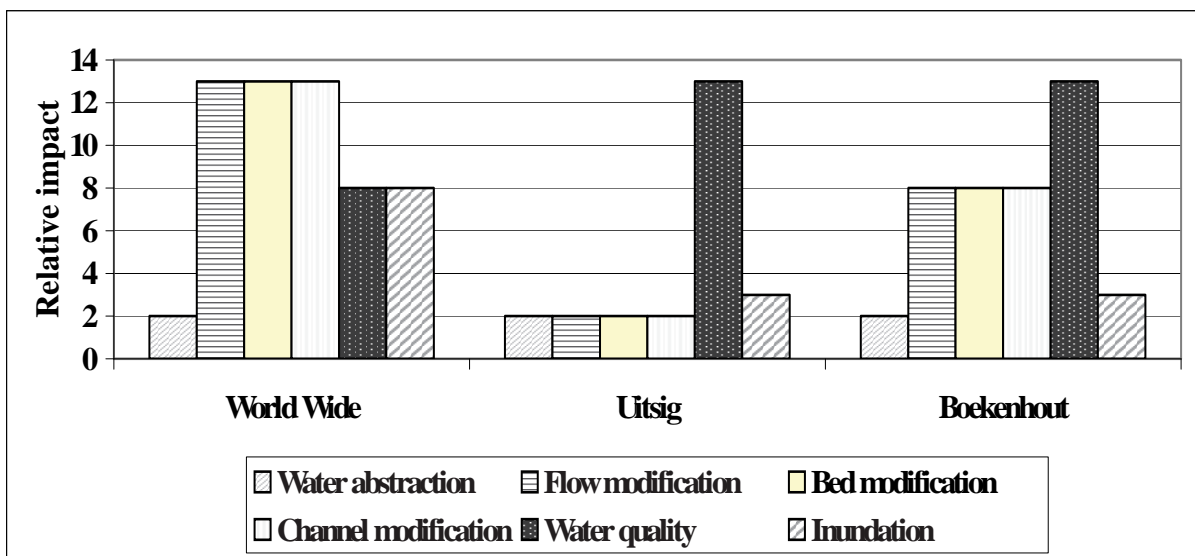


Figure 16. Comparison of riparian zone modifications in the Krokodilspruit because of different sand-winning operations.

The major impacts caused by small-scale mining that were observed during the regional site visits are summarised in Table 9 below.

Table 9. Major water-related environmental impacts observed during regional site visits.

Environmental impact	Alluvial diamonds Kimberley area	Sand-winning in KwaZulu-Natal	Sand-winning in Krokodilspruit
Channel hydraulics modification	X	X	X
Bank destabilisation	X	X	X
Bed modification, causing increase in suspended solids	X	X	X
Sedimentation	X	X	X
River diversion	X	X	X
Flow modification	X	X	X
River bed disturbance	X	X	X
Reduction or removal in vegetative bank cover	X	X	X
Islands created in river	X	X	-
Lowering of floodplain groundwater	X	-	X
Disturbance of flood attenuation areas	X	-	X
Solid waste dumps as no backfilling takes place.	X	X	-
Ponding in floodplain	X	X	X
Loss of river sediments	X	X	X
Loss of topsoil	X	X	X
Estuarine impacts	-	X	-

7.6 SUMMARY OF IMPACTS OBSERVED DURING REGIONAL SITE VISITS

Sand-winning and gravel extraction operations impact primarily on the instream habitat and on the riparian habitat. Specific impacts on the instream habitats that were observed include:

- Riverbed degradation, *e.g.* diamond-digging along Vaal River.
- An increase in suspended sediment, *e.g.* diamond-diggings at Amendelshoogte and the sand-winning operations along the Krokodilspruit River.
- Changes in morphology and in hydraulics of river channel, *e.g.* Vaal River.
- Destruction of spawning habitat of fish and macro-invertebrates, *e.g.* Umgeni and Umbogintwini Rivers where sand-winning takes place close to the river mouth.

Impacts on the riparian habitat that were observed during the regional visits include:

- Destruction of the riparian zone (stream banks, riparian vegetation and vegetative cover) - this phenomenon was observed where gravel diggings and sand-wining operations were present along the banks of the Vaal River in Windsorton, the Umbogintwini and Umgeni Rivers in KwaZulu-Natal and the Krokodilspruit River in Gauteng. Destruction of this zone leads to stream bank destabilisation and this leads to increases in erosion, stream temperatures and sediment input.
- Reduced vegetative bank cover – this is caused by undercut banks that may be removed during sand/gravel extraction, resulting in reduced shading and increased water temperatures.

7.6.1 Impacts due to suspended solids

The most common impact associated with small-scale mining is the increased production of suspended solids. The most important impacts associated with increased suspended solids levels are the often very visible changes that occur to aquatic habitats and the aquatic biota. Specific areas of concern are:

- Decreased light penetration to the bottom sediments, leading to a dramatic loss of benthic photosynthetic organisms.
- Clogging of fish gills, preventing them from breathing and leading rapidly to death. This can cause a dramatic change in the composition of fish populations, with only those species able to breathe air being able to survive (*e.g.* African sharptooth catfish, *Clarias gariepinus*).
- Inability of predatory fish to see prey due to water clarity being reduced due to high sediment loads. This can result in the reduction or total loss of certain predatory species of fish.
- Coating the surface of aquatic plant leaves with a layer of fine sediments that prevent photosynthesis and lead to the death of the plants.
- Deposition of previously suspended sediments onto the bottom of river beds when water flow rates decline leads to the smothering of both micro- and macro-habitats for aquatic invertebrates. This loss or alteration of habitat results in a rapid loss of these organisms and interruptions in the food webs of the affected area.
- Formation of sand bars in the river when the sediments are deposited. These sandbars become rapidly colonised by reeds and result in changes to the channel morphology and flow regime.
- Suspended sediments occur in a variety of different particle sizes and often “carry” considerable quantities of adsorbed ions, especially metal ions; these present a potential toxicity problem to both aquatic and terrestrial organisms.

7.6.2 Indirect impacts linked to small-scale mining

Successful small-scale mining activities can lead to several “peripheral” or indirect impacts on the biophysical environment. Specific examples are highlighted here to indicate the scope of the concerns (Ashton, *et. al.* 2001):

- The influx of miners and their families and dependants into new mining areas is often accompanied by the development of informal and unserviced settlements. In turn, these are characterised by poor or inadequate sanitation systems. This causes nearby watercourses to become contaminated with sewage and domestic garbage.
- Settlements that develop in the peripheral areas of small-scale mining operations will rely on subsistence agriculture for their livelihoods. This causes progressive de-vegetation of the areas around such mines as trees are cleared for fuel wood and to clear areas for cultivation.
- Increased population numbers places greater pressure on the natural resources of an area. This pressure varies from demands for fuel and water, housing and construction materials, to accelerated exposure of the catchment surface to erosion processes.

7.7 SINGLE VERSUS CUMULATIVE IMPACT

Singly, many of the effects of small-scale mining on the water environment may well be non-significant. However, when they occur simultaneously, their significance may increase by orders of magnitude. The overriding principle is that the greater the number of small-scale mines in an area, the greater the cumulative impacts are on the water environment. The major cumulative impacts include:

- Loss of riparian habitat due to large areas of riparian vegetation being removed.
- Riverbank destabilisation after vegetation removed.

- Soil erosion of arable land adjacent to mined areas.
- Increased surface areas of discard (sand, rock and other forms of waste) that can be mobilised during rain and ultimately are deposited in the rivers.
- Increased mobilisation of sediments, which become available and clog the aquatic environment.
- Increased incidents of oils (from machinery) and chemical (if refinement takes place) spills into rivers.
- Increased potential of mobilisation of metals, sulphates, Acid Mine Drainage (AMD) and other possible toxicants (such as arsenic).
- Loss of arable land due to no rehabilitation.
- Large tracts of land becoming a safety hazard (for people and livestock).

The duration of these impacts is mainly long term. For example, many areas along the Vaal and Orange Rivers were mined a century ago and the environmental footprints are still prevalent. Unless appropriate rehabilitation takes place in areas that are on the riverbanks, the land largely remains unusable unless the area is naturally restored by for example, floods. The mining that takes place within the riverbed or flood plain has more chance of being restored back to its original status over time due to floods.

The majority of the water-related impacts of small-scale mining are localised to the immediate vicinity of the mine. If, however, many mines occur within the same area then the cumulative impacts will be felt over a much larger area. Typically, the major impact would occur during high rain events when the mined areas will produce large volumes of silt, which will be washed downstream.

The size, type, and locality of each mining operation was assessed in order to compare the relative impact of each operation to the cumulative impacts.

7.7.1 Size of small-scale mine

An artisanal one-man operation compared to a more mechanised approach has less of an impact on the environment for example in diamond digging operations (Table 10). However, if many artisanal small-scale mines are operating in a small surface area, their impacts cumulatively have a significant negative impact on the environment. The environment would be able to assimilate one artisanal operation with no negative impacts, but it is not able to assimilate the impacts of many such operations.

Similarly, a single artisanal alluvial gold mining operation has a relatively insignificant impact on the water environment. However, many such mines operating in a limited area will have a significant cumulative impact on the environment. The cumulative impacts may lead to an increased silt load, riverbank instability, increased encroachment of macrophytes, a loss of biodiversity and a reduction in fish breeding habitats.

Table 10. Size of small-scale mines relative to significance of impact.

Type of mine & No. of employees	Level of mechanisation	Impact
Diamonds – diggers, < 5	Artisanal	Low
Diamonds – grease pans, < 20	Highly mechanised	High
Coal – reworking dumps, < 5	Artisanal	High
Coal – reworking closed mines, < 5	Artisanal	High
Coal – working exposed seams, < 5	Artisanal	High
Sand – dry pit mining, < 5	Mechanised (bulldozers)	Medium
Sand – wet pit mining, < 5	Mechanised (excavators)	Medium
Sand – bar skimming	Mechanised	Low
Sand – mining adjacent floodplains, < 5	Mechanised	Medium
Gold – panning	Artisanal	Low
Gold – sorting and crushing	Mechanised	Medium
Gold - ore vein	Artisanal	Medium

Mines are classified into 3 categories, according to the potential impacts that may occur on water resources due the mining activity: Category A, B or C (DWAF, 2000).

Category A mines:

- All gold and coal mines, irrespective of size.
- Any mine with any kind of extractive metallurgical process, including heap leaching. This includes most precious and base metal mines.
- Any mine where pyrites occur in the mineral deposit.

Category B mines:

- Mines with potentially significant and / or permanent impact only on non-water quality aspects of the water environment, such as yield or availability of water, dynamics of the river, riparian use, *etc.*

Category C mines:

- All other mines, including big mines with no significant impact on the water environment and small- or low-impact mines and prospecting operations.

