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Coal and Water Futures in South Africa

The case for protecting headwaters in the Enkangala grasslands

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Dedication

The report is dedicated to the memory of Prof Kadar Asmal – South Africa's first democratic minister of Water Affairs, a visionary thinker in sustainable water development and a supporter of WWF-SA.

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WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by: conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

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EXECUTIVE SUMMARY

South African government has committed itself to reducing greenhouse gas emissions and moving to a new path of Green Growth. This will improve our energy security with a diversified mix of renewable energy production and a reduction in our reliance on coal-fired power. The next 15 years will see a process of transition as new independent energy producers enter the market. At the same time we will be faced with the consequences of climate change and our already stressed water resources will come under increasing pressure as temperatures rise and rainfall becomes more volatile.

Many of our catchments are already heavily polluted by mining (eg Upper Vaal and Olifants catchments), and six out of 19 of our WMAs will not have enough water to meet demands by 2030. We ask government to plan strategically and in an integrated manner to ensure our future water security.

Twelve per cent of South Africa's land area generates 50% of our river flow. We need to plan the development of our landscapes to protect our most important water, soil and biodiversity resources. Headwater catchments, such as the Enkangala grasslands – source of the Vaal, Thukela and Pongola – should not be exposed to new coal mining.

South Africa has extensive coal reserves, and we can meet our future fossil fuel needs by planning for mining in less vulnerable areas. Coordinated strategic planning is needed now to prevent a repeat of the acid mine drainage crisis facing the Witwatersrand. Sustainable economic development and our water and food security require intervention at the highest levels to define where we will mine coal and where we will prioritise water and food (provisioning) in our landscape. WWF calls on government to 1 – Mitigate – 2 – Manage – 3 and Monitor.

This report addresses this question: *Should coal be mined in critical catchments?*

We examine the coal industry in South Africa and the documented impacts on water resources. The Olifants catchment is an area that has experienced over 100 years of coal mining and now has some of the poorest water quality in the country. Other economic development in the catchment, such as agriculture and tourism, is threatened because of the impact of coal. We assess the mining process to see where things are going wrong.

Surely now we can manage mining better so there are no impacts? The impact of coal mining is highly variable as result of different levels of environmental management and governance. However, the legacy of abandoned mines and weaknesses in governance of mining mean that South Africans cannot rely on a minimum standard of impact nor do polluters pay for the devastation they cause. Too often the tax-payer foots the pollution bill. With constrained capacity and resources in the government departments that over-see environmental compliance, we believe prevention is better than cure. High-value, sensitive areas should not be open to coal mining.

But how do we know where our critical catchments are? We have looked at a case-study in the Enkangala grasslands and defined no-go areas for coal mines. Conservation plans have been developed that highlight high conservation value areas. The South African National Biodiversity Institute (SANBI) have recently

published catchment maps that identify critical catchments for our aquatic ecosystems – Freshwater Ecosystem Priority Areas (FEPAs). The Department of Water Affairs continually monitors rainfall and river flow and knows which are our high yielding head-water catchments that are the source of water for users down-stream.
This knowledge should inform land-use planning at the highest level. We need to link strategic plans and policies for economic and industrial growth to spatially explicit provincial level planning that optimises our ability to adapt to and sustain growth in an increasingly uncertain future.

Key recommendations:

1 – Mitigate – strategic planning for a sustainable future for all.

The National Planning Commission and Departments of Water Affairs (DWA), Environmental Affairs (DEA) and Mineral Resources (DMR) must agree at the highest level to restrict mining in critical water source areas in order to mitigate the impacts of water pollution. Spatially explicit development plans are needed at a provincial level that take account of high yield catchment areas, critical biodiversity areas and high value agricultural areas. The water, jobs and food provided by these areas need strategic level protection from mining applications. If we can't afford to clean up our current environmental liability, we must prevent impacts in critical areas. Government needs to:

- Re-balance the power and responsibility among government departments, to enable co-operative governance.
- The impact of mining needs to be measured and assessed according to cumulative impact, and not individual impacts.
- South Africa has to strike consensus on a just balance between the necessity of coal mining and the need to protect the environment and social well-being.
- It should be of utmost national importance to determine the water (quantity and quality) requirements for food security, human provision and dilution in order to know how much further SA can continue to impact water.

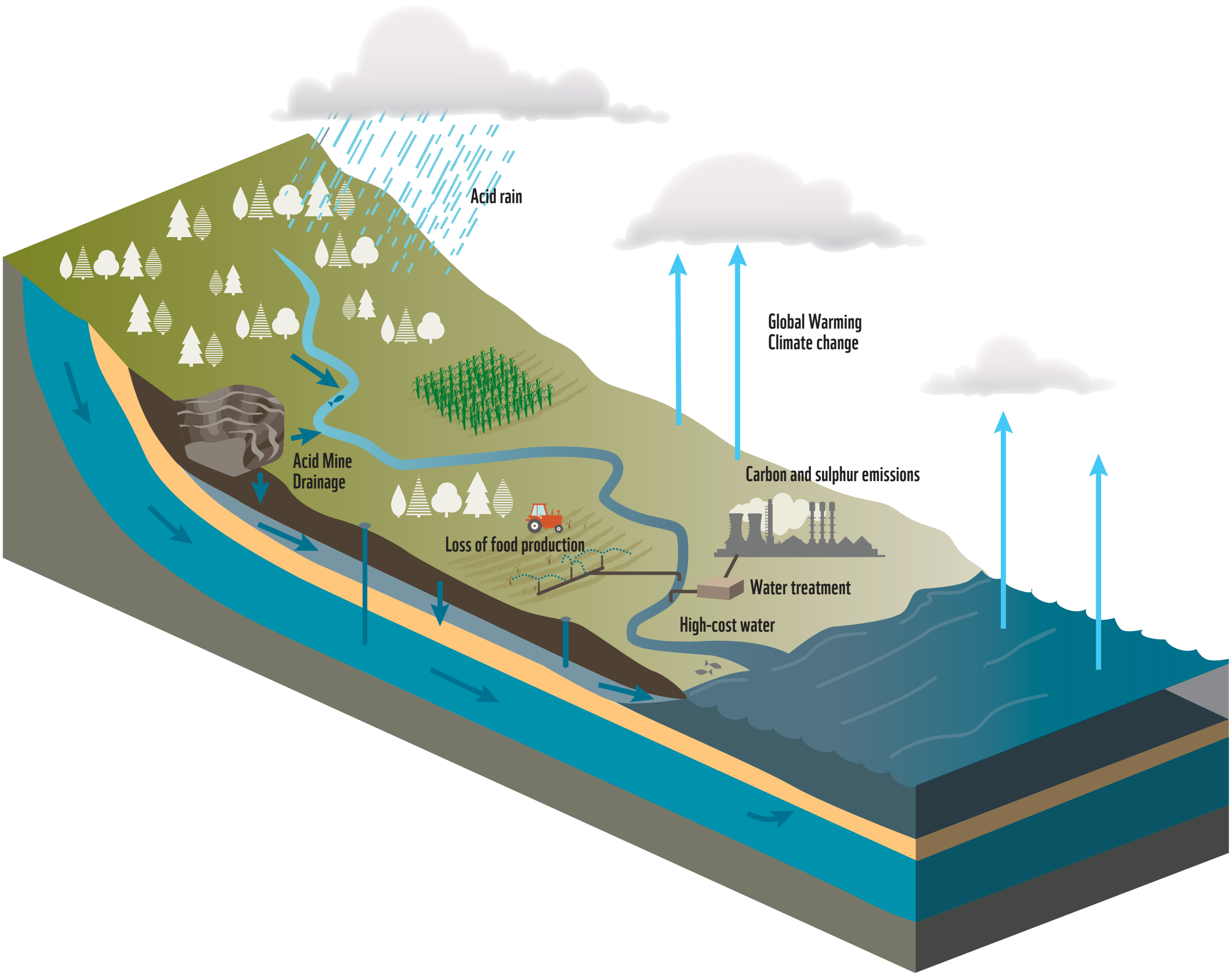
2 – Manage – improved management of the licensing and mining process.

Whilst our legislation currently aims to protect water resources, ensure the 'polluter pays' principle and enable sound environmental management – implementation is not coordinated between the necessary government departments. A strategic implementation rethink is required to enable our legislation to become more effective. The Department of Water Affairs licencing process must be properly accommodated within mining licencing and capacity within the Department should be strengthened urgently to enable this. Water management in South Africa needs to be prioritised. Processes which have almost stalled – such as the formation of Water User Associations, Catchment Management Agencies, and the implementation of the National Water Resource Classification system – must be invigorated and accelerated. Management of financing for decommissioning within DMR needs to be reviewed and improved. We cannot continue to issue new licences to an increasing number of junior operators when rehabilitation funding mechanisms are so inadequate.

3 – Monitor and enforce – growing jobs in the environmental sector.

The number and competence of environmental enforcement practitioners must be strengthened and expanded within DME, DWA and DEA. This will enable the effective harmonisation of licensing procedures within and between departments and strengthen government's ability to monitor and enforce compliance. Monitoring of mining activities and water resources in general is inadequate. There is significant scope for growing a new generation of graduate and matric level environmental officers and placing them in effective systems of cooperative governance.

EMPs and EIAs must be completed by trained environmental practitioners, even during the prospecting phase. EMP scores for the prospecting phase must take provincial and national conservation plans into account. Monitoring good practice in coal mining should influence consumers in procurement decisions. Currently some European consumers may require minimum environmental standards from their mining suppliers. If Eskom and Sasol, as major consumers in the domestic market, also required best practice in terms of environmental management and funding for rehabilitation, from their coal suppliers this could have far reaching effects in the sector.



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LIST OF ABBREVIATIONS

Al – Aluminium
AMD – Acid Mine Drainage
AECI – African Explosives and Chemical Industries
BAU – Business As Usual
BEE – Black Economic Empowerment
bn – billion
BOTSOC – Botanical Society of South Africa
CC – Climate Change
CGS – Council for Geoscience
CMA – Catchment Management Agency
Co – Cobalt
COP – Conference of the Parties (to the UN)
Cr – Chromium
CSIR – Council for Scientific and Industrial Research
Cu – Copper
DEA – Department of Environmental Affairs
DEAT – Department of Environmental Affairs and Tourism
DME – Department of Minerals and Energy
DMR – Department of Minerals and Resources
DWA – Department of Water Affairs
DWAF – Department of Water Affairs and Forestry
EC – Electrical Conductivity
EGP – Enkangala Grassland Project
EIA – Environmental Impact Assessment
EKZNW – Ezemvelo KwaZulu-Natal Wildlife
EMP – Environmental Management Plan
EMPR – Environmental Management Programme Report
ESKOM –Electricity Supply Commission
FAO – Food and Agriculture Organisation
Fe – Iron
FEPA – Fresh Water Environmental Priority Areas
FS – Free State
FSA – Fish Support Area
GDP – Gross Domestic Product
GHG – Greenhouse Gases
GVA – Gross Value Added
ha – hectares
IAPs – Interested and affected parties
IBWT – Inter-basin Water transfers
ISCOR – Iron and Steel Corporation
ISP – Internal Strategic Planning
km – Kilometre
kt – Kilotonnes
KZN – KwaZulu-Natal
Ltd – Limited
MAR –Mean Annual Rainfall
mg/l – Milligrams per litre
mm/a – Millimetre per annum
Mm^3/a – Million cubic metres per annum
mm – Millimetre
Mn – Manganese
Mp – Mpumalanga
MPRDA – Minerals and Petroleum Resources Development Act
MPRDAA –Minerals and Petroleum Resources Development Amendment Act
MR – Mining Right
Mt – million metric tonnes
MTPA – Mpumalanga Tourism and Parks Agency
Ni – Nickel
NEPA –National Environment Policy Act
NEMA – National Environmental Management Act
NEMAA –National Environmental Management Amendment Act
NGO – Non-Government Organization
NSDP – National Spatial Development Perspective
NWA – National Water Act
PAJA – Promotion of Administrative Justice Act
PE – Protected Environment
PR – Prospecting Right
PV – Present values
Ramsar – An international convention for the protection of wetlands
SANBI – South African National Biodiversity Institute
SASOL – South African Coal and Oil
SSF – Sasol Synthetic Fuel
SAPPI –South African Pulp and Paper Industries
STATSSA – Statistics South Africa
R – Rands
RBCT – Richard's Bay Coal Terminal
RM – Rands in millions
ROM – run of mine
RSA – Republic of South Africa
RWQO – Resource Water Quality Objectives
TDS – Total Dissolved Solids
UN – United Nations
V – Vanadium
WMA – Water Management
WW – Waste Water
yr – Year

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Top: Enkangala Grasslands: headwater areas with Mist Belt Forest.
Above: Coal mining pollutes neighbouring river systems and groundwater systems in the grasslands.

1. INTRODUCTION

This chapter outlines the purpose of this report and gives the strategic context to water and energy resources and sectors within South Africa. Our national policies currently direct us towards a new path of green growth and highlight the need for integrated planning. The proportion of our energy needs met by coal fired power should reduce from 92% to 60% by 2030.

1.1 Purpose of this report

This report presents the results of research carried out by WWF-SA, the Council for Scientific and Industrial Research (CSIR) and De Wit Sustainable Solutions on the impacts of coal mining on water resources in South Africa. This is a technical report presenting scientific and technical data, as well as information shared by stakeholders in workshops facilitated by WWF-SA. Information and data are presented from published scientific literature, sector assessments and reports, government reports and government databases such as the water quality database.

This report is aimed at government, the mining sector, environmental practitioners, regulators, and environmental journalists. A summary report has also been produced summarizing this information in a less technical way to ensure the key points are accessible to a wider audience.

The report aims to:

- summarise documented impacts of coal mining on water resources using the Olifants Catchment as a case study;
- demonstrate how current planning for coal mining does not take account of important water resources, using the Enkangala Grasslands area as a case study;
- recommend critical changes needed for integrated development and land-use planning that will improve our water security in the future.

1.2 Water resources and water security in RSA

South Africa is a dry country by global standards with the mean annual rainfall of about 490 mm compared with the global average of about 876 mm. Less than nine per cent of the rainfall ends up in rivers, and about five per cent recharges groundwater in aquifers[1,2,3]. Rainfall and thus river flows, are very unevenly distributed with 12% of the land area generating 50% of surface runoff. High water yield areas occur in our high mountain catchments including the Cape Fold belt, the Drakensberg and Lesotho, the escarpment and Soutpansberg.

Rainfall is highly variable from year to year, and more variable in the drier (western) areas. The coefficient of variation of rainfall ranges from about 15% in areas with more than 1000 mm p.a. to more than 40% in areas with <250 mm p.a.[4]. There are also marked multi-year cycles in rainfall, resulting in extended drought and wet periods across the country[5,6].

The volumes of river flows are driven by rainfall and amplify that variability by about two to four times[7]. The greater inter-annual variability in flows is also evident during prolonged droughts, where decreases in river flows may be more than twice those in rainfall. Rainfall is also strongly seasonal, which means that soil takes up most of the moisture in the early rains and river flows respond relatively slowly.

Climate change is predicted to result in more extreme events (droughts and floods) in many parts of the country[8]. While the central and northern interior will become significantly hotter, western areas are likely to become more arid. Rainfall impacts will be amplified in river flows and water availability. Temperature impacts will increase crop water requirements and will increase the risk of eutrophication in our dams[9].

The 2004 National Biodiversity Assessment highlighted the highly impacted state of river ecosystems in South Africa, with 84% of ecosystems associated large rivers being critically endangered, endangered or vulnerable. The 2011 National Biodiversity Assessment took smaller tributaries into account and showed that tributaries are in a better state than mainstem rivers and they offer excellent conversation opportunities. They also support the sustainability of hard-working rivers further downstream by diluting poor water quality and 'flushing' pollutants. Only 35% of the length of South Africa's mainstem rivers is in a good condition, compared to 57% of the tributaries. Some 57% of river ecosystems and 65% of wetland ecosystems are threatened. The high levels of threat result particularly from intense land pressures, especially around cities.[10]

By treating less than a quarter (22%) of our rivers as national freshwater ecosystem priority areas (NFEPAs), South Africa could conserve natural examples of its diverse freshwater ecosystems while contributing to sustainable development of water resources in the country[10].

South Africa has only 62 free-flowing rivers, which constitute only four per cent of our river length[10]. The priority areas identified in the atlas protect over 50 fish species that are on the brink of extinction. There are many threatened and near-threatened fish species in danger of becoming extinct but by managing a very small proportion of our rivers, this can be avoided.

The high variability in surface runoff reduces the usable yield, the amount of water than can be reliably supplied on a sustained basis (98% assurance of supply), to about 22% of the mean annual runoff of 49 000 million m^3 [11]. More than 95% of the usable water yield has been allocated for the ecological reserve, to meet international obligations and to supply water for domestic, industrial and agricultural use. In 2000, water stress was already experienced in the Olifants, Inkomati, Thukela, Mvoti and Gouritz water management areas. Internal demand is projected to increase by 32% (17 000 million m^3) by 2030 due to population growth and ongoing industrial development, including electricity generation[12]. This will increase stress in the north in the Limpopo water management area. This projected stress does not include the potential impacts of climate change on water availability.

In 2009 agriculture was the largest consumer of South African water resources, using 62%. Energy by contrast consumes only two per cent, but is the only 'strategic' use of water. The pie chart below shows water use by sector in South Africa in 2005. Currently surface water accounts for 77% of water used, return flows 14% and groundwater only 9% [13].

The South African water resource base is naturally dry and variable. Added to this are high levels of current use with significant threats of over-abstraction, increased transpiration losses due to invasion by alien plants, and pollution from mining, waste water treatment effluent and poor land management. Strong water governance is needed to ensure water security when a vulnerable resource base faces threats at this level. However, the Department of Water Affairs acknowledges internal challenges in meeting its mandate to protect water resources for sustainable use. Lack of technical skills and high rates of turn-over in leadership positions have hampered performance. The South African Institute of Civil Engineers (SAICE) characterizes the South African water sector with capacity constraints, inadequate funding, a reliance on ageing bulk

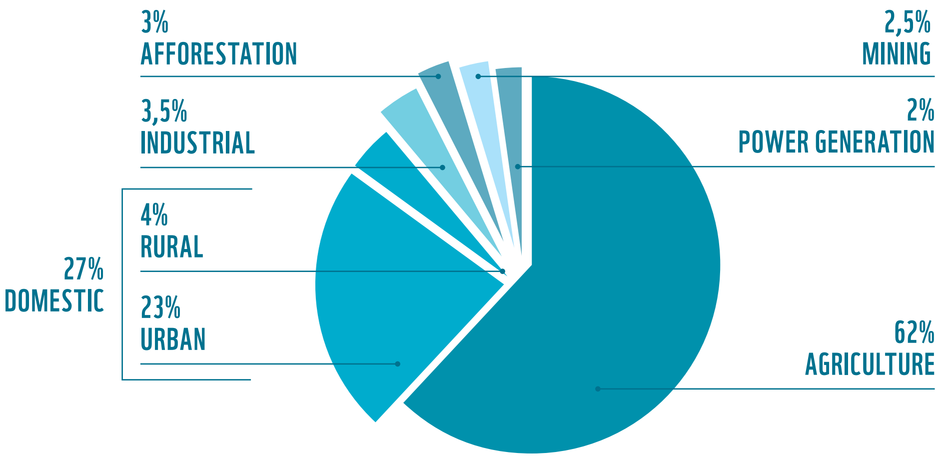
South Africa is the 30th driest country in the world and the "intensity" of South Africa's water use, at 31 percent of the available resource, is high by world standards, far greater than other countries in the region. As water use approaches 40 percent of average annual availability, ***South Africa will face a binding water constraint.***

As well as building new infrastructure to increase supplies and reuse more water, action is also needed to improve water resource management, promote more efficient municipal, agricultural and industrial usage and protect the resource from pollution.

NATIONAL PLANNING COMMISSION, 2010

Pie chart of water use by sector (% usable yield) 2005

Department of Water Affairs and Forestry, 2009.



infrastructure and erratic water quality in smaller municipalities and rural areas. South Africa's water security is therefore in question as we face an increasingly uncertain future with inadequate water governance. The National Planning Commission has recognized water as a binding constraint on future economic development (NPC Diagnostic Report, 2010).

The Water for Growth and Development Framework identifies Acid Mine Drainage (AMD) as the most important threat to water quality in South Africa[13]. It also stresses the need for water to be taken into account in strategic planning: '*The Department's position is that the country's economic growth target cannot be achieved at the expense of the ecological sustainability of water resources or meeting people's human needs. It wishes to respond to the needs of the different economic sectors and this is best achieved when water supply and the impact of use are factored in during planning. Rather than being an add-on or afterthought, the Department sees the need for water to be mainstreamed and placed at the nucleus of all planning decisions…*' [13]. This aim has not yet translated into planning decisions linked to other sectors such as mining. The National Water Resource Classification System (NWRCS) should provide a framework to define the level of acceptable, sustainable water resource use and impact within our catchments. This could provide a starting point for integrated resource and development planning. The NWRCS was introduced in the 1998 National Water Act and was gazetted in 2010. It has not yet been implemented.

1.3 Energy security and strategies for green growth

Historically, government has controlled energy production and distribution in South Africa with Eskom producing 95% of South Africa's electricity. This accounts for over half the electricity generated in Africa[14]. Currently coal accounts for 92% of South Africa's electricity generation. Seventeen coal fired power stations are currently operational, with a further two under construction (Kusile in Mpumalanga and Medupi in Limpopo)[15]. Our energy production infrastructure is aging and a quarter of our coal fired power stations will be over 50 years old and need replacing after 2020. In 2009, South Africa was the fourth largest exporter of thermal coal (65 Mt) after Indonesia (233 Mt), Australia (109 Mt) and Russia (82 Mt), producing three times China's output (18 Mt)[16]. In 2009, coal sales amounted to R65 billion rands, the highest value commodity for that year (platinum R58 billion, gold R49 billion)[17]. Approximately 64% of the coal sold domestically is bought by Eskom for energy production[18].

Reliance on coal-fired power has resulted in South Africa's green house gas (GHG) emissions being double the global average per capita and per GDP[19]. Airborne pollution from coal-fired power stations emits carbon dioxide, causes acid rain and soil acidification. In addition, AMD from coal mining areas has had devastating impacts on water resources, with acidification of rivers and streams, elevated metal levels and consequent fish die-offs.

Eskom is the only 'strategic' water user under the National Water Act. Water is required at the highest levels of assurance to provide steam for the turbines, to cool and clean machinery and to scrub pollutants. Eskom uses 316 billion litres of water per annum and they require good quality water. In the Olifants catchment, coal mining has contaminated rivers and streams to the extent that it cannot be used in the coal-fired power stations. Eskom's water either needs to be treated – costing money and more energy – or it must be supplied from another river system that has not been polluted by mining. Camden power station requires inter-basin transfers from the unimpacted Usutu river system (that originates in Enkangala) to provide water that is clean enough for them to use.

The global energy sector is responsible for around two-thirds of global greenhouse gas emissions. And its emissions are increasing at a faster rate than any other sector. "Business-as-usual" scenarios show an increase in emissions that would lead to very dangerous levels of warming, far above the threshold agreed by governments of 2 °C above pre-industrial levels.

WWF THE ENERGY REPORT SUMMARY, 2011

This paradox is part of what is known as the 'water-energy' nexus, the negative feedbacks between water and energy cycles in our current carbon-economy. Energy production that relies on fossil fuels consumes water and has a negative impact on water resources as a result of pollution during the mining process and as well as burning fossil fuels (eg. acid rain caused by atmospheric pollution from their emissions). Together this direct consumption and pollution, and indirect consumption and pollution embedded in the supply chain to the energy sector, results in a significant water footprint. When solutions are proposed that require more energy to clean or pump and transfer water to maintain supply for the energy sector, this in-turn results in more water to supply more energy to supply more water, etc. We need to move away from energy production with high carbon and water footprints to break the cycle.

Recent years have seen a policy shift by the South African government away from reliance on government controlled coal-fired production, towards enabling a diversified mix of energy production with increased contributions from renewable energy sources. The Integrated Resource Plan (IRP) was developed in 2009 and updated in 2011. This lays out government's targets to increase renewable energy contributions to 42% of new energy capacity by 2030[20]. It is envisaged that coal will only account for 60% of energy production by 2030. An important implementing agent for South Africa's Green Growth path is the South African Renewables Initiative (SARi) recently formed by the Department of Trade and Industry and the Department of Public Enterprises. SARi is part of the Industrial Policy Action Plan (IPAP) and aims to enable:

- Energy security;
- Investment and job creation in the renewables supply chain;
- Improving the carbon competitiveness of South Africa's energy-intensive export industries;
- Developing a regional renewables hub with export potential;
- Mobilising champions for greengrowth.

WWF promotes a scenario of 100% renewable energy use globally by 2050.

Food for thought:

Sustainability – this term has many different definitions. Equally, environmental sustainability, as understood by the WWF and other environmental agencies is not the same as sustainability in economic or mining terms. For the sake of this report environmental sustainability is defined as:

'Responsible stewardship of all natural resources so as to ensure biological diversity and ecosystem functioning that support human life as we know it.'

2. THE ENKANGALA AREA – A CASE STUDY FOR FUTURE DEVELOPMENT

The Enkangala area covers 1.6 million ha within the high Grasslands biome. It straddles the headwater catchments of the Klip and Wilge Rivers in the Vaal Basin, the Klip and Buffalo Rivers in the Thukela and the Pongola and Usutu Rivers in the Usutu/Mhlatuze catchment. As it receives more than twice the average rainfall of South Africa it is a critical water source area. Seventy-eight per cent of the area is currently untransformed and it is an important conservation area. Agriculture is the biggest sector, with a total employment impact of 164 059. Mining is currently limited in the area with an employment impact of only 1 611 jobs.

2.1 The Grasslands biome and conservation area

The Grassland biome covers an area of approximately 339 237 km² (roughly 29% of South Africa's land surface area). Over 30% has already been irreversibly transformed with more recent land-cover data suggesting a higher level of transformation. Approximately 2.8% is formally conserved making this one of the most threatened biomes in South Africa. It is widely acknowledged that grasslands provide vital ecosystem services (such as water production, pollination and carbon sequestration) which are necessary for economic development, but in some cases, this economic development threatens the biome[21].

Nested within the broader grassland biome is WWF's Enkangala Grassland Project (EGP). The EGP began over 11 years ago in Wakkerstroom and, through Green Trust funding, extended its project domain to cover an area of 1.6 million hectares of high altitude grasslands (located 1 700m above sea level). Enkangala is an isiZulu word meaning "high place without trees" and this essentially characterises the grasslands

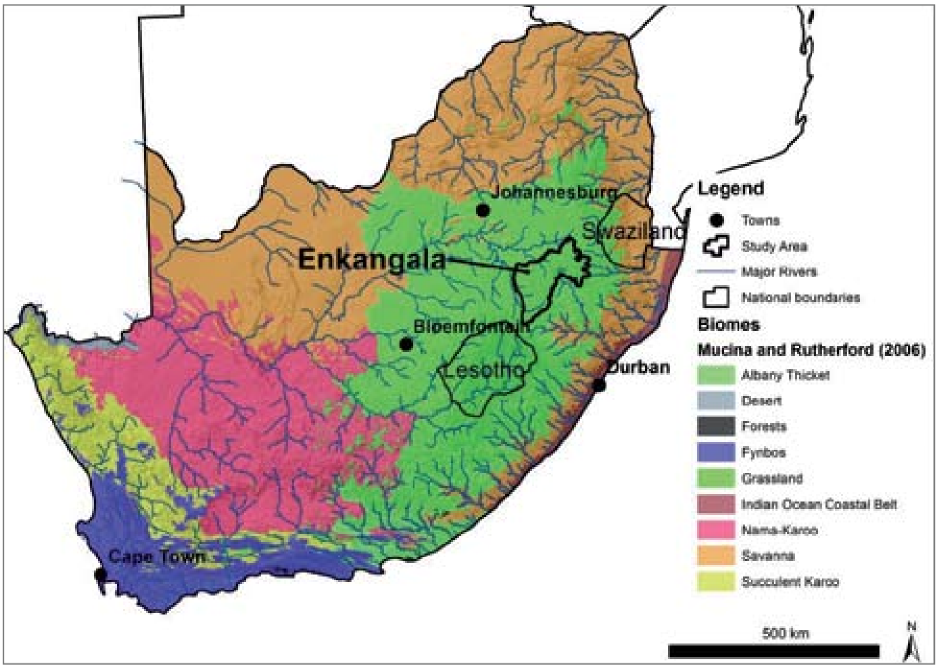


Figure 1: Map of the biomes of South Africa showing the grassland biome in green and the outline of the Enkangala Grasslands Project area.

located there (large open areas interspersed with isolated pockets of indigenous forest). The Project has always partnered with other NGOs such as The Botanical Society of South Africa (BotSoc), provincial conservation agencies (such as MTPA and EKZNW) and SANBI in order to realise its objectives of securing this critically important area from irreversible transformation. As a result, the first protected environment (PE) in SA (23 600 ha in extent) was proclaimed in Mpumalanga through the Protected Areas Act (Act 57 of 2003). Sustained engagements with landowners by the project executants succeeded in securing key biodiversity and hydrologically significant areas for the province. Expansion of this protected environment is currently underway within key hydrological and biodiversity areas within the project domain. A further 45 000 ha are earmarked for declaration and this figure is set to grow substantially over the next few years.