7.7.2 Type of small-scale mine

The type of mineral that is being mined should be considered when assessing potential water-related impacts. Coal mining for example may give rise to an acid mine drainage problem, whereas certain methods of gold mining may give rise to mercury pollution. The various types of small-scale mining, the level of mechanisation and an impact rating for each type of mine is summarised in Table 10. The impact of the type of mine should not be assessed on its own but should be looked at on a regional scale. The cumulative impacts of similar types of mines in close proximity to each other may cause significant environmental damage. This impact will not be a reflection based on the type of mine.

7.7.3 Locality of small-scale mine

The locality of the mine in relation to its position in the catchment area must be taken into account. If one compares a fast flowing river with high riverbanks such as the Umbogintwini River to a slower flowing river such as the Krokodilspruit located on flat topography, different impacts may occur. In the Krokodilspruit River where the plains adjacent to the river are mined, impacts on the water environment are related to changes in the topography and to the vegetation cover. These changes lead to impacts on the biota within the river and along the riverbank. A river such as the Umbogintwini River is a faster flowing river that flows over

much steeper topography. Small-scale mining impacts on such a river may accelerate erosion of the riverbank, with the subsequent destruction of riverine vegetation. This in turn will impact on aquatic fauna that may breed in the aquatic vegetation.

The cumulative impacts on instream habitat caused by multiple extractions and sites along a river or stream are compounded by other riverine impacts and land use disturbances in the catchment. These additional impacts may be caused by river diversions/impoundments, flood control projects, logging and grazing. The individual sand/gravel extraction operations along rivers such as the Vaal, Umbogintwini, Umgeni and Krokodilspruit should therefore be viewed from a perspective that includes their potential adverse cumulative impacts.

7.8 ENVIRONMENTAL MANAGEMENT MEASURES

The operational practices described below will contribute towards sand-winning and gravel excavation operations being conducted in an environmentally friendly and sustainable manner.

- Sand/gravel extraction sites should be situated outside the active floodplain and excavation should not take place from below the water table.
- Sand and gravel extraction activities for a single project should be located on the same side of the floodplain to eliminate the need for crossing active channels with heavy equipment.
- Dry pit mining is preferable to other methods of sand-winning or gravel extraction as it has a less severe impact on the environment.
- Larger rivers and streams should be used preferentially to small rivers and streams.
- Braided river systems should be used preferentially to other river systems.

Mitigation must occur concurrently with sand and gravel extraction activities. Restoration is part of mitigation and the aim of restoration should be to restore the biotic integrity of a riverine ecosystem, not just repair the damaged abiotic components.

7.8.1 Specific precautions for instream habitat (Hill and Kleynhans, 1999)

- Sand/gravel should only be removed during low flows and from above the low-flow water level.
- Berms and buffer strips must be used to control stream flow away from the excavation site and should be designed to last for two or more decades.
- Quantities should be strictly limited so that gravel recruitment and accumulation rates are sufficient to avoid extended impacts on channel morphology and instream habitat.
- The removal or disturbance of instream roughness elements during gravel extraction activities should be avoided.
- Turbidity levels should be monitored.
- Extracted gravels or sediments should not be washed directly in the stream or river.

7.8.2 Specific precautions for riparian habitat (Hill and Kleynhans, 1999)

- Sand and gravel extraction in vegetated riparian areas should be avoided.
- It is essential to redistribute overburden evenly over exposed areas as soon as possible after the operation has been completed for faster revegetation.
- Operation and storage of heavy equipment within riparian habitat should be restricted.

8. SOCIAL ASSESSMENT

8.1 INTRODUCTION TO SOCIAL ASSESSMENT

During September and October 2000, structured interviews were conducted with small-scale miners and local communities near Kimberley (Longlands, Barkley West and Windsorton), Wolmaransstad, Cullinan and Durban (Vukani informal settlement next to the Umgeni River and Izimbokodweni settlement next to the Umbogintwini River). The aim of these interviews was to:

- Gauge environmental legislation knowledge levels and perceptions of small-scale miners and nearby communities.
- Determine the access of small-scale miners and nearby communities to resources for mining and rehabilitation.
- Determine possible opportunities for local communities to get involved in rehabilitation and the kind of training that is required.
- Determine the willingness of the community to become involved in such a project.
- Gauge environmental education training needs for the miners.
- Determine knowledge levels of miners regarding impact of their operations on the environment.

The motivation for the interviews was based on the belief held by authorities and scientists that minimal rehabilitation is done where small-scale miners operate, with resultant negative environmental impacts on water quality, quantity and on riparian vegetation. The hypothesis was that the money set aside by miners as a rehabilitation guarantee could be used to pay disadvantaged communities to rehabilitate the mined areas. This would be done to ensure that rehabilitation does take place and to create employment.

The communities were seen as people living in close proximity to the small-scale mining areas. The distance between the community and the mining activity varied from the Cullinan community who were approximately 10 km away from the sand-winning activities, to the Northern Cape diamond digger communities who were located less than 1 km away from the mining activities.

8.2 METHODS USED FOR SOCIAL ASSESSMENT

Simeka facilitated the process of identifying suitably qualified field workers to conduct the questionnaire survey. Briefing of the field workers occurred before fieldwork commenced and included the purpose of the study; the target groups; how to ask questions and interview pitfalls to avoid. Most interviews were conducted by fieldworkers from Simeka's national network.

Interviews were undertaken with small-scale miners, as well as with members of the local communities who live close to the mining activities. The number of interviews conducted is indicated in Table 11.

Table 11. Sector of the small-scale mining area where interviews were undertaken.

Sector interviewed	Kimberley / Wolmaransstad	Cullinan	Umgeni / Umbogintwini
Miners	24	4	4
Community	22	8	9

A structured questionnaire was used consisting of questions requiring yes or no answers followed by more in depth questions. Participants were able to comment at the end of the interview on issues they considered as important.

8.3 RESULTS OF INTERVIEWS WITH SMALL-SCALE MINERS

The following is an overview of the results of the people who were interviewed: (The full text response of the survey of small-scale miners and communities is included in the CD Rom available from the WRC. The responses from the interviews with the community and the small-scale miners are summarised in Table 13.

8.3.1 Ownership of land

Ownership of the land being mined was regarded as a variable that could influence the extent of rehabilitation and responsible mining. If a person owns the land, there might be a motivation to rehabilitate the land due to an innate sense of ownership and not to devalue the land. It was evident from the responses received that there was no correlation between ownership of land and the extent of rehabilitation.

Only 40 % of the miners interviewed live in the immediate communities where they mine. Miners are not concerned about the damage to the environment caused by their mining activities. They are also not concerned about the environmental and human impacts they cause or of the opinion of the local community.

8.3.2 Employment opportunities

In general, it appears that local people are employed in the small-scale mining operations, especially in small-scale diamond mining operation but that this is only a small number of people. These mining activities however, occur in areas where job creation is desperately needed. Additional local employment could be generated if the opportunity was offered to the community to get involved in rehabilitation of degraded small-scale mining areas.

Table 12. Summary of interviews with small-scale miners and small-scale mining communities.

Issues	Small-scale miners	Small-scale mining communities
Ownership of land	No correlation between ownership of land and extent of rehabilitation. Only 40 % of miners live in nearby community.	No access rights, claims, mineral rights or land.
Employment opportunities	Few local people are employed in mining industry	Unrealistic possible employment opportunities. Locals are not employed by sand-winning operations.
Viability of small-scale mining	Seen as an attractive form of employment. Do not believe community is capable of mining in an environmentally responsible way. Rehabilitation guarantees viewed as inadequate.	Most people do not want to earn a living from rehabilitation work. Small-scale mining viewed as lucrative. Aware of problems involved with small-scale mining - lack of money, mineral rights, information and capacity.
Permit responsibilities and rehabilitation requirements	Superficial knowledge of legal requirements attached to permits. Aware of consequences for not rehabilitating – fines, permits being withdrawn, forced rehabilitation and confiscation of guarantees. Aware of rehabilitation requirements.	Unaware of permit responsibilities. Different communities - different levels of awareness. Where rehabilitation had occurred, community was aware of rehabilitation measures. Where no rehabilitation - community was unaware of rehabilitation measures.
Impacts of small-scale mining on environment	Superficial knowledge of impacts.	Very basic understanding of mining-related impacts. Impacts identified include dust, excessive sediment, destruction of plants, dead fish and diesel spills. Communities living close to mining operations are more aware of impacts than those living further away from operations.
Potable water	Variability in dependence on river water for potable use. No correlation between being dependent on river water and mining responsibly to prevent impacts to river.	100 % of community in diamond digging area use river water for potable purposes. Sand-winning community use river water for laundry, obtain potable water from boreholes.
Preventative measures	Suggestions to prevent impacts include: improved DME control, improved education, improved settling ponds, identify contact person at DME, improved method for handling of sediment, avoid riverbank damage, maintain buffer zone, rehabilitate disturbed areas, close illegal operations and follow DME guidelines.	Opinions varied from stating “the miners should rehabilitate as they go along” to “the government should be responsible for rehabilitation”.
Advantage of small-scale mining to communities	Operations viewed as beneficial to community as jobs were provided, services were required and skills were acquired by members of community.	50 % of diamond digging community - no advantages for them, 50 % - do benefit from diggers. Cullinan community - employment opportunities as advantageous (none of them are employed by sand-winning operations). Only 25 % of sand-winning community in along Durban rivers thought operations benefited them.
	Training and practical advice. Open door to the authorities.	Mineral rights needed, capacity, funds for capital outlay and information.
	Believe mining is the most appropriate land use.	

8.3.3 Viability of small-scale mining

Small-scale diamond mining and sand-winning is regarded by the miners as being lucrative and provides a good source of income and supplements other sources of income. It is therefore seen as an attractive form of employment. In a study conducted by the MEPC (1998), it was found that at approximately two-thirds of the small-scale mining operations interviewed, employees earn between R500 and R1 500 per month. The most common wage bracket is R751 – R1 000 per month.

The existing miners do not view everybody getting involved in mining as viable for a number of reasons. They state that all miners should have to pay deposits based on the same criteria. The miners are of the opinion that if it is made easier for the local communities to mine, the rehabilitation guarantee will have to be lowered, which will result in even less rehabilitation being done. As loans are difficult to obtain, most new miners will require a great deal of assistance from the government to pay for running and capital expenses and even to pay the guarantee.

The fact that small-scale miners have experienced the rehabilitation deposit to be insufficient for rehabilitation may be the reason that they are amenable for someone else to undertake the rehabilitation or for someone else to use their guarantees to pay for rehabilitation. This would mean they would not have to spend even more money to rehabilitate properly. It is however doubtful that the available funds would be adequate for proper rehabilitation. It appears that the economic cost factor prevents miners from rehabilitating, as the rehabilitation guarantees do not always cover the rehabilitation costs. Although overheads such as initial machinery are high, income is generated and a lack of funds cannot be used as the sole excuse for not rehabilitating.