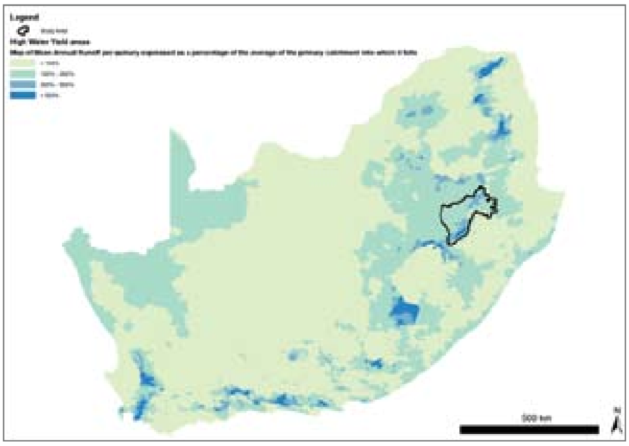
The Enkangala area spans three provinces: Free State, Mpumalanga and KwaZulu-Natal (Figure 1). Only a few small towns are situated within this large study area: Volksrust, Wakkerstroom, Memel, Vrede and Harrismith.

Biodiversity within the Enkangala Grassland Project (EGP) domain is of high importance with over 80 endemic plant species and critically endangered, threatened and vulnerable bird, mammal, invertebrate, amphibian and reptile species; all of which occur in the grassland habitat.

Located within the EGP and broader grasslands are significant wetland areas that ensure functional river systems, many of which find their origin in the biome. The mountainous grassland biome is a key water production area for South Africa, and most of the country's urban populations (along with agriculture and industry) rely on this water. The EGP is located at the headwaters of three major river systems – namely the Thukela, Vaal and Usutu/Mhlatuze catchments – thus making the EGP area strategically important for water security for downstream food producers, national potable water users and industry. Most of the rivers and their tributaries have been given "Fresh Water Ecosystem Priority Area" (FEPA) and "Fish Support Area" (FSA) status by the South African Biodiversity Institute (SANBI), making the area significant for aquatic biodiversity and water quality. Certain of the river systems provide water to dams (Zaaihoek/Heyshope) that are critical for electricity production because they provide good quality water to power stations elsewhere.

2.1.1 Enkangala: A Critical water source area

The 1.6 million ha Enkangala area is situated in one of the highest runoff regions of South Africa (Figure 2). Areas which contribute so much water to their catchments are often termed 'water towers' because their runoff contributions are of critical importance.



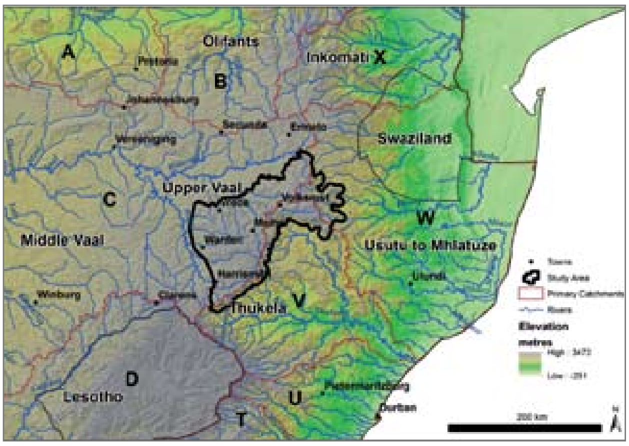


Figure 2: Outline of the Enkangala grasslands showing (a) high water yield areas or 'water towers'; and (b) primary catchments draining the area (C – Upper Vaal, W – Usutu to Mhlatuze, V – Thukela) and other primary catchments in the region (B – Olifants, X – Inkomati, U – Mvoti to Umzimkulu, A – Crocodile West and Marico)

Source: NFEPA, 2011

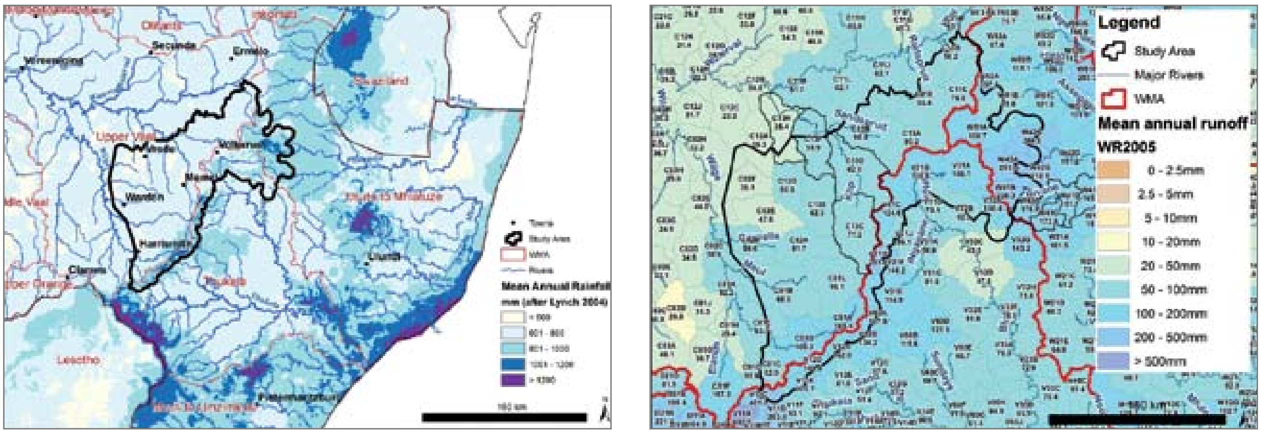


Figure 3: (a) Mean annual rainfall and (b) mean annual runoff (in mm) for the quarternary sub-catchments in and around Enkangala

Source: NFEPA, 2011; WR2005

The Enkangala area is located on the Highveld and varies in altitude from 1 600 to 2 200 metres above mean sea level (Figure 2b). The eastern areas along the Drakensberg escarpment include steep slopes and rapid altitude drops. The mountainous areas along the Drakensberg escarpment have particularly high water yields and the ruggedness and inaccessibility has ensured that the water is relatively good quality, helping to dilute pollutant inflows further downstream[22].

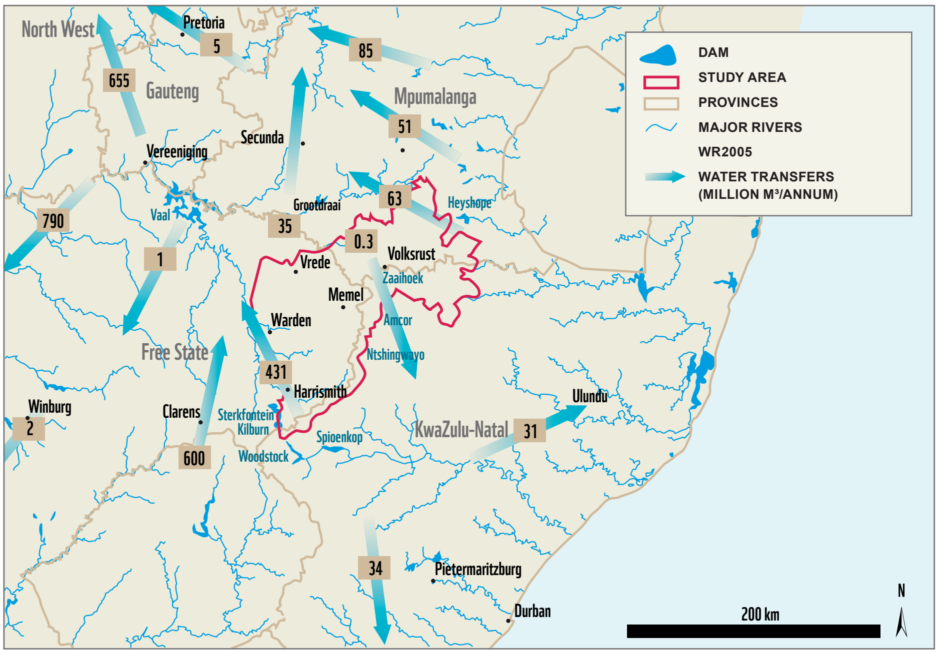
A number of key rivers drain the Enkangala study area, namely the Klip and Wilge Rivers in the Vaal Basin, the Klip and Buffalo Rivers in the Thukela and the Pongola and Usutu Rivers in the Usutu/Mhlatuze catchment[23].

The average rainfall of South Africa is about 450 mm/a and a mere seven per cent of South Africa receives rainfall more than 800 mm/a[2]. Yet the average rainfall for the Enkangala area is 727mm/a, with the eastern side of Enkangala receiving up to 1 197 mm/a and the western parts as little as 444 mm/a. This is what makes the Enkangala area an important water tower area for South Africa (Figure 3).

Runoff from quarternary catchments in the study area varies from less than 50 mm/a in the Highveld area to over 200 mm/a along the Drakensberg escarpment.

Figure 4: Map depicting inter-basin water transfers and major dams in and around the EGP

Source: WR2005



A runoff variability analysis shows that runoff during a one-in-ten year drought will be between 5 mm and 75 mm/a along the Highveld and up to 125 mm/a on the escarpment[22]. The wettest year in 10 years would produce between 95 mm and 300 mm/a on the Highveld, and up to 500 mm/a on the escarpment.

2.2 Down-stream dependency on Enkangala headwaters

Within the three main catchments, a number of key rivers drain the Enkangala study area (Figure 3), the largest of which are the sub-catchments we refer to as 'Upstream of Vaal Dam' (C11, C12, C13) and Wilge Rivers (C81, C82) in the Vaal Basin; the Upper Thukela (V31, V32), Buffalo (V11, V12) and Sundays (V60) Rivers as part of the Thukela and the Pongola (W41, W42) and Usutu (W51) rivers in the Usutu/Mhlatuze Basin[23].

The catchments have a complex network of inter-basin water transfer schemes in the area which involve some major dams (Figure 5). The number of schemes illustrates the complexity of the water management challenges of providing sufficient water to meet the ever-growing water demands.

Pringle[23] summarised the overall runoff and water use per catchment in the Enkangala area, based on detailed reports compiled by the Department of Water Affairs[24,25,26,27]. His key findings are summarised in Table 1.

The 55 565 km^2 Upper Vaal catchment is situated in the Gauteng, Free State, North West and Mpumalanga provinces. Its sub-catchments are the Grootdraai and Klip Rivers, also called 'the Vaal River above the Vaal Dam'. The other sub-catchment is the Wilge . Both originate in the western parts of Enkangala and flow in a westerly direction towards Gauteng.

The "upstream of the Vaal Dam" sub-catchment has a MAR of 1 109 million m^3/a. More than 20% of the water requirements for the entire WMA are located here because of the concentration of development and economic activity in this area. The remainder of the water from this sub-catchment enters the Vaal Dam, which

Table 1: Summary table of the sub-catchments originating in the Enkangala area, as well as their MAR, available yield*, actual use of yield** and proportional water demand of main economic sectors***

Source: DWAF, 2003; DWAF 2004b,c,d

Location			MAR	Total water yield (available)	Total requirement	Proportional water requirements of economic sectors					
Primary catchment	Key sub-catchment	Tertiary catchments in Enkangala	In Mm^3	Mm^3/a	Mm^3/a	Irrigation	Urban	Rural	Mining & Industry	Forestation	Transfers
Upper Vaal	Upstream of Vaal	C11 - C13	1109	302	283	10	11	6	49	0	24
	Wilge	C81 & C82	868	59	60	30	45	25	0	0	0
Thukela	Upper Thukela	V11, V12, V13, V14	1256	521	491	18	3	2	0	<1	77
	Buffalo	V31, V32, V33	884	206	151	33	15	6	8	<1	36
	Sundays	V60	220	8	32	81	3	13	3	0	0
Usutu to Mhlatuze	Pongola	W41 & W42	1344	645	293	73	<1	2	<1	12	13
	Usutu	W51 & W52	2360	202	200	7	3	4	0	21	66

*** Available yield includes surface, groundwater and return flows which can be captured by existing water supply infrastructure at 98% assurance. Environmental flows, dryland farming and invasive plant use are already subtracted**

**** Total sub-catchment requirement for Upper Vaal and Usutu/Mhlatuze as in year 2000, for Thukela as of 2005**

***** Calculated as percentage from Total sub-catchment requirement**

provides water to Johannesburg. Almost 22 mega cubic metres per annum (Mm^3/a) re-enter the catchment as return flows from mining, sewage and irrigation effluent. Approximately 118 Mm^3/a is transferred into this sub-catchment from the Usutu-Mhlatuze and the Thukela catchments. Water requirements in this sub-area are dominated by mining and bulk industrial use, particularly coal mines and the Sasol petrochemical complex. The water demand in the "upstream of the Vaal" sub-catchment actually is one of the highest of all South Africa's Water Management Areas. Power generation by the Lethabo, Tutuka and Majuba power stations, and urban use are the next highest consumers. Approximately 67 Mm^3/annum of water is transferred out of this sub-catchment including transfers of 36 Mm^3/a to the Olifants River system for power generation.