Miners are not opposed to the community becoming involved in rehabilitation, but they do not believe that the community has the machinery required to undertake rehabilitation work. The preferred option would be to make it compulsory to rehabilitate while mining to cover the costs of diesel, wages, and maintenance as part of running expenses and not an expensive add-on later. This would be particularly useful in the case where a miners venture was not very successful anyway.

8.3.4 Permit responsibilities and rehabilitation requirements

The miners are acutely aware of the legal requirements attached to their mining permits and the requirement to rehabilitate. Most of the miners could think of at least one requirement although the answers did not always include environmental responsibilities. The interviews also indicated that the miners knew the basics of rehabilitation. The perception that the consequences, according to DME in Klerksdorp, of not rehabilitating are not severe enough to not risk not rehabilitating.

The interviews clearly indicated that the miners have all the necessary resources required for rehabilitation. The same machinery that is used for mining could be used for rehabilitation purposes, *e.g.* bulldozer or scraper. However, if rehabilitation is left until the end of mine life and does not take place during mining, then extra money is required. This leads to a situation where no rehabilitation takes place at all. There appears to be a strong sense of legal consequences amongst the small-scale diamond miners for not rehabilitating. The consequences listed for not rehabilitating included fines, permits being withdrawn, forced rehabilitation and confiscation of guarantees. However, miners will not have much motivation to rehabilitate if illegal operators and transgressors of the law are not brought to book.

8.3.5 Impacts of small-scale mining on environment

Most of the small-scale miners have a sense that the environment can be impacted by their mining operations but they are vague about it and knowledge of exactly what the impacts may be or how these impacts occur, is superficial. It was seen that both miners and communities do not have in-depth knowledge of the impact of mining on water quality or other environmental aspects. This level of environmental knowledge could have a correlation with mining practices and real impacts. Environmental education regarding ecosystem response may contribute to the miners acting more responsibly.

8.3.6 Potable water

This aspect was included in the questionnaire as the possibility exists that if miners are directly dependent on local river water for potable use, they would mine more responsibly and rehabilitate to prevent water impacts. However, from the survey it was seen that there is not a direct correlation between being dependent on river water and mining responsibly to prevent impacts to the river. Both diamond miners (some of who depend on river water) and sand miners in Cullinan and Durban (not dependent on river water for potable use) are engaged in activities that directly impact on the quality of the river water.

8.3.7 Preventative measures

The miners suggested several ways in which impacts on the environment could be prevented. The following is a list of some of the suggestions:

- Improved control by DME.
- Improved education for small-scale miner.
- Clearer instructions on who to contact at the DME.
- Better dams for settling of water.
- Correct handling of sediment.
- Avoid damage of riverbanks.
- Mine a certain distance away from the river.
- Rehabilitate and vegetate areas disturbed by mining.
- Close all illegal operations.
- Follow the guidelines given by DME.

DME and DWAF do not seem to have a strong enough presence in the mining areas for policing, ‘being there’ or to give advice, training and assistance but the DME is of the opinion they should not play policeman. Real practical advice and assistance, having an open door message from the authorities might be more useful than environmental education. All the small-scale miners interviewed appeared to have a good knowledge of what actions to take to prevent impacts on the environment. It was however difficult to get more than one preventative measure from each individual and some of the answers given were of a very general nature.

8.3.8 Advantages of small-scale mining to communities

A large percentage of the small-scale diamond miners viewed their operations as advantageous to the surrounding communities as jobs were being provided and skills were being acquired. The miners also made use of services provided by the community, such as welding and sales of diesel and spare parts. The small-scale sand-winners stated that they provided employment opportunities and building materials to the local communities.

Thus, in communities where many small-scale miners operate and where locals spend their money locally, the economic spin-offs for the communities seem to be considerable. However, the miners view their contribution to the community more positively than the surrounding communities do.

8.3.9 Assistance in form of technical advice or training

If small-scale miners are provided with assistance relating to technical training and advice, it is believed that they will mine more responsibly and that they will rehabilitate. From the questionnaire results, it appears as if very few miners are offered proper assistance, advice and training and few knew where they could obtain it. However, the miners do not seem too perturbed by this lack of assistance, as they have other non-formal sources of advice and assistance. These sources are suspect and lack of proper advice and training could be a cause of irresponsible mining and non-rehabilitation.

The various sources of information listed by the small-scale miners (DWAF, Rand Water, Conservancy representatives, Consultants, DME and Nature Conservation officials) may reflect agencies with whom they have had a positive experience before or who have a definite presence in the area. In the questionnaires, the DME did not come across as an active, positive source of assistance. Most of the communities interviewed seem to know where to obtain information if they want to become involved in mining and related activities.

8.3.10 Alternative land uses

Although the land on which miners currently operate can be used for other applications, it is the miner's perception that their industry is the most viable for that land. This is a different perception when compared to that of the local community who would prefer activities which are more to their direct advantage.

8.4 RESULTS OF INTERVIEWS WITH LOCAL COMMUNITIES

This section discusses the results of interviews and the interpretation of the responses (Table 13). In the communities of Barkley West, Windsorton and Longlands, approximately 45 % of the population is under 19 years and 5 % is over 65 years old giving a high dependency rate. The average incomes range between R1 and R500 per month per person. Most of the economically active population in these communities are employed in construction, mining and quarrying, as well as in private households.

In the small-scale sand-winning communities of Izimbokodweni and Vukani, there is a high unemployment rate that ranges between 60 % and 80 %. Almost half the population is younger than 24 years and 33 % to 37 % of the population are between 25 and 44 years old. These data indicate that the communities in which the interviews were conducted are economically depressed with low incomes, high rates of unemployment and high levels of dependency. This would imply that job opportunities such as rehabilitation work, would be welcomed.

8.4.1 Ownership of land

A large proportion of the community expressed an interest in mining as a form of earning a living although they were not in possession of any claims, mineral rights or land.

8.4.2 Employment opportunities

The Cullinan community has unrealistic expectations about the employment opportunities at the local sand mines. They also stated that locals were not being employed at the sand-

winning operations. The community has the perception that many people are employed at the small-scale mining operations but that they are not locals. This particular community does not have much contact with people who work at the mines and therefore has little knowledge regarding mining practices.

8.4.3 Viability of small-scale mining

The majority of people stated that they would prefer to earn a living from mining rather than from rehabilitation work. This statement and the fact that they all view small-scale mining of diamonds and sand as lucrative, could be interpreted as mining being regarded by the community as a more viable option when compared to receiving payment for rehabilitation work.

However, the community listed many hindrances to becoming involved with mining, some of which include lack of mineral rights, no information or money, lack of capacity, not knowing where to obtain information, *etc.* These hindrances are valid in the light of the high guarantees that need to be paid, the capital outlay required, the running costs and the minimum knowledge required to start mining.

8.4.4 Permit responsibilities and rehabilitation requirements

The communities are not well informed regarding the responsibilities and requirements associated with small-scale mining and it may appear to them as if it takes place without regulation. The majority of the community members interviewed indicated that there are no legal consequences for not rehabilitating. In areas where rehabilitation had occurred, *e. g.* along the Umgeni River, the communities have knowledge that rehabilitation should be done in future.

Communities that had not observed implementation of rehabilitation could not list the rehabilitation measures that should be implemented. Respondents from these communities did not believe there were legal consequences for not rehabilitating, whereas 45 % of the community along the Umgeni River stated there were legal consequences for not rehabilitating. The communities who lived close to the mining operations were of the opinion that the miner's should be responsible for rehabilitation, whereas those living away from mining operations believed the state should be responsible for rehabilitation.

8.4.5 Impacts of small-scale mining on environment

Most of the communities do not have a good understanding of the impact of the various types of mining on the environment or of ecosystem functioning. Some do understand that plant life can be affected by their removal, that water can get trapped in pits and not reach the river, and that water life will die if too much sediment washed into the river.

The environmental concerns of the community in the small-scale diamond digger's area were primarily focussed on dust impacts. Impacts from the sand-winning community on the environment ranged from none to dust problems. Environmental impacts listed by the community in Durban who live adjacent to sand mining operations include muddy and polluted water, dead fish - no more fishing possible, collapse of riverbanks, removal of medicinal plants and other vegetation and diesel spills in the river. The number and variety of impacts listed by the community reflects the direct experience of the community with these impacts. It was noted that the communities that experience the environmental impacts directly are not willing to get involved in rehabilitation although it may reduce the impacts to a certain extent.

The impacts on the environment as perceived by the community because of no rehabilitation by the miners are closely related to what the community has observed and experienced first hand. Those communities such as the Cullinan sand-winning community who live far away from mining activities were not knowledgeable regarding environmental matters. Communities such as the diamond diggers and the Durban sand-winners listed many environmental impacts such as soil erosion and bank collapse and dangerous areas due to holes in river.

8.4.6 Potable water

Almost 100 % of the community in the small-scale diamond mining areas use the river water for potable and domestic purposes such as laundry. The sand-winning communities of Cullinan and Durban obtained their potable water from boreholes, while some of them used the river for laundry purposes. There is a correlation between dependence on river water and concern about the quality of river water in the diamond digging communities. This is understandable as the communities rely on the river water for domestic purposes.

8.4.7 Preventative measures

Most of the communities believed that training was required in order to undertake rehabilitation in an appropriate manner. Members of the community are not always aware what the legal environmental requirements related to mining are. If a community was aware of the responsibilities of the miners, they could influence the miners and labourers in such a way that they would mine more responsibly and rehabilitate disturbed areas. Although most of the miners do not live in the mining areas, the local communities should be empowered about their rights and the miners responsibilities to reduce the impacts on them and their local environment.

8.4.8 Advantage of small-scale mining to communities

Half of the community in the small-scale diamond mining areas are of the opinion that there are no advantages for the community, while the other half believes there are advantages to be had from mining activities. The advantages listed do not have large positive influences in the lives of the locals and in general, the locals do not see diamond digging as being advantageous to the communities. Members of the Cullinan sand-winning communities see employment opportunities as advantageous although the locals are not currently employed by any of the miners. Only 25 % of the community adjacent to the sand-winning operations in Durban thought these operations were profitable to the community.

In general, the communities do not think that the mining operations near them bring any real advantages to their communities. This is very different from the positive influence on the communities the miners perceive themselves to have.

8.4.9 Assistance required

The community would need machinery and money to rehabilitate areas disturbed by mining. The community did not have the funds and did not believe they would be able to gain access to such funds. This is a realistic assessment, as they will need substantial assistance if they want to get involved in rehabilitation, especially as it was determined that rehabilitation guarantees were inadequate.

8.4.10 Alternative uses of mining land

The community, in contrast to the miners, believed that alternative uses of land could bring in more money. This is because in some instances they do not see the miners really contributing to the economy of the area and because they experience the negative impacts of their activities. However, they all agreed that mining was a viable activity. Some community members believed that they would be able to get rich from mining and the majority wanted to get involved with mining. It may be that when they have to choose, it appears as if they would prefer activities that would provide clean water, housing, recreation space and food.

8.5 SUMMARY OF QUESTIONNAIRE FINDINGS

Table 13 summarises the key findings of the social questionnaire study. One of the most relevant findings was that the local communities would prefer to become employed in the mining sector rather than become employed in the rehabilitation of small-scale mines. Mining is viewed as a more viable option than mere payment to do rehabilitation. Those communities living in close proximity to small-scale mining operations were much more aware of issues such as rehabilitation and the environmental impacts associated with mining activities.

Table 13. Summary of social questionnaire findings.

Small-scale miners	Small-scale mining community
No correlation between ownership and rehabilitation.	Do not have mineral rights or access to land.
Do not view community as able to successfully operate a small mine.	Would prefer to earn a living by mining, rather than by being employed in rehabilitation of small-scale mines.
Few locals employed.	Unrealistic employment expectations.
Regard mining as financially lucrative.	View mining as financially lucrative.
Acutely aware of permit responsibilities.	Unaware of permit responsibilities.
Superficial knowledge of impacts.	Only communities in close proximity to mining operations are aware of impacts.
Variability in dependence on river water for potable purposes.	Variability in dependence on river water for potable purposes.
Suggested several measures to prevent environmental impacts.	Few preventative measures were suggested.
Assistance needed in form of training and practical advice.	Assistance needed in form of mineral rights, finance and capacity.
Mining is most useful type of land use.	Mining is not seen as the most useful type of land use.

9. ENVIRONMENTAL ASSESSMENT TOOLS

9.1 INTRODUCTION

The preceding chapters contain an inventory of water-related issues including information on the types of small-scale mining that presently exist; the main methods used for mining; constraints to mining in terms of infrastructure and skilled labour; typical impacts from an identified range of small-scale mines; identification of cumulative impacts; and the relative importance of each of these impacts.

This section aims to describe appropriate environmental assessment tools that will assist in the management of the water-related environmental impacts of small-scale mines that were identified. All mining practices and processes must comply with appropriate statutory and legal requirements, as well as with industry best practice management systems.

A river should be assessed based on its sensitivity to the type of mining extraction activities. An impact that poses only a slight risk to an ecosystem in one geographical region may result in a much higher risk in another geographical region. This depends on the resilience of the adapted ecosystem, the background quality of the water and the natural flow regime. In order to determine whether a river will be able to remain environmentally viable after mining takes place in a certain type of river at a certain level of intensity, the following aspects need to be addressed:

- The type of mining operation, as well as its intensity and extent.
- The sensitivity of the particular river type in terms of the riparian and instream habitat to sand-winning and gravel extraction operations.
- The sensitivity of a particular river to a specific activity needs to be established.

The sensitivity of a river to a specific activity can be determined by obtaining the following information (Hill and Kleynhans, 1999):

- Specific geological information, *i.e.* presence of sand/gravel deposits (from 1:250 000 geological map).
- Specific information on the catchment and river such as slopes, hydrology, sand cover, land use and erodability.
- A rating system for the ecological importance of the river.
- A rating system for the sensitivity of instream and riparian habitats and biota to the effects of small-scale mining.

9.2 DWAF'S RIVER HEALTH PROGRAMME

The ecological health of South Africa's river and wetland systems is currently not well documented. In order to set ecologically sound management objectives for South Africa's aquatic resources, information on ecosystem health is crucial. The ecological health of a system is best determined by the study of the fauna and flora living there. For instance, macro-invertebrates such as aquatic insects are good indicators of the short-term health of the system, while fish communities or riparian vegetation reflect the long-term health of the system. These are termed biological indicators, biotic indicators or bio-indicators.

Although biomonitoring per se has little predictive capability and should not be used to establish causal relationships, biological indicators give a direct and integrated measure of ecosystem health. They give an indication of conditions of the river over the lifetime of the organisms being measured. Biomonitoring is a robust form of assessment, which can make use of low-tech methods, thus increasing cost-effectiveness. Additionally, results are most often instantaneous. Inevitably, the requirements of managers and the resources they have available to them differ from area to area. A great advantage of using biological indicators is

that biomonitoring offers a range of tools that can be tailored to particular purposes, as well as to the resources available. For instance, more advanced eco-toxicological studies may indicate potential effects of specific pollutants on the environment, while the assessment of macro-invertebrate communities using SASS (South Africa Scoring System) will indicate whether or not the ecosystem is suffering from organic or other pollution.

The River Health Programme (DWAF initiative nationally) itself will have significant benefits for water resource management in South Africa. The information collected can be used to support:

- Assessments of the likely impacts of changes in water quality or flow regime on the health of aquatic systems;
- The formulation of ecologically sound environmental quality objectives and regional and national audits of the status of aquatic environments.

The experience gained from this programme can contribute to the development of protocols for ecological investigations on a catchment, reach or site-specific level, *e.g.* small-scale mines. Although the River Health Programme will be primarily designed to meet the information requirements of water resource managers, it has advantages for a variety of organizations, each with a different mandate. For instance, state-of-the-environment information assists the Department of Environmental Affairs and Tourism to fulfil its national and international obligations. The Ramsar Convention, which South Africa has ratified, aims to stem the loss of wetlands, promote their wise use and afford special protection of listed wetlands, is another example of an organization that uses this information.

At a provincial level, the programme will assist nature conservation authorities to identify top-priority conservation sites in the catchments under their jurisdiction, as well as encourage the participation of local conservation bodies and promote research.

Seven components have been chosen in the River Health Programme:

- invertebrates (SASS)
- fish (FCII)
- riparian vegetation
- habitat integrity
- water quality
- hydrology
- geomorphology

Invertebrates, fish and vegetation together give a good picture of the ecological integrity of a site and reflect the condition of the bio-physical habitat which are described by the remaining components, *i.e.* habitat integrity, water quality, hydrology and geomorphology. Changes to the stream biota must therefore be assessed against a background of possible changes to channel morphology and channel condition.

A successful biomonitoring index must meet a number of criteria: it must provide a meaningful and accurate representation of the river condition, it must be based on field data that is simple to collect, it must be simple to interpret by the non-specialist manager. It is not always easy to marry the first criterion with the second two and most indices will be a compromise. Indices can also be developed at a number of levels. The manager would like a single value, which can be used to flag problems, but this single index may be disaggregated into its component parts so that the cause of the problem can be pinpointed.

The DWAF River Health Programme matrices should be used to determine the impacts of small-scale mining so that the results would be congruent with those of DWAF's current status of biomonitoring. The matrices allowed the extent of the impact to be rated on a

numerical scale so that the different sites could be compared to each other. In the current study, (chapter 7) three assessment indices were applied to each site – habitat assessment matrix (HAM), habitat quality index (HQI) and the Intermediate Habitat Integrity Assessment (IHIA) of the resource directed matrix (RDM). These indices evaluate each mining site on a numerical scale so that results are readily comparable. The indices developed in South Africa for the River Health Programme that should be used to determine the impacts of small-scale mines are discussed in Section 9.2.1 to 9.2.7.

9.2.1 Habitat Assessment Matrix

The aim of the habitat assessment matrix (HAM) is to assess the conservation status of a stream and the impact of physical habitat degradation using a scoring system. A HAM should be completed for each site. Where possible, a matrix should be completed for a point upstream of the mining activity, a point within the mining activity area and at a point downstream of the mining activity.

The following biotopes are defined by the HAM and if present, they were noted on the scoring sheet:

- Stones in current
- Stones out of current
- Sand
- Gravel
- Mud
- Marginal vegetation (MV) (mesic sedges and grasses)
- Aquatic vegetation (AV)

HAM has a range of scores from 1 – 135 and this value is shown as a percentage. The higher the value, the healthier the habitat and the lower the value, the poorer the habitat.

9.2.2 Habitat Quality Index

The habitat quality index (HQI) is very similar to the HAM. HQI also has a range of scores from 0 – 135 and the scores obtained by using these two indices are very similar. The value obtained is expressed as a percentage in order to compare the sites.

9.2.3 Intermediate Habitat Integrity Assessment

The Intermediate Habitat Integrity Assessment (IHIA) is one of the RDM indices used for the protection of water resources in river ecosystems. This simplified procedure was formulated based on the Habitat Integrity (HI) approach (Kleynhans, 1996).

IHAS attempts to account for the variability in the amount and quality of habitats or biotopes available for habitation by aquatic biota. It is related to the South African Scoring System (SASS5) in that the IHAS scores may be used to adjust the SASS5 scores. This habitat scoring system is based on 100 points and is split into two sections: the habitat sampled and the stream characteristics. The sampling section is further broken down into three sub-sections: stones in current, vegetation and other habitat or general. The method is currently under further development and details are given in McMillan (1998).

The criteria considered indicative of the habitat integrity of the river were selected on the basis that anthropogenic modification of their characteristics could generally be regarded as the primary causes of degradation in the integrity of the river. The severity of certain modifications will therefore have a detrimental impact on the habitat integrity of a river. The

assessment of the severity of impact of modifications is based on six descriptive categories with ratings:

- 0 (no impact),
- 1 to 5 (small impact),
- 6 to 10 (moderate impact),
- 11 to 15 (large impact),
- 16 to 20 (serious impact) and
- 1 to 25 (critical impact).

9.2.4 South African Scoring System Version 5 (SASS5) Assessment

This assessment determines the number and abundance of macro-invertebrates in an array of habitats per site. Biotopes have been grouped into two types, namely SASS biotopes and specific biotopes. They relate to the type of habitat available for habitation by aquatic organisms as well as the hydraulic conditions in some instances. The relative percentage of each SASS biotope at the site and the relative percentage of each specific biotope within each SASS biotope should be estimated. Details of the biotopes are given below:

SASS biotopes include:

- stones-in-current (SIC)
- stones-out-of-current (SOOC)
- marginal vegetation (at water's edge)
- aquatic vegetation (in-channel, submerged or partially submerged)
- gravel
- sand
- silt/mud/clay

The standard sampling protocol is to be used, except for SASS biotopes, which are to be sampled separately as follows:

- Stones in Current (SIC) (**SI**): riffle and run, sample for 2 minutes if all kickable, otherwise for a maximum of 5 minutes.
- Stones out of current (SOOC) (**SO**): backwater and pool, kick 1 m²
- Marginal Vegetation (**M**): back and forward sweep - 2 m
- Instream/aquatic vegetation (**A**),
- Gravel, sand and mud (**G**): stir with feet and sweep net over disturbed area for 0.5 minute

For each, tip net contents into tray, remove leaves and twigs, check taxa present on list for the lesser of 15 minutes or 5 minutes since the last taxon was found. Estimate abundances using the following scale provided for in the SASS5 manual.