The Wilge sub-area has a MAR of 868 Mm^3/annum and this sub-catchment, together with the Liebenbergsvlei River, contributes 36% of the total surface runoff in the Upper Vaal Water Management Area (DWAF, 2004a). Approximately 736 Mm^3/a is transferred into the Wilge River via the Thukela-Vaal transfer scheme and 457 Mm^3/a is transferred via the Lesotho Highlands Project. Urban use comprises almost half the water requirements in the Wilge sub-catchment, particularly for the towns of Bethlehem, Harrismith and Phuthaditjhaba. The remainder of the water use is split between rural use (domestic and livestock) and irrigation.

The Upper Thukela has a MAR of 1 256 Mm^3/a and about 521 Mm^3/a is available for use, mainly from the Spioenkop Dam and Woodstock/Driel systems. The largest user in the catchment is irrigation, and this water is primarily drawn out of the dams rather than directly from the rivers. There are plans to build the additional Jana Dam, approximately 30 km southeast of Ladysmith.

The Sundays River is the smallest of all catchments originating in the Enkangala region and it flows in a south-easterly direction from the Eastern Escarpment until it joins the Thukela River. The sub-catchment is mainly used for commercial dryland agriculture and large tracts are communal land in the lower areas of the catchment. Mining is key activity in the upper catchment. Below Enkangala, the river is impounded by the Slangdraai Dam near Ladysmith.

The MAR of the Buffalo River is 884 Million m^3/a and between 173 and 205 Mm^3/a is available for use depending on where in the catchment the water is utilised. The majority of the water is obtained from the Ntshingwayo and Zaaihoek dams with the balance obtained from river flows and farm dams. The main water user in the catchment is irrigation, with high urban, rural and industrial uses in and around Newcastle. There are substantial transfers of water out of the catchment from the Zaaihoek Dam to the Majuba Power Station and Vaal System.

The Pongola catchment is shared with Maputo so the water needs of Mozambique and Swaziland should be taken into account when managing this catchment. The Pongola River rises in the far eastern Drakensberg escarpment in the Enkangala region. It flows east and joins the Usutu River before flowing through Mozambique. In South Africa, the Pongola produces an estimated 1 131 Mm^3/a and approximately 1 344 Mm^3/a if runoff is provided by catchments in Swaziland and Mozambique. The main water uses in this catchment are irrigation of sugar cane and afforestation (Table 1). Irrigators in the upper reaches of the Pongola abstract water from river flows and farm dams.

The Usutu River is another internationally important river, rising in the north-eastern part of Enkangala and flowing east through Swaziland before joining the Pongola and entering Mozambique. The MAR for the Usutu is an estimated 2 360 Mm^3/a, of which about 901 Mm^3/a originates in the upper catchment before it enters Swaziland. Over 50% of the total available water in the catchment (202 Mm^3/a)

is transferred from four dams between Enkangala and Swaziland to the Vaal and Olifants catchments to coal-fired power stations. Good quality water is transferred from Heyshope dam for use at Camden Power station. The most important water use within the catchment is forestry and there is a limited amount of irrigated agriculture. Farming and rural water requirement are met by farm dams and river flows.

2.2.1 Water Infrastructure

Most farms within the Enkangala area depend on boreholes, farm dams and direct abstraction from rivers for domestic use and stock watering. No major irrigation schemes occur in the area but there are large scale irrigation schemes downstream that rely on the integrity of the upstream resource. One example being the members of the Impala Water User Association.

The catchments with most water stored in farm dams are V32G, C13G and V11F, but only C13G is located entirely within the Enkangala area. The total dam storage in C13G is 3.77 Mm^3 which is used by the Phumelela Local Municipality (Vrede).

The Zaaihoek Dam is located in the Thukela basin on the Slang River (V31A) and transfers water from Enkangala to the Upper Vaal River (Table 2). Approximately 19 Mm^3/a were supplied to the Majuba Power Station during 2005, and this can be increased to 25.6 Mm^3/a. Some of the transferred water is used in government water schemes as well as irrigation schemes and the surplus is transferred to the Vaal River catchment[28]. The Zaaihoek dam can also supply downstream demands through releases into the Slang River[29].

There are several larger dams inside or just beyond the Enkangala boundaries (Table 2). These include the Grootdraai in the Vaal catchment as well as the Kilburn, Woodstock, Spioenkop and Ntshingwayo dams in the Thukela catchment. The Heyshope and Morgenzon dams are situated in the Usutu/Mhlatuze catchment[22].

Table 2: Large dams in and around Enkangala, their storage capacity and main uses. IBWT = inter-basin water transfer

Source: Pringle et al. (2011)[23]

Quaternary catchment	Total Volume stored (Mm^3/quaternary)	Large dam in quaternary contributing to volume	Used for
V60A	10	Slangdraai	
V11C	27	Kilburn	Eskom
W53A	102	Morgenstond	IBWT, Eskom
V31B	196	Zaaihoek	IBWT, downstream demands
V31E	202	Chelmsford	
C11L	364	Grootdraai	Flood attenuation, IBWT, urban, Sasol, Eskom
V11D	374	Woodstock	IBWT
W51B	453	Heyshope	IBWT, Eskom, Sasol
C81D	2652	Driekloof and Sterkfontein	IBWT

The upper Vaal and Olifants catchments are highly developed and industrialized and, as a result, the water requirements in these areas exceed the amount available.

The Enkangala area is surrounded by several inter-basin water transfer schemes that all move water between the catchments in order to meet the urban, industrial and power generation demands (Table 3[30])

Table 3: Inter-basin water transfers in the Enkangala area, their purpose and transfer capacity Mm^3/a

Source: Pringle et al. (2011)[23]

Scheme name	Use of water	Transfer capacity Mm^3/a
Thukela – Vaal transfer scheme	Urban use and power generation	431
Heyshope to Grootdraai	Power generation	63
Vaal – Olifants	Urban	35
Lesotho Highlands	Overall Gauteng	600
Vaal – Thukela	Urban	0.3
Thukela – Mhlatuze	Urban	31
Usutu – Olifants	Power generation	51

2.2.2 Groundwater resources in the area

The groundwater in the Enkangala area is predominantly found within secondary aquifers formed mainly from the fractured sandstones in the Karoo formation (fractured sedimentary aquifers). The groundwater flows along these fractures and often forms springs along faults and dykes within the hard rock formations. Primary aquifers formed from unconsolidated alluvium (unconsolidated deposits) are of minor importance and occur north of Memel.

Annual groundwater recharge is rated as low to medium, with an average 46 mm/a[31]. Recharge increases from about 15 mm/a in the west to a maximum of 180 mm/a in the north-east. The higher recharge values are associated with the Bivane and the Pongola catchments.

The estimated groundwater yield in the seven tertiary catchments in Enkangala is summarised in Table 4 [23,25,26,27].

Table 4: Main catchments and sub-catchments of the area and their groundwater yield (Mm^3/a)

Source: DWAF, 2003; DWAF 2004b,c,d

Primary catchment	Key sub-catchment	Groundwater Yield Mm^3/a
Upper Vaal	Upstream of Vaal	8
	Wilge	4
Thukela	Upper Thukela	5
	Buffalo	1
	Sundays	6
Usutu to Mhlatuze	Pongola	8
	Usutu	2

2.2.3 Wetlands in Enkangala

About 3.46% of the Enkangala area comprises water bodies, including rivers, wetlands and dams. However, almost all the rivers in the south-west and north-east of Enkangala have been delineated as river FEPAs (Figure 5)[32]. This is because the tributaries in these areas are in a near-pristine condition and should be managed in a way that ensures their good condition. Few rivers, like the Upper Vaal, are still free-flowing and in a good condition (up to the Vaal Dam) so those that are, are highly valuable ecologically. Flows from healthy tributaries are essential for diluting and flushing the pollutants that enter the main rivers such as the Vaal which supports the main hub of economic activity in South Africa. Without the dilution factor provided by healthy tributaries, the pollution levels in mainstream rivers would become unacceptable to consumers.

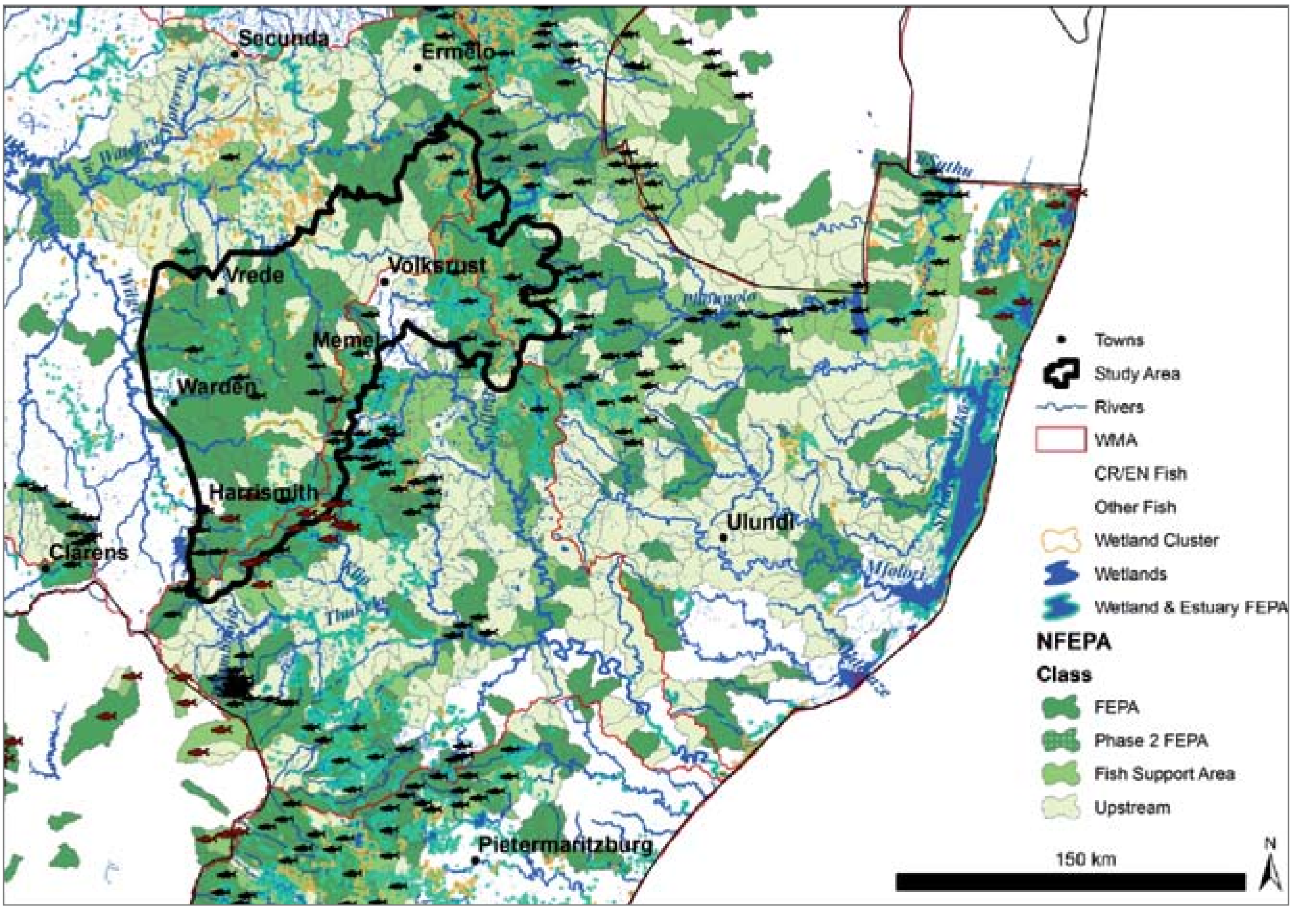
The Wakkerstroom wetland system is one of the few peat wetlands found in South Africa. It forms a mosaic of marshes that seasonally hold water with only the central wetland being permanently wet. The wetland is an important water storage and filtering system at the crest of the Thukela catchment and it plays an essential role in feeding clean water into this river. Peatlands also act as major carbon sinks and their destruction would result in CO_2 being released into the atmosphere[33]. This wetland has been officially classified as irreplaceable from a conservation perspective because it hosts several endangered and critically endangered bird species. It is also a prized tourism spot[34].

The largest wetland on the southern Highveld is situated in the Klip River catchment of the Vaal basin near Memel[22] (Figure 5). This Ramsar site consists of approximately 220 seasonally flooded small oxbow lakes. One of its important roles is supporting large numbers of local and migratory waterbirds. A large portion of this wetland is presently included in the Seekoeivlei Nature Reserve[35]. Apart from its conservation status, this wetland also performs essential water storage, retention and filtering functions that benefit downstream water users .

Many tributaries in the Upper Thukela are sanctuaries for endangered or critically endangered fish species and several tributaries of the Buffalo River support vulnerable indigenous fish species (Figure 5). Tributaries in the Upper Vaal, situated in the northernmost corner of Enkangala also provide refuges for threatened fish species. The Pongola River remains an important fish sanctuary throughout its length. The map in FEPAs contribute to a national biodiversity goal of conserving representative and intact examples of South Africa's unique diversity of river and wetland ecosystem types[32].

Figure 5: River and wetland FEPAs for the Enkangala study area, as well as important fish sanctuaries

Source: NFEPA, (2011)



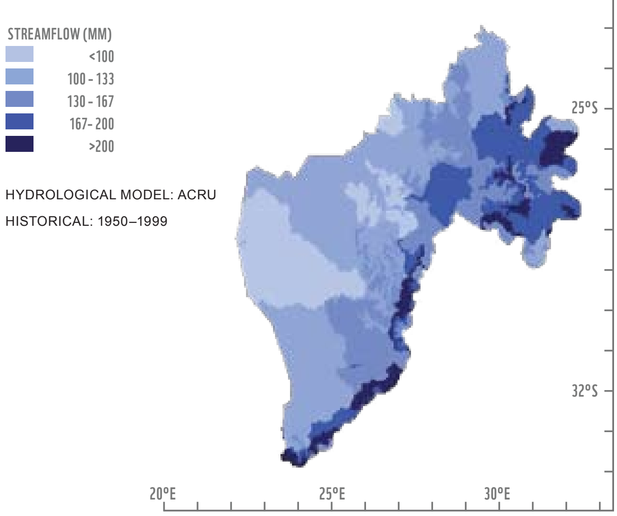
2.2.4 Climate change predictions

The current river flows in the Enkangala area are well-understood but, for future developments in the area, it is also important to understand the potential impacts of climate change. For this purpose, we depict a modelled intermediate scenario (2046 – 2065) of accumulated streamflow, as well as a distant future scenario (2081 – 2100)[36] modelled using the Agricultural Catchment Research Model (ACRU) developed by the University of KwaZulu-Natal. These projections involve adjusting daily rainfall and temperature patterns to match the changes projected by global climate models, simulating the effects on daily river flows and summarizing them as annual values to show the changes from modelled current river flows (Figure 6a). The projections from a number of different climate change models, each run with a range of projected changes in green-house gases were used in this modelling, an approach known as ensemble modelling. These projections are subject to substantial uncertainties but they provide plausible future river flows that can be used to make long-term plans for ensuring water security. In this case the changes are expressed as ratios (Figure 6b,c) so that any value greater than one means an increase, and any value below one means a decrease. A 50% increase, for example, is expressed as a value of 1.5.