Collect the invertebrate sample from each biotope in benthic jar and preserve with alcohol (70%). Label jar inside and outside and repeat for other biotopes. It is important to adhere to the time limits specified in the protocol. * indicate that the taxon or the adult life-stage of the taxon (A*) are air-breathers.

9.2.5 Water chemistry

Water quality measured at a site should be reduced to a minimum and should take account of DWAF's national WQM and HIS systems for historical record.

Instrument positioning: Instruments should be positioned in clearly-flowing points of the river where possible, otherwise location of meter and hydraulic biotope type (e.g. riffle, run, rapid, pool, etc.) should be specified.

Samples collected? Details of the filtering, freezing, preservation and analysis method should be recorded.

Macrophytes and algae: The presence of macrophytes (*e.g.* water hyacinth, Kariba weed, *etc.*) and algae should be recorded and their percentage cover estimated. Species details should be recorded if known and an indication given if an algal sample was collected.

Variables measured: It is important to measure the system (temperature, dissolved oxygen, pH using field instruments) and non-toxic inorganic (conductivity or total dissolved solids, turbidity or total suspended solids) variables. If possible, the concentrations of alkalinity, total inorganic nitrogen, total inorganic phosphorus, orthophosphate, ammonia or ammonium should also be measured.

9.2.6 Geomorphological Index of the River Health Programme

River channels are geomorphological features, which are formed by the water and sediment that they transport. Channel change can occur for two reasons. It can occur both naturally (over short and long time periods) and as a result of anthropogenic modification to rivers or their catchments, *e.g.* impoundments, water transfers, small-scale mining, agriculture. The geomorphological processes determine the morphology of the channel, which in turn provides the physical framework within which the stream biota lives. Geomorphology is therefore an important consideration in the assessment of the River Health Programme (Rowntree and Wadson, 1999).

Two components of the geomorphological index have been recommended as part of a site rating and monitoring programme: firstly **a channel classification and index of channel stability** and secondly **an index of channel condition**.

A geomorphological classification of the site would serve three purposes:

- to classify the channel with respect to channel type so as to allow similar sites to be grouped together;
- to provide archival reference data to which later surveys can be related;
- to provide data from which a geomorphological index of channel stability can be derived.

A geomorphological index of channel stability is used to classify sites according to their potential for morphological change because of both natural and anthropogenic change. Such an index is important in interpreting biotic changes observed during the monitoring programme. It is unlikely that the site classification would change over the time span of the envisaged monitoring programme and would therefore only need to be carried out during the site rating.

The assessment of channel condition should be carried out on a regular basis as part of the long term monitoring. An index of channel condition, based on bed and bank conditions, would be coupled with a hydraulic biotope diversity index (HBDI). The HBDI describes the diversity of hydraulic habitats at a site in terms of both flow hydraulics and substrate conditions. Habitat is classified using hydraulic biotope classes, which can be assessed from observations of flow type (surface flow characteristics) and substrate class, backed up by point velocity and depth measurements. Long term monitoring using the HBDI would provide a good measure of changes in habitat related for example to changes in substrate conditions or channel morphology.

The Geomorphological Index is composed of two main parts:

- A measure of the inherent stability of the channel based on its classification using Rowntree and Wadson's (1999) hierarchical scheme, and
- A measure of the observed channel condition.

9.2.7 Hydrology

The Hydraulic biotope diversity index (HBDI) describes the diversity of hydraulic habitats at a site in terms of both flow hydraulics and substrate conditions. Habitat is classified using hydraulic biotope classes, which can be assessed from observations of flow type (surface flow characteristics), and substrate class, backed up by point velocity and depth measurements. Long term monitoring using the HBDI would provide a good measure of changes in habitat related for example to changes in substrate conditions or channel morphology. Flow conditions at the time of the survey will assist in the interpretation of the results.

9.3 PRESENT STATUS

The term present status refers to the number and severity of anthropogenic perturbations on a river and the damage they potentially inflict on the system. These disturbances include abiotic factors, such as water abstraction, weirs, dams, pollution and dumping of rubble, and biotic factors, such as the presence of alien plants and animals.

The method adopted for the establishment of reference conditions is a modified version of Kemper and Kleynhans' (1998) preliminary present status. Their version was developed as one of the procedures to be used for the determination of the preliminary ecological reserve for rivers of South Africa. However, the emphasis in the present assessment is placed on the field-based site assessment, supplemented where possible, with information gleaned from other sources such as catchment study reports, GIS coverages, together with local knowledge. It should be noted that any site-based assessment will lack longitudinal continuity and therefore may not adequately reflect the present status of the river. Aspects considered in the assessment comprise those instream and riparian zone perturbations regarded as primary causes of degradation of a river ecosystem (Section 7.1). The severity of each of these impacts is assessed using scores as a measure of impact (Table 14).

Table 14. Summary of the scoring procedure used to determine Present Status

Impact Class	Description	Score
None	No discernible impact, or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.	0
Limited	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability is limited.	1 – 5
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability are fairly limited.	6 – 10
Extensive	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not affected.	11 – 15
Extreme	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not influenced.	16 – 20
Critical	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.	21 – 25

9.3.1 Individual criteria

It is a near impossibility to remove all subjectivity involved in making Present Status assessments such as those presented here. Descriptions of each criterion are provided to assist with the assessment.

Criterion 1: Water abstraction

Direct abstraction from within the specified river/river reach as well as upstream (including tributaries) must be considered. This excludes indirect abstraction, for example by exotic vegetation. The presence of any of the following can be used as an indication of abstraction: cultivated lands, water pumps, canals, pipelines, cities, towns, settlements, mines, impoundments, weirs and industries. Water abstraction has a direct impact on habitat type, abundance and size; is implicated in flow, bed, channel and water quality characteristics; and riparian vegetation may be influenced by a decrease in water quantity.

Criterion 2: Inundation

Destruction of instream habitat (e.g. riffle, rapid) and riparian zone habitat through submerging with water by, for example, construction of an on-channel impoundment such as a dam or weir. This leads to a reduction in habitat available to aquatic fauna and may obstruct movement of aquatic fauna; in addition it influences water quality and sediment transport.

Criterion 3: Water quality

The following aspects should be considered: untreated sewage, urban and industrial runoff, agricultural runoff, mining effluent and effects of impoundments. Ranking may be based on direct measurements or indirectly via observation of agricultural activities, human settlements and industrial activities in the area. Water quality is aggravated by a decrease in the volume of water during low or no flow conditions.

Criterion 4: Flow modification

This relates to the consequence of abstraction or regulation by impoundments. Changes in temporal and spatial characteristics of flow such as an increase in duration of low flow season can have an impact on habitat attributes. This results in low availability of certain habitat types or water at the start of the breeding, flowering or growing season. Effects of flow regulation of floods and low flows are assessed separately.

Criterion 5: Bed modifications

This is regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment. Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation is also included.

Criterion 6: Channel modifications

This may be the result of a change in flow, which alters channel characteristics causing a change in marginal instream and riparian habitat. Purposeful channel modification to improve drainage is also included.

Criterion 7: Presence of exotic aquatic fauna (e.g. fish)

The disturbance of the stream bottom during feeding may influence, for example, the water quality and lead to an increase in turbidity. Predation on indigenous fish is also a factor. The extent of the effect is dependant upon the species involved and their abundance.

Criterion 8: Presence of exotic macrophytes

Exotic macrophytes may alter habitat by obstruction of flow and may influence water quality. The extent of infestation over instream area by exotic macrophytes, the species involved, and its invasive abilities should be considered.

Criterion 9: Solid waste disposal

The amount and type of waste present in and on the banks of a river, *e.g.* litter and building rubble is an obvious indicator of external influences on stream and a general indication of the misuse and mismanagement of the river.

Criterion 10: Indigenous vegetation removal

This refers to physical removal of indigenous vegetation for farming, firewood and overgrazing. Impairment of the riparian buffer zone, which the vegetation forms may lead to movement of sediment and other catchment runoff products, *e.g.* nutrients) into the river.

Criterion 11: Exotic vegetation encroachment

This excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Encroachment of exotic vegetation leads to changes in the quality and proportion of natural allochthonous organic matter input and diversity of the riparian zone habitat is reduced.

Criterion 12: Bank erosion

A decrease in bank stability will cause sedimentation and possible collapse of the river bank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or encroachment of exotic vegetation.

9.3.2 Weightings and calculation of instream and riparian status

Once a score has been allocated to an impact, it is moderated by a weighting system, devised by Kleynhans, *et al.* (1988) and modified by Kemper and Kleynhans (1998). Assignment of weights is based on the relative threat of the impact to the habitat integrity of the riverine ecosystem. The total score for each impact is equal to the assigned score multiplied by the weight of that impact (Table 15). Flow modifications (indicated with an * in Table 15) were divided into floods and low flows as specified in Eekhout and Brown (1996).

Based on the relative weights of the criteria, the impacts of each criterion are estimated as follows: Rating for the criterion /maximum value (25) x the weight (percent). Example: for a criterion, which receives a rating of 10 in the assessment, with a weighting of 14, the impact score is calculated as follows:

$$10/25 \times 14 = 5.6$$

The estimated impacts of all criteria calculated in this way are summed, expressed as a percentage and subtracted from 100 to arrive at a present status score for the instream and riparian components, respectively.

Table 15. Criteria used to assess assessment of instream and riparian status and the weightings accorded them (Kemper and Kleynhans, 1998)

Instream Criteria	Wgt	Riparian Zone Criteria	Wgt
Water abstraction (presence of pumps, irrigation, <i>etc.</i>)	14	Water abstraction (presence of pumps, irrigation, <i>etc.</i>)	13
Inundation	10	Inundation	11
Water quality (clarity, odour, presence of macrophytes)	14	Water quality (clarity, odour, presence of macrophytes)	13
Flow modification: Floods*	7	Flow modification: Floods*	6
Flow modification: Low flows*	6	Flow modification: Low flows	6
Bed modification (bulldozing, <i>etc.</i> of river bed)	13		
Channel modification (<i>e.g.</i> bulldozing of macro-channel, floodplain)	13	Channel modification (<i>e.g.</i> bulldozing of macro-channel, floodplain)	12
Presence of exotic macrophytes	9		
Presence of exotic fauna (<i>e.g.</i> fish)	8		
Solid waste disposal	6		
		Removal of indigenous vegetation	13
		Exotic vegetation encroachment	12
		Bank erosion	14
Total	100	Total	100

The present status scores (%) for the instream and riparian zone components are then used to place these two components into a specific preliminary present status class. These classes are indicated in Table 16.