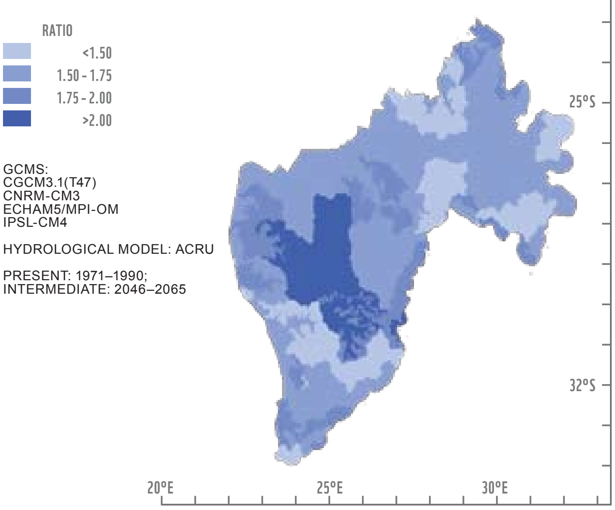
Figure 6: Streamflow maps of the (a) average historical accumulated annual streamflow (1950 – 1999), (b) modelled intermediate future accumulated annual streamflow (2046 – 2065), and (c) modelled distant future accumulated (2081 – 2100) streamflow. Maps b and c are ratio maps relative to the present period (a). Values > 1 = increase, values < 1 = decrease.

Source: Schulze (2011)

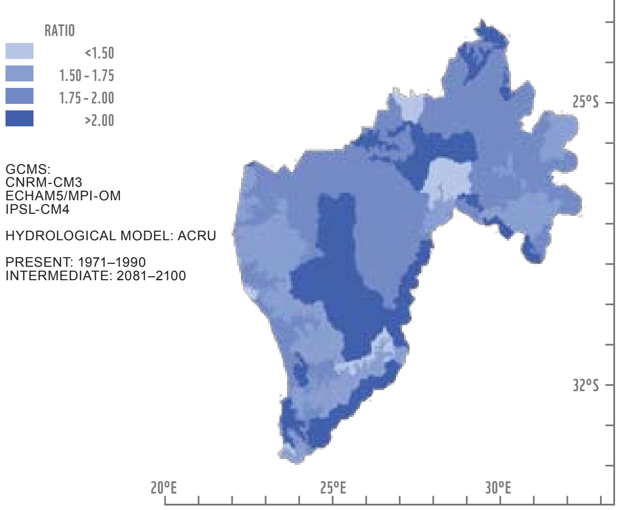
A.



B.



C.



Currently the highest runoff (>200 mm/a) occurs along the eastern escarpment and there is a gradual decrease in streamflow in an east-west direction to <50 mm/a (Figure 6b). The projections show that the area is likely to experience an increase in streamflow in both the intermediate and distant future, with increases up to 200% expected in the Wilge and Upper Vaal and small parts of the Buffalo, below the escarpment. The distant future scenario suggests that further areas will experience and increase of more than 200% , including more of the Buffalo and Upper Vaal as well as the Upper Thukela along the eastern escarpment.

Increased streamflow in the steep escarpment areas could also lead to increased soil erosion, especially if land-use practices involve damaging the important top soils. Increased streamflow may also increase the movement of pollutants originating in the Enkangala area, such as pesticides and fertilizers from agricultural practices, or pollutants from coal mining activities.

2.3 Current economic activity dependent on the Enkangala water supply

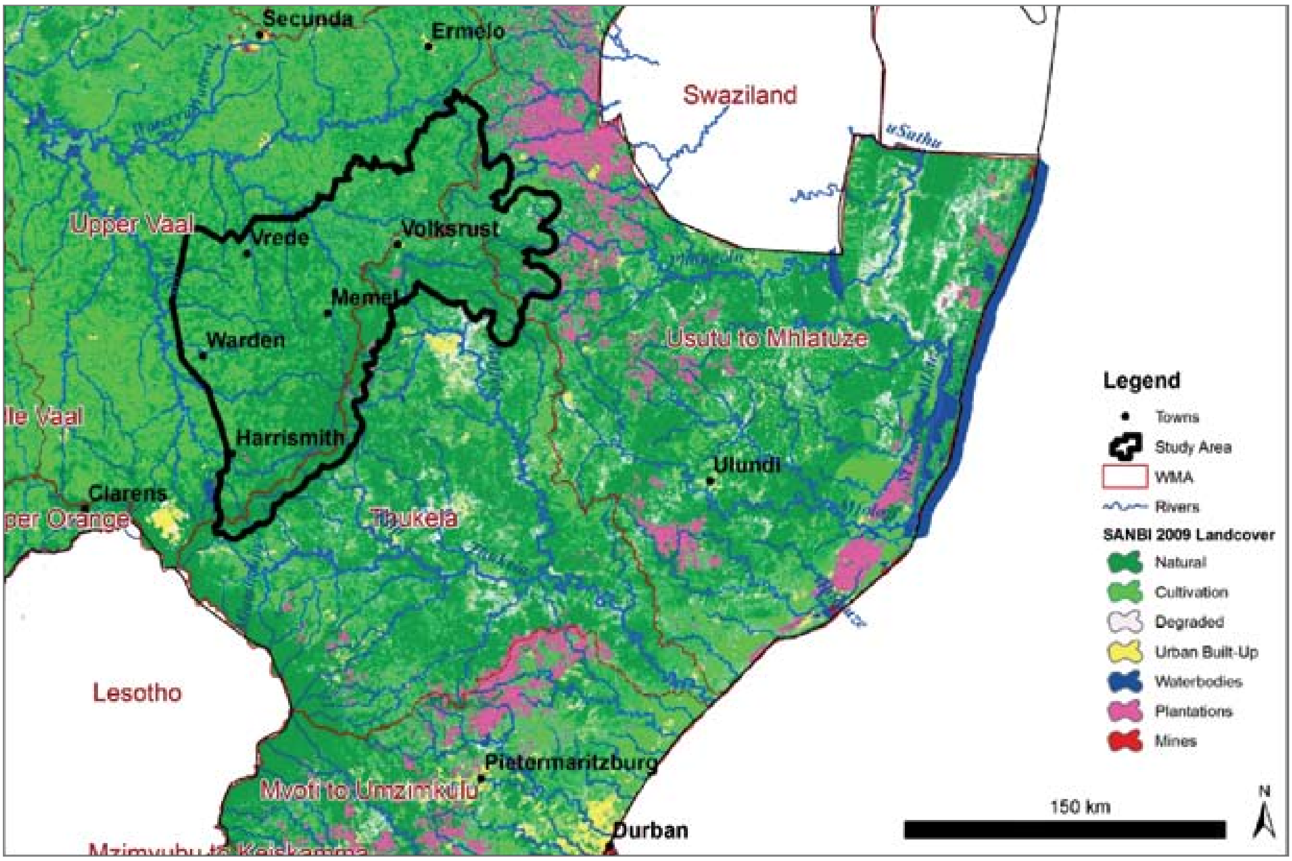
Land cover in the area was summarised from the National Land Cover Map of 2009 which includes updates in some provinces. This is summarised in Table 5 and Figure 7.

2.3.1 Enkangala

The Enkangala area is predominantly covered by natural vegetation (78%, Table 5) and relatively untransformed. Fifteen grassland vegetation types are found in the area, and two types of forest types occur in patches along the eastern escarpment[37].

Figure 7: National Land Cover Map for the study area and relevant catchments, summarised from SANBI (2009)

Source: NLC, (2009)



WMA	Natural	Water	Cultivation	Degraded	Urban	Plantation	Mines
Upper Vaal	75.38%	2.72%	21.46%	0.00%	0.28%	0.14%	0.01%
Usutu to Mhlatuze	76.15%	8.22%	7.44%	3.22%	0.21%	4.72%	0.04%
Thukela	87.40%	3.18%	4.50%	1.18%	0.90%	2.82%	0.00%
Enkangala study area	77.79%	3.46%	16.55%	0.61%	0.39%	1.20%	0.01%

Table 5: National Land Cover data for the study area and catchments in percent

Source: NLC, (2009)

The Enkangala study area is an important agricultural region, dominated by livestock farming on the natural rangelands and in the degraded areas. Most of the livestock are cattle but there are also poultry, goats and sheep. The animal products include fresh milk, eggs and livestock for slaughter. Livestock farming is the most sustainable and suitable land use practice for the area, and the opportunity for cultivation is limited over the long term. Currently, approximately 17% of the area is under cultivation with field crops including maize, sugar cane, wheat, hay, sunflower seed, tobacco and groundnuts. Significant horticultural crops include: deciduous fruit, viticulture and sub-tropical fruit production, although these make up a relatively small share of total production. In addition, parts of the area have been earmarked for biofuel production. The primary crop associated with this is soya beans. According the Integrated Development Plans (IDPs) of the local municipalities in the area, at least four percent of the area currently designated for field crops could potentially be used for biofuel production in the future. Most crops in the Enkangala area are cultivated as dryland crops, with only a small percentage being commercially irrigated.

A small amount of land is under plantations (1.2%) and less than one per cent is currently under mining, although the areas under prospecting are currently much more extensive. The main towns falling within the Enkangala area are Harrismith, Warden, Memel, Vrede and Volksrust.

2.3.2 Upper Vaal

The Upper Vaal provides water to Gauteng, which generates 10% of the Gross Domestic Product (GDP) of the entire African continent[38]. The Upper Vaal Water Management Area is the most populous in South Africa, with an estimated 5.6 million inhabitants in 1995, more than 80% of whom live in urban areas below the Vaal Dam[39]. Land use is dominated by the cultivation of dryland maize and wheat. Densley populated areas occur in the Wilge and Vaal Dam sub-catchments. About 75% of the irrigated agriculture is supplied from run-of-river or farm dams and is situated upstream of the major storage dams.

Extensive urban sprawl and many industrial areas are found in the northern and western parts of the Upper Vaal near the mines. The mines in the Upper Vaal produce coal, precious metals (gold, uranium), base metals, semi-precious stones and industrial minerals. The major industries in the catchment are Sasol 1 (Sasolburg), Iscor, Sappi, AECI and Sasol Synthetic Fuels (SSF) (Secunda)[41]. Important towns in the upper Vaal include Standerton, Ermelo and Secunda.

2.3.3 Thukela

Irrigated agriculture is an important land use in the Thukela catchment, with an estimated 264km² under cultivation and mainly using farm dams or river flows. Commercial dryland agriculture dominates the Sundays River catchment and the lower reaches are mainly communal land with livestock farming and subsistence agriculture. The upper catchment is heavily utilised for timber production (a total 2.82% of the catchment is under plantations), while the coastal areas are dominated by sugar cane cultivation. Major industries include SAPPI and the Isthebe industrial area and smaller industrial centres are located further up in the catchment around Newcastle, Ladysmith and Estcourt. Other towns include Utrecht, Madadeni, Osizweni, Dannhauser, Dundee and Glencoe. Coal mines are scattered across the upper catchment and are largely abandoned or in the process of closing down. These mines are often inadequately rehabilitated and they are a major contributor to acid mine drainage (AMD) in the Thukela catchment, especially around Newcastle[25].

2.3.4 Usutu/Mhlatuze

Fourteen different vegetation types are found in the Usutu/Mhlatuze WMA. Most of the grassland is used for cattle pasture, but there are also pastures crops for dairy production. The major irrigated and dryland crops are maize, wheat, sugar-cane, cotton, citrus, vegetables, nuts and soya. Irrigation is most widespread in the middle Pongola catchment with an estimated 199 km^2 upstream of the Pongolapoort Dam[26]. Forest plantation areas are located in the area from Richards Bay to St. Lucia, around Melmoth, Nongoma and in the northern areas from Paulpietersburg to the upper Bivane and Pongola tributaries.

The main urban areas of this catchment are Richards Bay, Empangeni, Ulundi, Vryheid, Paulpietersburg and Piet Retief. The minor settlements include Mtunzini, Eshowe, Melmoth, Amsterdam, Pongola and Jozini.

Large coal mines are found in the Vryheid area (Hlobane Collieries) as well as Piet Retief and at Richards Bay. Heavy industries are located in the urban areas of Richards Bay and Empangeni on the coast, as well as around Piet Retief and Paulpietersburg.

The Usutu to Mhlatuze catchment includes large natural park and wetland areas. The entire coastline from St Lucia up to the Mozambique border at Kosi Bay is a wetland sanctuary. Other reserves include Tembe Elephant Park and the Umfolozi, Ndumo, Itala and Hluhluwe Reserves[40].

2.4 Economic activity in the Grasslands project area

The two main economic activities described in detail in this report are agriculture and coal mining, but tourism is also important as it is the third largest economic activity. It is concentrated especially around Wakkerstroom, which is an internationally acclaimed birding area.

2.4.1 Agriculture

The gross value of national agricultural production was R131 billion in 2010, of which 50 percent was livestock production, 27.1 percent horticulture, and 22.9 percent field crops (Table 6). Maize is an important cash crop in South Africa contributing 45% of the value of all field crops.

Farming in the Enkangala contributed - R3.1 billion or 2.4% of national agricultural production. Field crops were the most important (comprising 62%), followed by livestock (33%) and horticulture (6%). Roughly 35% of the area of field crops planted is devoted to maize production, making it an important crop for food security both nationally and in Enkangala.