Table 16. Present status classes (Kleynhans, 1996)

Class	Description	Score (% of Total)
A	Unmodified, natural.	90 – 100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place, but the assumption is that ecosystem function is essentially unchanged.	80 - 89
C	Moderately modified. A loss of change in natural habitat and biota has occurred, but basic ecosystem functioning appears predominantly unchanged.	60 - 79
D	Largely modified. A loss of natural habitat and biota and a reduction in basic ecosystem functioning is assumed to have occurred.	40 - 59
E	Seriously modified. The loss of natural habitat, biota and ecosystem functioning is extensive.	20 - 39
F	Modifications have reached a critical level and there has been an almost complete change of natural habitat and biota. In the worst cases, the basic ecosystem functioning has been destroyed.	0 - 19

9.4 THE BASE LINE SURVEY

Standardised data sheets for the base line survey have been developed by the RHP and are available from the DWAF and CSIR websites. This assessment should be carried out by experienced experts in invertebrates, geomorphology, fish, hydrologists and habitat assessment.

In order to determine the impacts of small-scale mining, a representative site shall be chosen for the baseline survey.

Basic site details are derived from a 1: 50 000 map (river name, altitude, channel gradient, latitude and longitude) or from a GPS (latitude and longitude). The datasheets contain several sections to be completed at the site. The choice of site will depend in part on criteria required by the specialist fields, but the site should be representative of all the required indices. Examples of the required datasheets are included in the CD Rom available from the WRC.

The following standardized data is required per site in accordance to the RHP. This information must be entered and will be available for viewing in the Rivers Database.

Site Code: naming sites. The site code needs to be a unique entry so if a duplicate site code will result with the standardized naming method, a change to the location code should be made.

River: name of river assessed.

Site Description: details of site location, e.g. farm name, road bridge, village, etc.

Site Length: length of river being assessed, recommended length 30-50 m.

Tributary of: parent river

Map Reference: either 1: 250 000 or 1: 50 000.

Political Region: one of seven regions.

Bioregion: one of 18 bioregions as identified in Brown *et al.* (1996).

Ecoregion: one of 18 as identified in Kleynhans *et al.* (1998).

Water Quality Management Region: one of seven as identified in Day *et al.* (1998).

Secondary Catchment Code: DWAF secondary drainage region.

Catchment Area: area (km²) of secondary catchment.

Quaternary Catchment Code: DWAF quaternary drainage region.

Sub-region: based on Rowntree *et al.*'s (1996) geomorphological zonation of river channels.

River Segment: based on aerial or other surveys wherein the river is divided into 5 km sections.

Lat/Long: GPS (degrees and minutes and seconds) or degree/minutes/seconds co-ordinates of the site (preferably GPS).

Source Distance: distance from source of river estimated from 1: 50 000 map.

Contour Range: altitude range within which site falls estimated off 1:50 000 map.

Stream Order: order estimated of 1: 50 000 map using the Strahler method.

Slope/gradient: calculated: vertical difference between contours (m) divided by horizontal distance between contours, estimated from 1: 50 000 map.

Geological Type: based on Vegter's (1995) simplified lithostratigraphic units.

Vegetation Type: based on Low and Rebelo's (1996) potential natural vegetation of South Africa, Lesotho and Swaziland.

Hydrological Type: based on perennial, seasonal: or ephemeral

Rainfall Region: season in which the majority of rain falls.

DWAF Gauging Station: indicate the presence of a DWAF gauging station and estimate distance upstream or downstream of the site.

Associated System: indicate the presence of important systems that may be associated with the site or river, e.g. wetlands or estuaries.

Photographs should be taken to record the characteristics of the site. In particular every attempt should be made to take a good overhead shot to show the plan view of the site. Shots looking up and down stream should include the riverbanks.

The **condition of the local catchment** will also allow the observer to judge the extent to which the channels and vegetation are likely to have been modified from natural conditions.

The observers to make a **sketch of the channel plan** and channel cross section across a hydraulic control (normally a riffle or rapid) and a pool. A cross-section template is provided to assist the observer in identifying the main channel features. A good sketch map and cross-sections are invaluable when assessing change at some future date. Once available, the site photographs can be used to tidy up the field sketches. The channel dimensions should be recorded in the appropriate table.

Table 17. Proposed environmental assessment process for determining and monitoring the impacts of small-scale miners on the water environment

Phase of ecological assessment	Tools
Assess situation on a regional scale (desk top)	<ul style="list-style-type: none"> • 1:250 000 map (CSIR - SA National Land Cover) • Define 1:100m floodline (impacted area) • Discussions with DME, DWAF, DEAT • Aerial photographs • Collate available data (DWAF water quality data, EMP's, River Health Programme, catchment studies etc.) • Determine background vegetation, river and geology
Plan site visit	<ul style="list-style-type: none"> • Liaise with authorities and miners • Chose representative sites
Site specific assessment (field exercise). First visit called baseline survey	<ul style="list-style-type: none"> • Liaise with miners, authorities and communities • Field assessment of the following matrices: • HAM, IHAS, HQI • SASS5 • Geomorphological Index • Water chemistry (upstream and downstream in-situ water quality - pH, EC, Turbidity) • Hydrology (HBDI)
Collation of data	Review data and compare to historical data and reference site
Present Status Report	Class of river currently and status of impact caused by small-scale mining
Ongoing monitoring	Frequency twice a year – summer and winter

9.5 PROPOSED ENVIRONMENTAL ASSESSMENT APPROACH FOR SMALL-SCALE MINES

The proposed environmental assessment process for determining and reducing the impacts of small-scale miners on the surface water environment is indicated in Table 17. The area of study will be limited to the 1:100 year flood line which will be clearly defined at the onset of the project. The tools used for the detailed site investigation will be those used by the River Health Programme. The standardised data sheets will also be used and the data stored on the Rivers database.

It is suggested that after the site visit a decision is made as to what method of follow up sampling is required. If the environmental impacts are minimal then it would not be appropriate for the small-scale mine to undertake a baseline survey. It would, however, be expected of the mine to comply to the requirements of the SEMPR. It would further be advisable that the small-scale miner be made aware of the Handbook on "Environmentally

Responsible Mining : Water Management Guidelines for Small-scale Mining" and possibly undertake appropriate training in accordance to this handbook.

If after the site visit it is clear that either the individual mine, or the cumulative effects of several mines are causing a significant environmental impact, then the specific site assessment (baseline survey) should be undertaken (Table 17). This assessment should be paid for by the mine or miners. If the results of this assessment indicate water related environmental impacts, the following needs to be undertaken:

- Miners should receive a copy of the "Environmentally Responsible Mining : Water Management Guidelines for Small-scale Mining" handbook and should be trained on how to use it.
- The requirements of the SEMPR should be reviewed with the miners
- Appropriate mining methods should be implemented so as to minimise the environmental consequences
- Ongoing monitoring (Table 17) must be implemented on an at least 6 monthly basis (could be daily or monthly depending on the magnitude of the environmental impacts). The mine must submit the findings of this monitoring programme to the DME and a copy to DWAF.

The monitoring frequency will be determined by the initial assessment of the severity of the impact. If the present status impact class is None to Moderate then it is suggested that the situation is merely monitored by annual site visit to compare the extent of impact using aerial photographs and the drawings made on the base line survey. If there is a significant market change in the extent of impact then more frequent, site visits should be undertaken (as for present status impact classes Extensive to Critical).

For the impact classes Extensive to Critical it is suggested that the monitoring frequency undertaken is twice a year (summer and winter) for the following matrices:

- Habitat (HAM, HQI, IHAS)
- SASS5
- Water quality
- Riparian vegetation

10. IMPLEMENTATION ISSUES AND HANDBOOK

In order to establish enabling conditions for small-scale mining development and achieve the objective of responsible mining with minimal impact on the environment, a number of training and education initiatives are required. A co-operative and supportive or “mentor” approach is necessary to encourage small-scale miners to operate within sound environmental principles. In an effort to achieve this objective, a user-friendly handbook, focusing on the water related impacts of small-scale mining in South Africa, was developed with the project. This was done in consultation with various small-scale mining associations, regulators and specialists involved in the small-scale mining sector. The handbook entitled: “*Environmentally Responsible Mining: Water management guidelines for small-scale mining*” is available from the WRC (ISBN 186845 8334)

10.1 STAKEHOLDER WORKSHOP

Participation by interested and affected parties was vital in assisting the project team with the design, planning and implementation of the guideline / handbook. It was necessary to ensure that any decisions regarding content took into account the needs, interests, and values of the community, mining sector, regulators etc. A stakeholder workshop was convened at the WRC on October 25th, 2001. The aim of this workshop was to discuss possible education and implementation strategies and to engage in an understanding of the water related issues of small-scale mining.

The following groups were invited to this workshop:

Authorities:

- DME (NSC SSM; Head Office SSM Division and regional offices: Gauteng and KwaZulu-Natal);
- DWAF (Institute for Water Quality Studies)
- DEAT (Gauteng)

Small-scale mining group / association representatives from

- Namaqualand; Steinkop, Limpopo areas
- Kimberley, Winderton, Gong Gong, areas
- GP, KZN and Mpumalanga, area

Sedibeng and Bakakga Mining
South African Women in Mining (SAWIMA)
Minerals and Energy Policy Centre (MEPC)
GEMS
Chamber of Mines
CSIR –(Environmintek and Miningtek)
De Beers
University Mining Departments (University of Witwatersrand and Venda)
WRC steering committee members

Twenty-five representatives attended the workshop. The workshop attendance list is attached in the CD Rom available from the WRC. Delegates who had to travel to Gauteng from out off town, viz. Namaqualand, Kimberley and Dundee, were assisted with travel allowances and accommodation.

Consultations were also had with representatives who were not able to attend the workshop to get their input and requirements for this project.

10.1.1 Workshop proceedings:

A presentation of the project finding was made at the workshop and then discussions and brain storming sessions were held to:

- Establish level of understanding and information gaps with regard to environmental aspects of small-scale mining, in particular-water related impacts.
- Understand difficulties in compliance with regulatory requirements
- Investigate guidance approach to potential environmental problems associated with small scale mining
- Outline contents of guideline /handbook document to be produced as a deliverable of this project. This handbook would assist in the management of water related impacts and would be developed in such a manner that would ensure that it can be used and understood by persons with limited or no formal training.

The workshop agenda and minutes are included in the CD Rom available from the WRC.

10.1.1.1 Identification of Water Related Impacts

The workshop delegates were divided into five groups of between four to five people. They were each given a list of possible water related impacts from the project findings (refer to Table 9) and asked to discuss the impacts that they were familiar with or could identify with. The following impacts were recognized:

Sedimentation; Floods; Reduction of vegetative bank cover; Loss of arable land use; River bed disturbance; Aesthetics; River diversion / ponding in flood plains

10.1.1.2 Training and education needs

A number of training and education gaps were identified by delegates during the group and plenary discussions Table 18 outlines the training needs cited by participants to manage the water -related impacts of small scale mining effectively.

Table 18. Training needs identified by delegates.