	Cultivated land	Producer values (PV) (R million)				External cost (waste-water)		GVA current prices[1]	Employ-ment[2]
	million ha	*Total*	*Livestock*	*Horticulture*	*Field crops*	*R million*	*External cost as % of PV*	*R million*	
Year	2000	2010	2010	2010	2010	2010	2010	2010	2007
National	15	131 099	65 550	35 528	30 022	1 836	1.4	59 543	830 194
Provincial:									
Free State	4	26 429	10 491	1 534	14 404	464	1.8	5 517	65 363
KwaZulu-Natal	2	16 076	11 529	1 262	3 285	197	1.2	15 681	169 150
Mpumalanga	1	13 827	5 694	1 872	6 261	173	1.2	5 572	54 388
Enkangala study area[2]	0.44	3 133	1 019	183	1 931	54	1.7	926	8 319

Table 6: Summary table for agricultural production. PV = Producer Values are the income earned by the farmer; GVA = Gross Value Added is a measure of the value of goods and services generated in an economic sector or area

Source: Fairbanks et al. (2000[41]; CSS (1998); DAFF (2011)[42]; NSDP (2006); Stats SA (2009, 2011b)[43,44] and own calculations

NOTES:

1 Agriculture, forestry and fishing

2 1993 areas and for field crops and horticulture only

In 2004, agricultural gross value add (GVA) was the single largest contributor to GVA at basic prices and to employment in Enkangala.

Furthermore, the agricultural sector in the Enkangala study area has significant multiplier impacts on the rural economy and job security (Table 7). Many of the labourers employed in this area have been here for over five generations, making agriculture a very stable employer in Enkangala. The total impact of agriculture on GVA, including downstream and induced impacts, amounts to an estimated R 2.7 billion. Total employment impacts amounted to 1.33 percent of South Africa's formal sector employment in 2007.

Table 7: Direct and induced economic impacts of agriculture in the study area

Source: Own calculations based on Pundo (2005); NSDP (2006); Stats SA (2011b)[46]

Agriculture (study area)	Direct	Indirect	Induced	Total impact
GVA at current prices (2010 R million)	926	741	1 000	2 667
Employment (2007)	8 319	8 913	66 827	164 059

Agricultural prices, particularly those of field crops, have declined in real terms in recent years. The weighted average field crop price declined by 6.2 percent between 2009 and 2010, driven mainly by the fall in maize prices (-24%). This is an incentive for farmers to shift away from maize production to other more lucrative crops.

2.4.2 Coal

Mining and quarrying in Enkangala contributed an estimated R196 million to GDP in 2008 (Table 8). However, this estimate is based on the average growth in mining between 2004 and 2008, which may or may not reflect the growth in coal mining in the study area. The distribution of mining GVA in Enkangala by province is as follows: R33 million (17% of Free State's mining GVA), R55 million (28% of Mpumalanga's mining GVA) and R108 million (55% of KwaZulu-Natal's mining GVA). By contrast, the share of coal production by province is 0% of Free State's coal production, two per cent of Mpumalanga's coal production and 12 percent of KwaZulu-Natal's coal production. This suggests that coal is not the only contributor to mining GVA in the study area, and that there could be significant mining impacts (both positive and negative) from other mining industries in the area. KwaZulu-Natal has the greatest potential for coal mining expansion, with Free State and Mpumalanga both below the national average for the estimated years to depletion of economically recoverable coal reserves (Table 8).

	Recoverable reserves	Production	Years to depletion	Producer value	External cost of production	GVA current prices[1]	Employment[2]
	2008 kt	2008 kt	2008	2009 R million	2009 R million (high scenario)	2008 R million	2007
National	30 156 000	252 699	119	65 498	3 007	201 381	449 724
Provincial:							
Free State	1 507 800	17 689	85	4 585	210	17 955	68 262
KwaZulu-Natal	1 305 755	2 022	646	524	24	6 871	14 049
Mpumalanga	22 767 780	212 267	107	55 018	2 526	36 971	50 923
Enkangala study area	2 714 040	4 031	673	1 045	48	196	641
External cost as % of producer value					4.6		

Table 8: Summary table for coal mining

Sources: UN Data (http://data.un.org/); DME 2007[45]; DMR, 2011c[46]; NSDP, 2006; Stats SA (2011a, 2011b)[23,47] and own calculations.

NOTES:

1 Mining and quarrying

2 Note: Uncertainty increases with increasing levels of disaggregation.

In addition to the direct impacts of mining on the economy, mining and quarrying contribute R165 million from increased production from downstream industries (indirect effects), and a further R249 million once households and wage impacts are taken into account (induced effects) (Table 9). Therefore, in total, mining in the Enkangala study area contributes R610 million to GVA, which amounts to only 0.03 percent of South Africa's total GVA in 2008.

Table 9: Direct and induced impacts of mining in the Enkangala study area

Source: Own calculations based on Pundo (2005); NSDP (2006); Stats SA (2011b)[46]

Mining: Enkangala study area	Direct	Indirect	Induced	Total impact
GVA at current prices (2008 R million)	196	165	249	610
Employment (2007)	641	529	441	1611

Nationally, coal mining employed 60 439 workers in 2007, or 13.4 percent of total mining and quarrying employment. By 2009 this had grown to 70 792 – an increase of 17% – reflecting the strong growth in the sector in recent years. Employment in the mining and quarrying sector in the Enkangala study area amounted to an estimated 641 workers in 2007 (Table 8), or 0.14 percent of national mining and quarrying employment. The estimated total employment impact of mining in Enkangala area amounts to 1 611 workers, or just 0.01 percent of total formal sector employment, taking indirect and induced employment impacts into account. Mining labour is typically associated with migrant labour which brings with it the social costs of temporary employment, separated families, health issues and unemployment upon mine termination[48].

2.5 Coal reserves in the Enkangala area

2.5.1 Broad geology of Enkangala area

The Karoo Supergroup sediments deposited during the Palaeozoic (354 to 250 Ma) and Mesozoic (250 to 144 Ma) Eras (Table 10, Figure 8a), dominate the southeastern two-thirds of the study area. Because the Karoo Basin deepens from northeast to southwest, the oldest stratigraphic units represented by the Dwyka Group (tillite) at the base and the overlying Ecca Group strata (sandstone, mudstone, siltstone, shale and coal) define the north-eastern margins. Younger sedimentary strata (mudstone and sandstone) of the Beaufort Group form the south-western and central portion

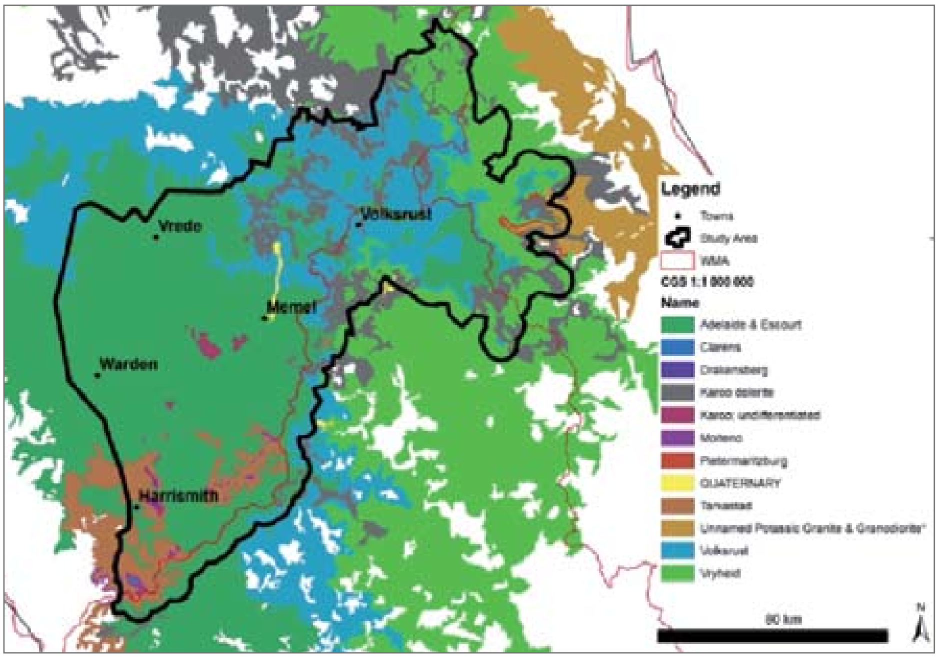
Basic Lithology	Occurrence	Lithostratigraphic Unit			Era (Age)	
Aeolian sand, calcrete, colluvium, floodplain deposits, alluvium	< 1%	Quaternary sediments			Late Cenozoic (<10000 yrs)	
Dolerite, diabase, syenite	11%	Dyke / sill intrusive structures			(~144 Ma)	Mesozoic
Basaltic lava	< 1%	Drakensberg Group		Karoo Supergroup		Mesozoic
Sandstone, mudstone & shale	< 1%	Molteno Formation		Karoo Supergroup	(~250 Ma)	Mesozoic
Mudstone & subordinate sandstone	52%	Adelaide Formation	Beaufort Group	Karoo Supergroup	(~250 Ma)	Palaeozoic
Shale & subordinate sandstone	18%	Volksrust Formation	Ecca Group	Karoo Supergroup		Palaeozoic
Sandstone, shale & coal beds	11%	Vryheid Formation	Ecca Group	Karoo Supergroup		Palaeozoic
Shale	< 1%	Pietermaritzburg Formation	Ecca Group	Karoo Supergroup	(~354 Ma)	Palaeozoic
Granite, gneiss	< 1%	Halfway House Granite Suite	Intrusive Complex		Swazian (>3100 Ma)	

Table 10: Occurrence and relative importance of the geological formations represented in the Enkangala area

Source: Council for Geoscience

of the study area, and the Molteno Formation the rising terrain to the southeast. Extensive intrusions of dolerite in the form of dykes and sills occur within the Karoo Supergroup strata. The sills form the typical rock caps on the mountain and hill tops. The youngest formation of the Karoo Supergroup, the Drakensberg Group basalts, occur only in the south-eastern parts of the study area[49]. Coal deposits are typically associated with the Vryheid Formation in the Highveld, Ermelo, Utrecht and the Klip River coal fields, all of which fall partly within the Enkangala area[50].

Tertiary and Quaternary sand deposits are represented by aeolian sands, calcrete, colluvium, floodplain sediments and alluvium. These sandy deposits are generally only a few metres thick and localised[24]. The typical cross-section shows the relationships between the different geological formations from south (Drakensberg area) to north (45 kilometres west of Harrismith) shows the marked differences in altitude and relief (Figure 8b).



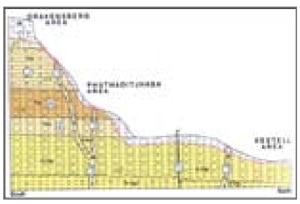


Figure 8: (a) A simplified map of the geology found in the Enkangala area and (b) Geological cross–section from south to north, whereby (1 Jdr) Drakensberg Basalts; (2 Trc) Clarens formation; (3 JD) Dolerite Dykes Karroo; (4Tre) Elliot formation; (4 Trm) Molteno; (5 P-Trb) Beaufort Subgroup & Ecca Group

Source: (a) CGS, (1993) and (b) after DWA, (2003)24

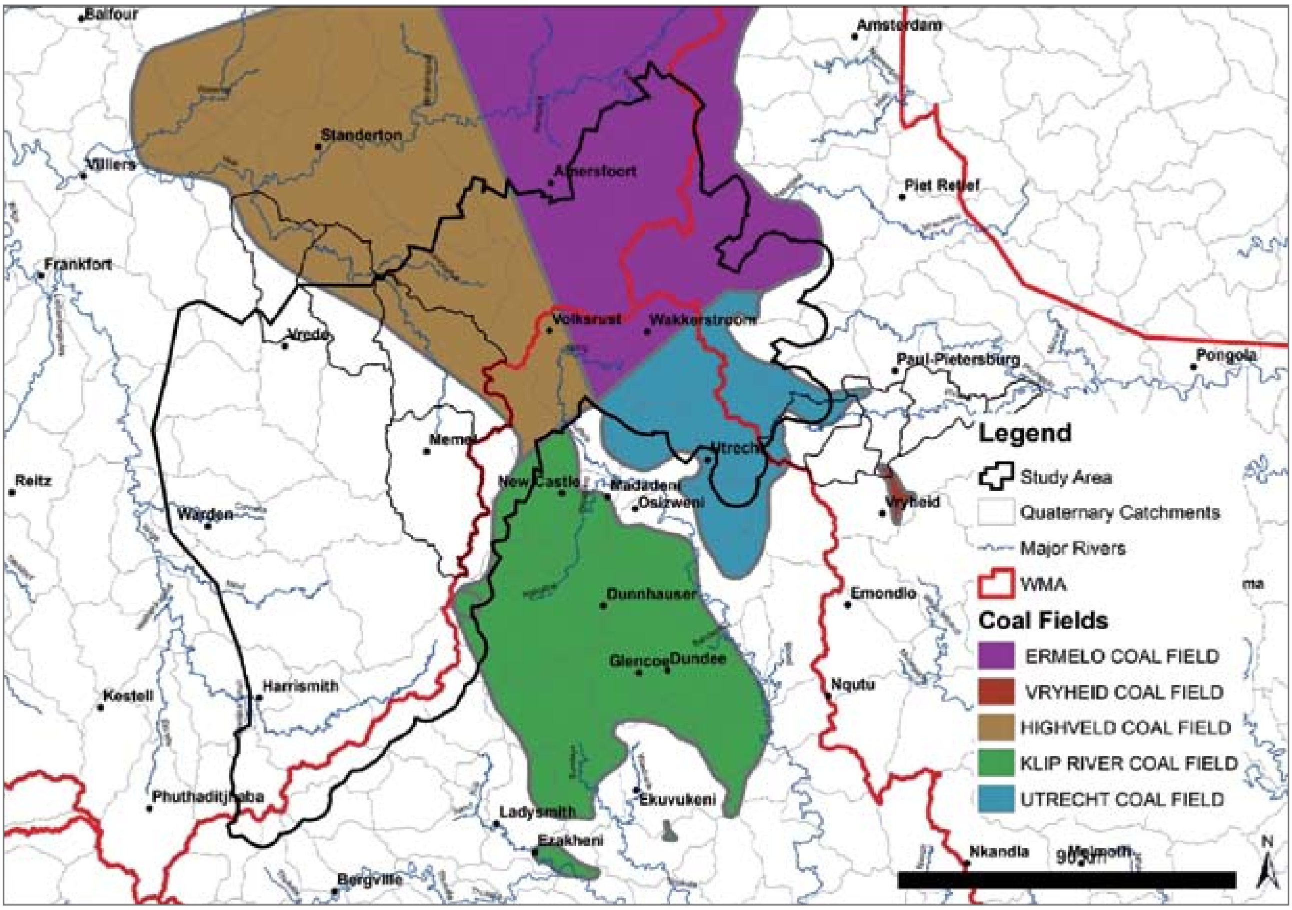


Figure 9: Distribution of coal fields in the Enkangala region

Source: CGS, 1995-2004

2.5.2 Coal production and reserves in Enkangala and broader regions

The majority of known coal reserves in South Africa are located in the Free State, Mpumalanga and KwaZulu-Natal. The Council for Geoscience data show that the areas of four coal fields cross extensively into Enkangala, namely the Ermelo (32%), Highveld (29%), Klip River (6%) and the Utrecht (69%) coal fields (Figure 9).