Category	Description	No. of responses
A	How mining activities impact on the water environment On-site training of do's and don'ts (Importance of water as a resource that needs to be protected; Waste management; Recycling; Water use; Buffer zones, Preventing sedimentation; Awareness of both groundwater and surface water impacts)	15
B	Legal requirements User friendly regulations that are comprehensive to SSM / thumbnail procedures and common pitfalls Advice Centre Co-operative governance in relation to SSM	8
C	Best Practice (sector based) Mining processes that have less of an impact; Weighing up the positive and the negative; New environment-friendly mining methods.	7
D	Rehabilitation- (do it as you are mining-it is more cost effective)	6
E	How to follow or produce an EMPR; What is an EMPR?	4
F	Consequences (environmental) of improper mining practice (the bigger picture)	4
G	Community education and community policing Use of SSM Associations for monitoring purposes (be trained to train others)	3
H	Water quality indicators; Pollution loads	1

10.2 HANDBOOK

The final session, at the stakeholder workshop, was held to discuss the stakeholder requirements for a handbook or guideline document. The handbook would assist small-scale miners and regulators in the management of water related impacts of small-scale mining. Various participatory techniques were used to draw out and understand the principal needs in this sector.

The majority of participants cited information regarding:

- a) on site acceptable practices in water management i.e. on arrival; during operation, and when leaving; and
- b) legislative and payment issues, *i.e.* What to do?; Outline requirements; and Who can help?, as key requirements of this document. A detailed synopsis of the ideas expressed by participants is included in the minutes of the workshop (Table 1. (CD Rom available from the WRC))

10.2.1 Terms of reference

Once the project team had the basis for the handbook from the various discussions held with stakeholders, a terms of reference could be prepared.

The following is a description of the scope of work based on stakeholder requirements (Table 19):

Table 19. Scope of work provided for handbook.

Product:	Practical guideline document
Size	Not more than 16 A4 pages
Number:	Three (3) sample copies (printing for distribution not included in this project) and electronic copy;
Finish	Final format in colour
Language:	English (To be translated but translation not included in this project)
Style	To be understood by target audience (see below); Simple; Easy to Understand and Translate
Target audience	Small-scale miners who may have little or no formal training.
Aims	<ul style="list-style-type: none"> • To create awareness regarding water related impacts mining operations may have on the environment • To assist small-scale miners and entrepreneurs to manage their water related impacts. • To relate this to legislative/regulatory requirements (SEMP or EMPRs) • Rehabilitation or water management is done in conjunction with relevant authorities • To highlight the South African situation- photographs used would be identified as local landscapes and environments
Content	<ul style="list-style-type: none"> • Define individual and cumulative effects of impact • Define concept of integrated water resource management • Portray impact using: Source, Pathway and Receptor concepts • Describe examples of impact (clear problem identification; general and sector specific) together with appropriate rehabilitation methods and benefits if managed: • Include three way perspective: i.e. miners, community and regulators • Describe basic site management actions for: “<i>Arrival; During operation; On leaving</i>” that will minimize water related impacts (e.g. link surface activity with groundwater) • Include who to contact for further advice e.g. DME, DWAF, Small Scale Mining Associations

10.2.2 Methodology and approach

The approach of Clacherty and Associates who have been active in materials development for adult users for many years, was based on constructivist principles, whereby the handbook would seek to activate and engage the learners own existing ideas and attitudes about the topic. The material would be able to stand-alone and be useful to a usable by an isolated individual. It would have to infer some of these ideas and attitudes on the subject but it would raise questions that may extend or challenge miner’s notion of what a responsible or good miner is. Another guiding principle in this the approach would be to help the learners create links for themselves between seemingly unrelated ideas e.g. miners may regard issues of health and safety of water users and the practices in the mining site.

The methodology included initial planning and conceptualization, conducting research and agreement on content, writing and selection of photographs, development of the design, getting feedback and approval from client; field testing with stakeholders, and final drafting and handover.

10.2.3 Stakeholder participation

The stakeholder participation process that was followed is outlined below:

Two rounds of field testing of the handbook with stakeholders were conducted. The first round focused on the text and content only. The second round was used to assess the final designed colour proof copy.

- Review One:

Copies of the draft text and format were sent to stakeholders for their comment and input. Briefing documents were prepared for the technical reviewers and user group reviewers. They are included in the CD Rom available from the WRC. Technical reviewers included members of the steering group and regulators. User group reviewers were selected from SSM associations, training and capacity building organisations, regional DME officers and small-scale mining regulatory departments.

- Review Two:

Changes proposed to the handbook by the review panel were compiled and incorporated. Furthermore, appropriate photographs were selected and drawings finalized. Once the revisions to the handbook were made it was sent to the designers to prepare a colour proof. A copy of the colour proof was then sent to all the stakeholders identified for the workshop and educational specialists for their final proof reading comments. The final colour proof product was then handed over to WRC for printing and distribution and translation if found necessary.

It is proposed that in order to maximize the impact of the booklet, it should form part of a wider education and training process. The handbook is designed as an interactive resource that can be used by individuals but also lends itself to facilitation through a workshop or use by regulatory staff, small-scale mining association representatives, *etc.*

11. MANAGEMENT STRATEGIES FOR WATER-RELATED IMPACTS

The challenge in environmentally managing small-scale mining is to develop appropriate implementation strategies and environmental management systems. These strategies must be relevant, understandable, and affordable to the small-scale miner and should aim at maintaining a balance between encouraging economic development and preserving high standards of environmental management.

Over the years, increasing consciousness of the need to minimize impacts on the biophysical environment has driven considerable international and local debate around the impacts of mining and mineral processing operations. This has proceeded in tandem with a mounting awareness that modern society relies heavily on minerals and the goods and services acquired from and/or with minerals. The process has been accompanied by new and progressive developments in regional and international legislation that seek to balance the costs of environmental impacts to society against the benefits derived so as to ensure greater equity for all beneficiaries and stakeholders (Ashton *et. al.* 2001).

Most miners are fully aware that it makes good business sense to prevent unnecessary impacts to the environment and that efficient management of their mining operations will help to maintain costs at low levels. In achieving a balance between the need to minimize impacts on the environment, enhance the wider social benefits of mining, and maintain shareholder confidence in their investments, the mining sector as a whole has had to progressively collaborate more closely. This has helped to develop a wider acceptance of mining amongst society in general and has allowed mine operators the opportunity to demonstrate their commitment to sustainable development principles.

11.1 IMPROVED AND HARMONIZED LEGISLATION

In the past, mining has been subject to legislation that contained conflicting principles, policies, and requirements and was passed by several different government departments. This made it extremely difficult for mine operators to comply fully with legislation and exposed them to unnecessary legal problems. Recent developments include:

- In each southern African country, greater attention is being paid to harmonizing different pieces of legislation that control or affect mining activities and their consequences in an effort to eliminate inconsistencies and unnecessary duplication of effort. This activity is being extended beyond national borders in an effort to ensure that the different pieces of legislation in each SADC country are aligned and congruent with one another.
- The new draft Minerals Bill in South Africa represents a fundamentally new way of approaching the issue of mineral rights and the responsibilities of the different parties involved in mineral exploitation activities. In the process of developing specific clauses in the new Minerals Bill, government is consulting with all stakeholders.
- In South Africa, the Department of Mineral and Energy Affairs is in the process of revising and updating the Aide Mémoire for environmental management programmes on mines. This will facilitate the prevention of environmental impacts (particularly those on the water environment) and assist mine management to undertake targeted remedial actions where these are required.

11.2 GOVERNMENTAL STRUCTURE AND MINING LAWS

There is a need to lobby for a small-scale mining sensitive legal framework, giving equal opportunities to the big and small players in the mining sector (Drechsler, 2001). Even if the legal framework is made more appropriate, government mining ministries and departments do not have the capacity and resources to address the needs of the many small-scale miners. They also lack resources to implement and monitor regulations. Self-legislation is recommended, as there is not adequate capacity within the regulatory authorities. Associations such as Catchment area Forums/a, River Forums; small-scale mining associations, 2020 Vision for Water Schools project, *etc.* should become involved in ensuring legislation is adhered to.

Due to limited manpower, as well as the remoteness of many of the small-mining sites, the implementation of relevant regulations, *e.g.* SEMPR's, and the enforcement of legislation to ensure environmental protection is not always possible. Alternatives to traditional methods of policing the compliance of mining operations methods need to be sought for small-scale mines. Methods that promote voluntary compliance and the involvement of stakeholders (including neighbouring communities) need to be sought.

11.3 EDUCATION AND TRAINING

There is a need for training and information in the management and technical skills areas. Appropriate mineral processing technology is a weak point within the small-scale miners skills. Minerals processing, rather than the mining itself is mainly responsible for environmental damage. Technical skills transfer in the minerals processing field would therefore benefit the small-scale mining sector. Any training for small-scale miners has to include awareness raising and information about the negative environmental and social impacts of their operations and how to avoid it. Training and information dissemination workshops should include not only the miners but also all members of the community and other stakeholders.

11.4 CAPACITY BUILDING

Capacity building projects are very important for the sustainable development of the small-scale mining sector. Marginalized groups within the mining sector, *e.g.* women, need to be supported to strengthen their role in the sector (Drechsler, 2001). Building the capacity of small-scale miners to improve mining methods, business management, mineral processing and environmental management must be regarded as priorities for intervention. Education institutions, in partnership with government and industry should develop and offer appropriate capacity-building programmes for comprehensive technical skill acquisition by small-scale miners. The University of Venda, in the Limpopo Province, has a Department of Mining that could be used to train students to not only understand the principles of best practise in the mining industry but also be used to undertake research projects with local small-scale miners.

11.5 COLLABORATION FORUM AND CO-ORDINATION

There is a need for integrated solutions to the problems of the sector and improved co-operation between the various institutions. A forum needs to be established that would provide a co-ordinated approach to assessing and addressing some of the problems associated with the small-scale mining sector. The forum should assist in improving the health and living conditions of small-scale mining communities by introducing and investing in more appropriate, environmentally responsible and safer mining techniques.

Many more small scale mining associations for the various mining categories and regions are required. One way to solve problems, even for mines with low reserves, is to search for economies of scale and common solutions for a group of neighbouring mines or share issues.

11.6 WORKING FOR REHABILITATION

In line with the government's commitment to implement programmes of land reform and support small-scale mining, a programme similar to the success of the "Working for Water" initiative run by the Department of Water Affairs and Forestry is suggested.

Working for rehabilitation would be aimed at sustainable rehabilitation of mining land resources through a process of economic empowerment and transformation. Social development will be an integral part of the Working for Rehabilitation programme and the thrust would be aimed primarily at poverty relief and decreased unemployment.

Secondary industry initiatives could provide an ideal opportunity to encourage entrepreneurship amongst people from historically disadvantaged communities. In doing so, the programme has the potential to leave a legacy of social equity and legislative, institutional and technical capacity.