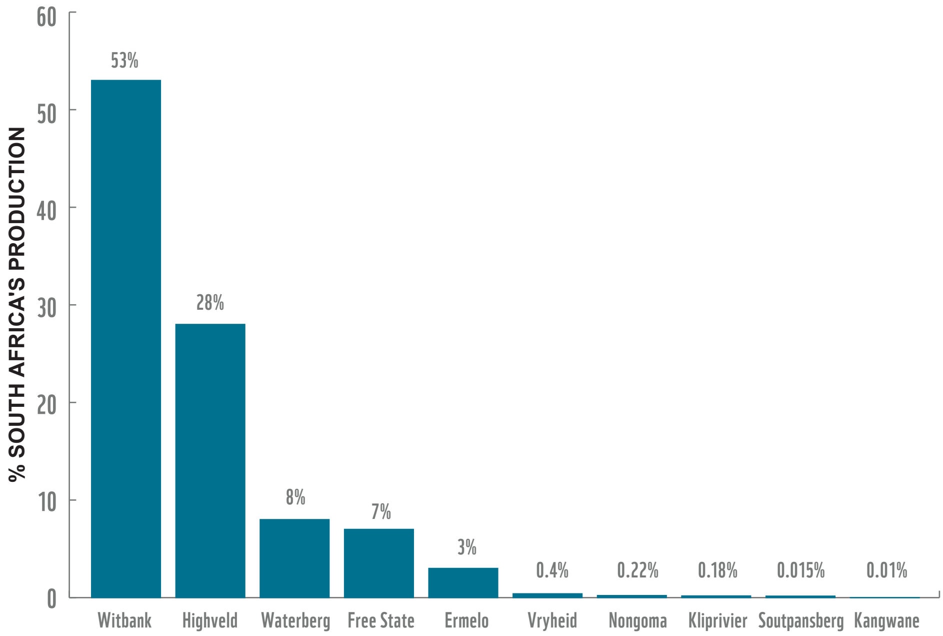
An estimate of the distribution of reserves by coalfield is given by the Council of Geosciences (2000), Schmidt[51], as well as Jeffrey[29]. Comparisons revealed estimates to be similar and the estimates are summarised in Table 11. The country's main coal reserves are concentrated in the Highveld and Witbank areas, but a high proportion of the Utrecht coal field is situated in of Enkangala and is thus also an important concentration of coal in the study area. It needs to be noted that the figures of Schmidt[31], were used for economic modelling, as the data represent the most recent estimates (2006).

No known reserves are situated within the study areas in the Free State Province. Ermelo, Kliprivier and Utrecht together accounted for 30 percent of the total known reserves in 2005. An estimated nine percent of South Africa's coal reserves are in the Enkangala area.

Actual production data at a local level are difficult and time-consuming to obtain because it would require identifying each coal mine in the study area and aggregating information from each individual mine. So a top down approach was taken and the share of production is based on each coalfield's production. In 2006, Mpumalanga's total coal production (50 mines) represented more than 84% of total production,

Figure 10: Coalfields run of mine (ROM) production, 2006

Source: GMI (2010)[52]



Free State's two mines seven per cent and KwaZulu-Natal's six mines only 0.8%[24]. It is assumed that run of mine production is roughly proportional to saleable production. Ermelo's share of production is three per cent, Klipriver 0.18% and Utrecht is not mentioned but is less than 0.01%. As was the case for the reserves, we furthermore assume that 50% of the production within these coalfields occurs in the study area. These calculations suggest that approximately 1.6 percent of total national production occurs within Enkangala.

A comparison of the estimated share of reserves with the share of total production suggests that there may be scope for growth in coal mining production in Enkangala, subject of course to socio-economic viability and the potential environmental impact.

3. COAL MINING IN SOUTH AFRICA

South Africa is a coal rich country with significant reserves. Power production has been dependent on coal and government plans for the majority of our electricity to be generated from coal-fired power for the foreseeable future, even with an increase in the contribution from renewables. This section discusses coal resources, the key players, relevant legislation and the application processes for prospecting and mining licenses. Then it discusses the current gaps, pitfalls and criticisms of the laws, the application processes and the institutions involved.

3.1 South African coal reserves

South Africa has 19 coal fields within the Karoo super group strata. South Africa's coal resources rank fifth in the world with total recoverable reserves are estimated 55 333 Mt[53] or 50 years of coal supply remaining. The Waterberg, Highveld, Witbank, Free State and Ermelo field have the greatest proportion of remaining reserves.

Currently coal accounts for 92% of South Africa's electricity generation. Seventeen coal fired power stations are currently operational, with a further two under construction (Kusile in Mpumalanga and Medupi in Limpopo)[54]. In 2009, South Africa was the fourth largest exporter of thermal coal (65 Mt) after Indonesia (233 Mt), Australia

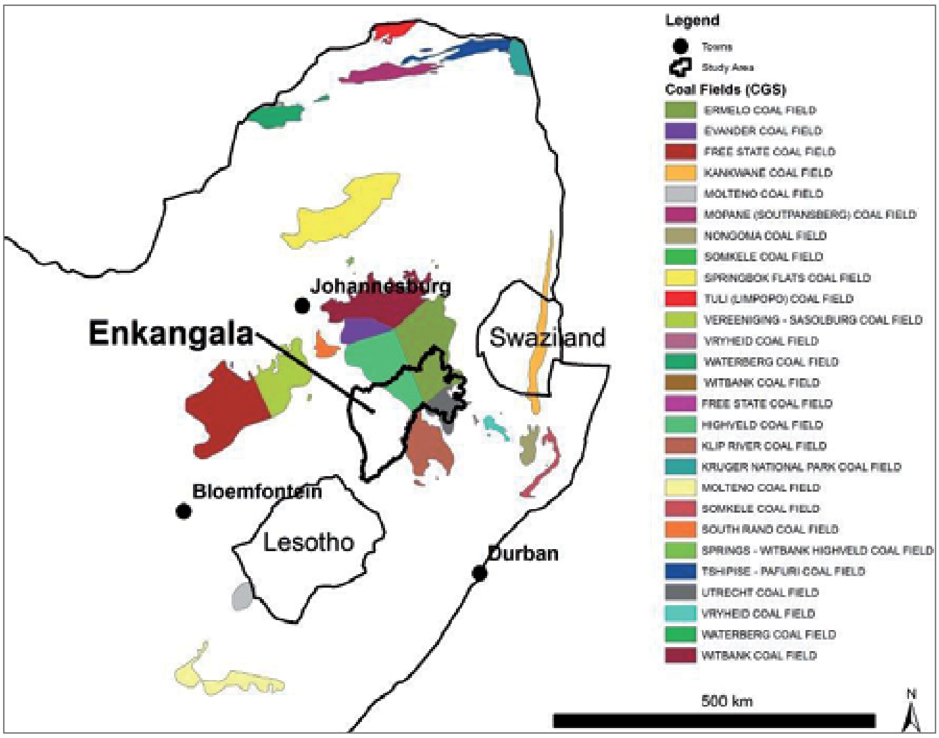
Table 11: Estimated distribution of reserves by coalfield by 2005. ROM.

Source: CGS (2000), Jeffrey (2005)

Coal Field	Area km²	In Study Area (km²)	Percentage of Coal Field in EGP	Recoverable Mt	Recoverable of Nat Recoverable Reserves (2000)	% recoverable (Mt) in EGP National Recoverable Reserves (2000)	ROM production (1982-2000) Mt	ROM production % of National ROM production	Remaining Mt	Remaining %	Remaining of National Remaining Reserves (2000)
Ermelo	10028	3231	32%	4698	8%	3%	101	2%	4597	98%	9%
Highveld	7712	2243	29%	10979	20%	6%	972	22%	10007	91%	20%
Utrecht	2249	1551	69%	649	1%	1%	64	1%	585	90%	1%
Klip River	4894	308	6%	655	1%	0%	85	2%	570	87%	1%
Waterberg	2416			15487	28%		384	9%	15103	98%	30%
Witbank	7627			12460	23%		2320	53%	10140	81%	20%
Free State	10577			4919	9%		0	0%	4919	100%	10%
Vereeniging - Sasolburg	5658			2233	4%		335	8%	1898	85%	4%
Springbok Flats	8769			1700	3%		0	0%	1700	100%	3%
South Rand	780			730	1%		22	1%	708	97%	1%
Soutpansberg				267	0%		6	0%	261	98%	1%
Vryheid				204	0%		82	2%	122	60%	0%
Kankwane	3037			147	0%		1	0%	146	99%	0%
Tuli (Limpopo)	1242			107	0%		0	0%	107	100%	0%
Somkele & Nongoma	2170			98	0%		15	0%	83	85%	0%
TOTAL				**55333**		**9%**	**4389**		**50944**	**92%**	

Figure 11: Coal fields of South Africa

Source: Council for Geoscience



(109 Mt) and Russia (82 Mt), producing 3 times China's output (18 Mt)[55]. In 2009, coal sales amounted to R65 billion rands, the highest value commodity for that year (platinum R 58 billion, gold R49 billion)[56]. Approximately 64% of the coal sold domestically is bought by Eskom for energy production[57].

3.2 Key corporate role players in the coal mining industry

The main operators in the coal mining sector are Anglo Coal, BHP Billiton, Xstrata Coal and Exxaro mining (the largest BEE mining company in South Africa). Sasol, a world leader in commercial coal to liquid technologies, is also a major player in the coal mining industry, albeit the coal mined by Sasol is used directly to produce coal-derived fuels. The top five producers (Anglo American Thermal Coal, Exxaro Resources, Sasol Mining, BHP Billiton Energy Coal South Africa and Xstrata) accounted for 88% of total coal sales in 2009 (Table 12).

Table 12: Main operators in the mining sector

Source: Chamber of Mines, 2010[58]

Corporate role player	Share of sales (2009)
Anglo Operations Ltd	26%
Sasol Coal	20%
BHP Billiton	14%
Exxaro (Kumba Resources)	10%
Exxaro (Eyesiswe)	9%
Xstrata Coal	9%
Optimum Coal	4%
Umcebo Mining	3%
Siyanda Coal	2%
Kangra	1%
Total Coal SA	1%
Kuyasa	1%
Tweewaters Fuel	0%

3.3 Junior (new and BBBEE) mining companies

There are no major mining companies operating in the Enkangala area, but there are many smaller BEE companies. Nationally, the growing number of smaller mines is often the result of BEE deals with the larger operators, who dispose of non-core assets to be benefit of new or existing BEE companies[59]. Many of these are currently starting or re-starting production, such as Optimum coal, which is a BEE initiative of BHP Billiton, and Anglo Inyosi Coal, a BEE company valued at R7 billion. In the coal industry the number of BEE companies has grown more than in other mining sectors in the last decade, because the coal mining industry is considered one of the most promising vehicles for realizing BEE ventures61. Black-owned enterprises were estimated to extract about half of all local coal mined in South Africa in 2010 compared with just 10% in 2002. This is directly aligned with a key objective of the Minerals and Petroleum Resources Development Act (MPRDA) (Act 28 of 2002)[60], namely to work towards equitable access, transforming the mining sector and promoting ownership of mines by the previously disadvantaged sector[61].

There are over 3 000 artisanal to small-scale mining ventures which provide a living for 20 000 workers[61]. A shortage of appropriately skilled people is a major stumbling block for the development of these mining operations. Thousands of micro and artisanal miners also operate illegally[63]. These smaller mines also give reason for concern about environmental degradation as well as mismanagement of mine water and related issues[62]. This is because many small operators do not abide by environmental and safety regulations. Furthermore, most small coal mining enterprises do not operate in an economically viable way[63].

The expansion of the Richard's Bay Coal Terminal has enabled a number of new mines to obtain an export share. The empowerment mines receiving this allocation for 2007–8 include Anker Coal (Mpumalanga), Black Gold Coal (Mpumalanga), Endulwini Resources (Mpumalanga), Exxaro Coal (Limpopo), Ilanga Coal Mines (Mpumalanga), Leeuw Mining (Mpumalanga), Mashala Resources (Mpumalanga), Mmakau Mining (Mpumalanga), Polmaise Colliery (Mpumalanga), Riversdale Holdings (KwaZulu-Natal), Shanduka Coal (Mpumalanga), Shanduka Resources (Mpumalanga), Tweewaters Fuel (KwaZulu-Natal), Umcebo Mining (Mpumalanga), NuCoal (Mpumalanga), Worldwide Coal (Mpumalanga) and Zinoju Investments (KwaZulu-Natal). The proposed expansion of the coal terminal could also promote further development of small-scale mining in Enkangala, given its relatively close proximity to the Richards Bay Coal Terminal. The share given to the empowerment companies (4 Mt/a) is nonetheless small in relation to the overall capacity of the terminal (91 Mt/a).

3.4 Coal exports and domestic sales

Both coal exports and local coal demands are predicted to grow significantly in the future. South Africa produces approximately 250 Mt of coal annually, with 75% of the saleable coal being sold locally in 2009[61]. In 2006 approximately 61% of local sales went to the electricity sector, 25% to the synthetic fuels sector, six per cent to industrial users (such as sugar, cement, textiles and brick making), five per cent to merchants and the domestic sector and three per cent to the metallurgical industry (dominated by ArcelorMittal) and 0.2% was used by the mining industry itself[47]. Eskom is planning massive capacity expansion programmes[61], including the Medupi and Kusile power stations.