11.7 TECHNICAL SUPPORT AND APPROPRIATE TECHNOLOGY

Machinery and mining equipment is usually developed for medium to large-scale mining operations and is not always appropriate for small-scale mining. It is therefore necessary to develop technology appropriate to the scale of mining operations and to the special needs of the particular small-scale mining region.

The National Steering Committee and various other initiatives being undertaken by Miningtek, Council for Geoscience, Mintek and some large mining houses will all assist the small-scale miners to develop appropriate business plans, use the appropriate technology and mine in an environmentally sustainable manner.

Small-scale miners and the associated communities need to be included in environmental education programmes. More emphasis needs to be placed on the development of a procedure for sustainable and responsible small-scale mining. Emphasis must be placed on the development of a process that will promote ownership of the environment within the small-scale miners and the community and not be reliant on a legislative drive.

The DWAF initiative on Best Practise Guidelines (Section 11.8) is a good example of appropriate technology that will assist both the regulators and small-scale miners to understand the process of registering for mining as well as reduce the risks associated with small-scale mines.

An initiative by DME to classify ownerless and abandoned mines in terms of their environmental impacts, as well as the rehabilitation costs will not only assist DME in identifying where they should be concentrating their efforts but will also assist in determining where small-scale miners could further be assisted with regards to environmental management.

11.8 BEST PRACTICE GUIDELINES

DWAF is developing a series of Best Practice Guidelines (BPG) for the mining industry and one of these will be for small-scale miners. This Best Practice Guideline will be aimed at both the regulators and miners with the major objective being to ensure that there is consistency

within the application of the mining legislation. The guideline will ensure that the principles of the water management hierarchy are complied to and assist with:

- compliance with all legislation;
- a life cycle approach;
- the cradle to grave principle;
- the precautionary principle;
- a risk based approach

The small-scale mines BPG is intended to be a practical "hands-on" document that will give practical advice on the very important topic of water management in the small-scale mining sector. This particular guideline will be prepared in two versions:

- A Standard format guideline aimed at Department officials, *viz.* water pollution control officials and environmental management personnel in the DME and DWAF.
- A simplified guideline aimed at the small- scale miners, produced in English, Zulu and Sotho.

This BPG will be consistent with the general principles outlined for the other BPGs which are that consensus and acceptance of the guidelines are required from the people who will use the guidelines, *i.e.* small-scale miners and DWAF.

The Standard BPG will not be enforced by regulation but will rather be used by DWAF personnel as a basis for negotiation with the small-scale mining industry.

11.9 IMPROVED STAKEHOLDER PARTICIPATION IN DECISION-MAKING

Worldwide, the general public has expressed a keen desire to participate fully in all aspects of decision-making and southern Africa is no exception to this trend. The government is extending the range of debates and processes that enable all stakeholders to contribute. Some typical examples are listed below:

- The proponents of all new developments (including mining) are required to identify and seek out the relevant stakeholders and help them to participate fully in decisions that may affect their livelihoods.
- The Environmental Impact Assessment (EIA) process requires stakeholder participation by law.
- Water resource management legislation in several SADC countries now makes specific provision for stakeholders to take an active part in decision-making processes and in the execution of water conservation and management practices.
- The SADC protocols on water resource management and the sharing of trans-boundary watercourse systems have been ratified by all SADC countries and represent two examples where all the countries in the region will ensure full collaboration.

11.10 ENVIRONMENTAL MANAGEMENT SYSTEMS

In recent years, there has been far greater awareness of the need for effective and efficient management control systems that will help to maximize the effectiveness of waste control systems; ensure a standard level of quality control; and make sure that all staff members within a mining operation are fully aware of their responsibilities. The most widespread systems in use today are those of the International Standards organization (ISO), in particular the ISO14000+ series of environmental management systems. The added benefit of these systems is that they represent an internationally accepted system of accreditation and

certification that provides all stakeholders with a guarantee of specific levels of performance and care.

Unfortunately, not all mining operations have implemented a formal system of environmental management such as the ISO14000+ system advocated here. Many smaller mines, all alluvial gold mining operations and most quarrying operations have no formal environmental management system in place.

A concerted effort should be made by the relevant authorities to enhance the awareness of all mine operators that an environmental management system such as the ISO 14000+ series will help to minimize any adverse effects their operations may have and will also help to improve the effectiveness and efficiency of their operations.

12. CONCLUSIONS

Mineral exploitation provides an opportunity for the creation of sustainable livelihoods, and governments and local authorities should ensure that rural development programmes include and support the development of small-scale mining as an integral part of their strategic plans. The challenges are great, but there is a very real potential for the small-scale mining sector to contribute to sustainable development and sustainable livelihoods in the mining and minerals sector and in the region. Section 11 (management strategies for water-related impacts) summarises the different management strategies that should be adopted. These strategies will therefore not be repeated in this concluding section. The following issues were identified as being problematic for small-scale mining and contributed to the water-related impacts:

Illegal sector

The question of the illegal sector needs to be addressed with urgency. In most cases illegal operations interviewed by the MEPC (1998), were making a valuable contribution to the local community through employment and, in the case of brick making (clay and coal mining), cheap building products. However, such operations are accompanied by a flagrant disregard for environmental management, adequate health and safety standards or the long-term sustainability of the deposit and the land. These operations need to be legalised so that standards can then be enforced. Thereafter, support systems need to be set up to encourage better mining practices.

An example would be the development of environmentally benign processing equipment, particularly for gold processing that would remove individuals from direct exposure to mercury. The eradication of illegal operators will require careful analysis of the reasons why the activity has begun in the first place and education on the benefits of being legal, accompanied by economically viable legal options for previously illegal operators. Greater government control over formal and “informal” mining operations and “ownership” of mineral / water resources needs to be exercised.

Legislation

Mining has been subject to legislation that contained conflicting principles, policies and requirements and was passed by several government departments. Small-scale miners found it difficult to comply with legislation. This situation is changing, as there are moves by the government to harmonise the different pieces of legislation.

Public involvement

There should be increased public involvement in the decisions around environmental issues. The emphasis should be on equitable sharing of costs and benefits. The local community should be made responsible for maintaining and rehabilitating land in a Working for Rehabilitation approach. This approach would be similar to the “Working for Water” approach.

Regional approach

Greater emphasis should be placed on regional approaches to “water security” and economic development. Pilot scale projects using District Councils as partners should be considered by the small-scale miners and the regulatory authorities.

Environmental Management

Environmental management should be a consideration prior to the commencement of any operation. Therefore, education and training is needed to ensure that environmental management skills are present from the start.

Training and Education

Environmental education of both the miners and affected communities is necessary. Environmental management and health and safety knowledge must form part of training for small-scale operators.

Regulatory authorities

The DME needs to ensure ongoing environmental health and safety monitoring. It is proposed that the DME manage a national database of small-scale mines throughout South Africa. The research undertaken for the national inventory indicated that there is a lack of spatially controlled data. Cost of data sets is expensive and maps are not readily available. It was noted that capacity of regulators with regards to small-scale mines is limited.

Rehabilitation bond

The DME must ensure that rehabilitation bonds are sufficient to cover projected costs. The calculation of the rehabilitation bonds needs to be verified by the DME, as this value may be underestimated by the small-scale miner.

Regulations

There is inconsistency in the application of legislation between large and small-scale mines and between regional offices of the DME and DWAF.

Nature of water-related impacts

Water environmental impacts are localised. Riparian impacts are localised but can be significant.

Rehabilitation and Government policy

The Government policy relating to small-scale mining suggests that the development or promotion of mining is regarded as a higher priority than the environmental protection and rehabilitation. The rehabilitation of small-scale mines is not regarded as a priority activity. Alternative ways of rehabilitation needs to be considered. Hands-on training relating to rehabilitation needs to be offered to the small-scale miners. Ownership versus State land needs to be cleared in terms of responsibilities for rehabilitation. Social costs to the State for undertaking rehabilitation need to be budgeted for.

Loans

Loans are not readily available for small-scale mining. It is recommended that the economic experiences from the Department of Land Affairs and Housing need to be assessed.

Incentives

Tax relief and incentives must be promoted for environmentally acceptable mining. Small-scale miners trust should be promoted.

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14. RELEVANT TERMINOLOGY / GLOSSARY

A Mine

According to the Minerals Act, No. 50 of 1991, a “mine means any place where a mineral deposit is being exploited, including the mining area and all buildings, structures, machinery, mine dumps, access roads or objects situated on such area and which are used or intended to be used in connection with such searching, winning or exploitation or for the processing of such mineral: Provided that if two or more such excavations, boreholes or places, or excavations, boreholes and places, are being worked in conjunction with one another, they shall be deemed to comprise one mine”.

Mining Area

According to the Minerals Act, No. 50 of 1991, the “mining area” means the area comprising the subject of any prospecting permit or mining authorisation, including any:

Adjacent surface of land;

Non-adjacent surface of land, if it is connected to such area by means of any road, railway line, power line, pipeline, cableway or conveyor belt; and

Surface of land on which such road, railway line, power line, pipeline, cableway or conveyor belt is located.

Mining Authorisations

According to the Minerals Act, No. 50 of 1991, a

“Mining licence” means any authorisation issued in terms of Section 9 for any period exceeding two years.

“Mining permit” means any authorisation issued in terms of Section 9 for a period not exceeding two years.

“Prospecting permit” means any authorisation issued in terms of Section 6.

Watercourse

In terms of the National Water Act, No. 36 of 1998, a “watercourse” means a river or spring; a natural channel in which water flows regularly or intermittently or a wetland, lake or dam into which, and from which water flows.

Water Resource

According to the National Water Act, No.36 of 1998, “water resource” refers to a watercourse, surface water, estuary or aquifer.

Riparian Habitat

According to the National Water Act, No. 36 of 1998, the riparian habitat “includes the physical structure and associated vegetation of the areas associated with a watercourse, which are commonly characterised by alluvial soils and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from the adjacent land areas”.

Resource Quality

In accordance with the National Water Act (No.36 of 1998) “resource quality means the quality of all aspects of a water resource including the:

Quantity, pattern, timing, water level and assurance of instream flow;

Water quality, including the physical, chemical and biological characteristics of the water;

Character and condition of the instream and riparian habitat; and

Characteristics, condition and distribution of the aquatic biota”.

Instream Habitat

According to the National Water Act, No. 36 of 1998, “instream habitat includes the physical structure of the watercourse and the associated vegetation in relation to the bed of the watercourse”.

Water Pollution

In terms of the National Water Act, No. 36 of 1998, “pollution means the direct or indirect alteration of the physical, chemical or biological properties of the resource as to make it:

Less fit for any beneficial purpose for which it may reasonably be expected to be used; or Harmful or potentially harmful to the welfare, health or safety of human beings; to any aquatic or non-aquatic organisms; to the resource quality; or to property”.