The remainder of coal is exported, with the bulk of South Africa's coal historically going to Europe (88% in 2006, with the UK, Spain, France, the Netherlands, Italy, Germany, Denmark and Belgium as the largest customers)[47]. Approximately four per cent is exported to other African countries, and two percent goes to South America[47]. In 2006, seven per cent of South Africa's total coal exports were sent to the Middle East and Asia. By 2010 the delivery to eastern markets had risen notably and this is likely to continue. India, and to a lesser degree China, receive increasing proportions of thermal coal, and both large and small mining companies are reporting that they are profiting from this[61].

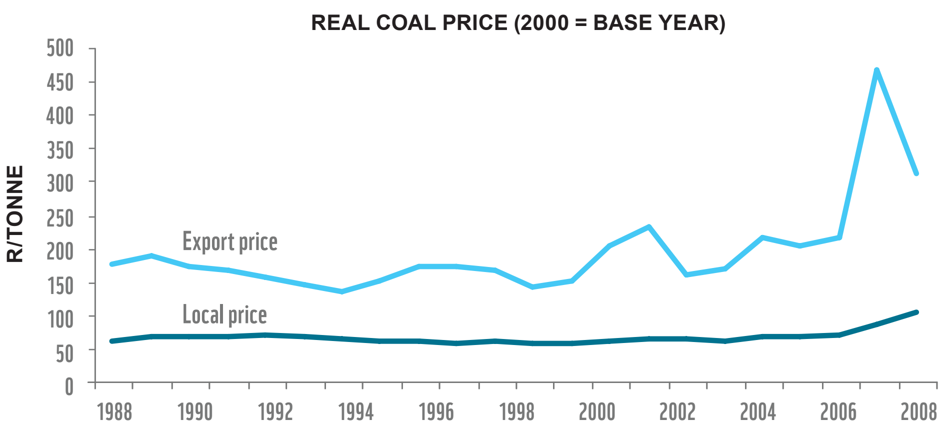
The rise in overseas coal demands, especially for lower grade coal, has created significant tensions among players in the coal mining industry. Eskom is concerned about the security of national coal supplies, while some mining companies are exercising their right of a free market by preferentially selling coal to higher bidders overseas (notably India). Eskom would welcome government intervention that ensures security of national supply, similar to what is exercised in China, India, Brazil and Australia. However, government is currently not imposing such measures and is rather imploring the mining industry to co-operate in order to meet Eskom's requirements. Eskom has signed new supply contracts with several mining companies to ensure its supply[61].

3.5 The economic value of the current level of coal mining

The gross value added (GVA) for coal mining in South Africa was R48,5 billion in 2008 values[63]. Total mining and quarrying GVA for the same period was R201,4 billion, so that coal mining's contribution to mining GVA is estimated at 24 percent. In 2009, 251Mt of coal was produced, of which 74 percent was sold locally and 24 percent exported. The good quality coal (calorific value of 27.5 MJ/kg, ash content <20%) is usually exported, leaving the lower quality coal (17 – 22MJ/kg, ash content 21 – 36%) to be burned by South African coal-fired power stations61, adding to South Africa's greenhouse gas emissions and air pollutants. The difference between local and export prices reflects this discrepancy, but the gap between the local and export price is decreasing. The local sales price averaged R187/tonne in 2009, an increase of 22 percent over the 2008 price (in nominal terms). The export price, by contrast fell from R737/tonne in 2008 to R512/tonne in 2009, a fall of 31%. As a result, the total value of sales fell by 12.5%, from R74.8 to R65.5 billion, although this masks a rise in the value of local sales of almost 16% over the same period. In real terms, domestic prices have grown by less than 3%/a in the period 1988 to 2009 (Figure 12). Export prices have been far more erratic, although have shown stronger real growth over the same period (average 6%/a).

Figure 12: Local and export coal prices, 1988–2009

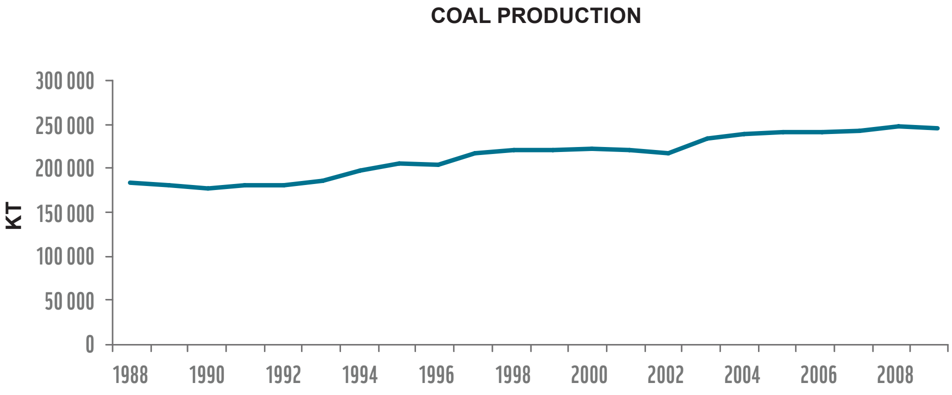
Source: Own calculations based on DMR (2011c)[48]



NOTE: Local price deflated using Producer Price Index (PPI) for domestic output, export price deflated using PPI for exported commodities

Figure 13: Coal production in South AFrica from 1988–2009

Source: DMR, (2011c)[48]



Coal production has steadily increased over the past two decades, from 182 Mt in 1988 to 251 Mt in 2009, an annual growth of around 1.5% (Figure 13). This is less than both local and export price increases over this period, and might signal increased production costs, increased difficulty accessing reserves, or both.

3.6 Legislation affecting coal mining

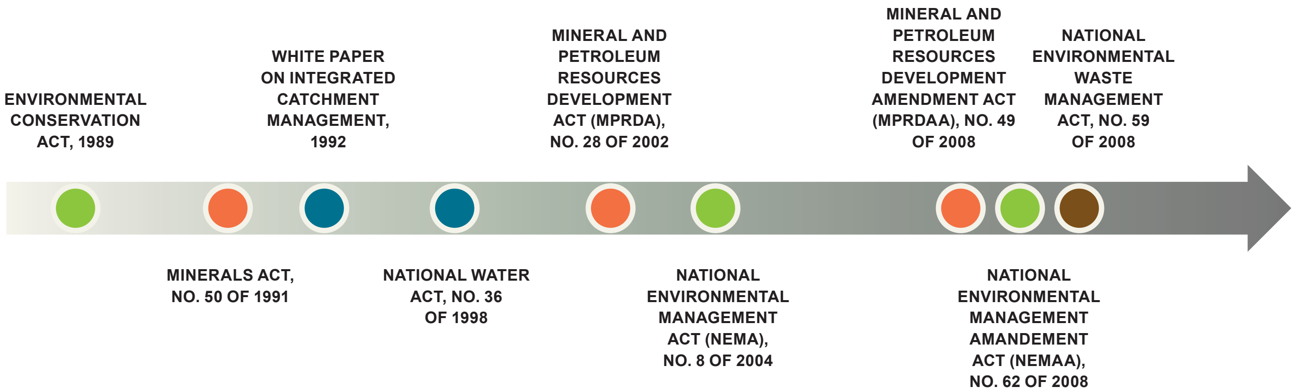
During the apartheid era, mining legislation did not address the protection of the environment or water resources. The Minerals Act (Act 50 of 1991)[64] introduced specific requirements for the environmental management on mines in the form of Environmental Management Programme Reports (EMPRs)[87]. Since the political changes in South Africa, the mining, water, environmental and waste legislation have all undergone significant revisions to align them with the constitution and other legislation. Today, the legislation protecting environmental and water resources is sound and comprehensive[65] (Figure 14).

The three main Acts are the National Water Act (NWA) (Act 36 of 1998)[127], the Minerals and Petroleum Resources Development Act (MPRDA) (Act 28 of 2002)[62] and the National Environmental Management Act (NEMA) (Act 8 of 2004)[66].

The NWA placed all water under the custodianship of the national government. Department of Water Affairs (DWA) is responsible for the regulation of water use and its protection. The 'Polluter Pays' principle is enshrined within this Act. The NWA requires all water use associated with mining operations to be authorised by the DWA before it can commence. This includes non-consumptive 'use' such as contamination and discharge of mine effluent.

Figure 14: Timeline of major legislation changes that inform mining water management

Source: adapted from Mey and van Niekerk (2009)[46]



Section 21 of the National Water Act states that licenses need to be obtained for all water uses*. 'Use' includes any of the following: taking water from a water resource, storing it, impeding or diverting water flow in a water course, reducing streamflow, discharging waste or water containing waste into a water resource, disposing of water in a manner that contains waste from, or which has been heated in, any industrial or power generation process; altering any characteristics of a water course; and removing, discharging or disposing of underground water if it is necessary for the efficient continuation of an activity or for the safety of people.

Section 19 (1) of the National Water Act states that "An owner of land, a person in control of land or a person who occupies or uses the land on which

a) any activity or process is or was performed, or undertaken; or

b) any other situation exists, which causes, has caused or is likely to cause pollution of a water resource, must take all reasonable measures to prevent any such pollution from occurring, continuing or recurring."

**Excluding Schedule 1 activities, General Authorisations or an existing lawful use.*

The Department of Minerals and Energy (DMR) administers the MPRDA. This Act enshrines the 'Polluter Pays' principle and requires Environmental Management Plans (EMPs) to be drawn up prior to mining. This includes ensuring that the applicant has made financial provision for rehabilitation, as well as monitoring and auditing. These clauses link this Act to the NWA and the NEMA, however the MPRDA also has another objective, namely to transform the beneficiaries and owners of the minerals and mining industry, thus addressing political inequities of the past. The aim is stated as "to substantially and meaningfully expand opportunities for historically disadvantaged persons, including women and communities, to enter into and actively participate in the mineral and petroleum industries and to benefit from the exploitation of the nation's mineral and petroleum resources" [Section 2d].

The NEMA is enforced by the Department of Environmental Affairs and Tourism (DEAT) and requires Environmental Impact Assessments (EIAs) and Environmental Management Plans (EMPs) for any activities that affect the environment. Like the other Acts, it enshrines the 'Polluter Pays' principle.

The discrepancy between the sound laws governing mining in South Africa and the visible 'coal rush' that is currently happening in the coal-rich areas of South Africa highlights that there are gaps between the written provisions and their actual implementation. The literature frequently criticises the ability of government to implement and police its own laws and policies and prevent malpractices[50,91,67].

3.7 Application processes for prospecting and mining licences

The manual application approach to prospecting and mining permits was recently modernized with an attempt at streamlining the prospecting and mining licence application process with a new DMR online application facility, launched on 18 April 2011. This new and supposedly comprehensive "streamlined approach" was not fully clarified at the time of writing this report, so the historical method of acquiring a prospecting right (PR) is described below:

- Desktop screening (identification of potential sites for coal to be found based on desktop geological modelling and historical records)
- Application to the DMR for PR; if accepted this confers a right to apply . This process appears to be significantly streamlined by the DMR online application facility.
- Completion of an Environmental Management Plan (EMP) and consultation process before submission to the DMR (total 60 days). This process requires notification and consultation with IAPs and a basic EIA process intended for non-professionals to be able to complete (in the form of the EMP).
- Prospecting right awarded by DMR if the EMP score is below a certain threshold (if a "high risk" is revealed through the EMP, the PR may be refused and/or the applicant ordered to rewrite the EMP).

If a prospecting license is awarded, prospecting can take place. This has to be done within a prescribed time period of 60 days or else a renewal is required. The prospecting may be cursory in the beginning and become more detailed as data is gained through the process. Once prospecting is complete, evaluation of the reserve from an economic perspective is undertaken. In the event that the prospecting process looks favourable, it will result in the actual application for a mining license. The first step in a mining application is thus:

- To lodge an application to the DMR for a Mining Right (MR).
- The DMR will then issue the applicant with authority to proceed to apply for an MR (note this is not a MR but authority to proceed to apply for one).
- The applicant will then conduct a scoping study as part of an EIA/consultation process (this requires a qualified practitioner to conduct the process correctly). Again, the time period given is 60 days (thus from prospecting right application to mining right acquisition, the total period is 120 days). The scoping study includes a feasibility study and prefeasibility study.
- If the EIA and consultation process is conducted to the DMR's satisfaction and the results are below a certain risk profile, the DMR will issue an MR to the applicant.
- Then begins the construction phase involving creating access for construction, land clearance, actual implementation and extraction of minerals.

3.8 Links to ministries other than DMR

Within the DMR-issued pro forma EMP document, it is made clear that other relevant legislation applies to any PR application. As such a list of relevant Acts is provided in section A6 of an EMP for an applicant to be aware that matters pertaining to environment and water (amongst others) are to be considered alongside any prospecting (and additionally mining) right application done under the MPRDA. The DEA and DWA (as well as provincial conservation authorities) must be consulted prior to the awarding of a right. This consultation is done via the DMR, who then submit the EMP documents to DEA and DWA for comment prior to the awarding of a right.

EMP Application form:

A.6 OTHER RELEVANT LEGISLATION

Compliance with the provisions of the Minerals and Petroleum Resources Development Act, 2002 (Act 28 of 2002) and its Regulations does not necessarily guarantee that the applicant is in compliance with other Regulations and legislation. Other legislation that may be immediately applicable includes, but is not limited to:

- National Monuments Act, 1969 (Act 28 of 1969)
- National Parks Act, 1976 (Act 57 of 1976)
- Environmental Conservation Act, 1989 (Act 73 of 1989)
- National Environmental Management Act, 1998 (Act No. 107 of 1998)
- Atmospheric Pollution Prevention Act, 1965 (act 45 of 1965)
- National Water Act, 1998 (Act 36 of 1998)
- Mine Safety and Health Act, 1996 (Act 29 of 1996)
- Conservation of Agricultural Resources Act, 1983 (Act 43 of 1983)

3.9 Process to decommission

The process of decommissioning a mine involves a series of steps that should culminate in a closure certificate being awarded by the DMR with liability being transferred to the department. The steps towards basic closure and decommissioning are as follows:

- A planning process is conducted prior to the start of decommissioning in order to set relevant objectives and to design appropriate methods/approaches that will lead to actual implementation of the closure plan.
- Pollution prevention measures are put in place and rehabilitation commences
- Stabilization of waste areas and attendant rehabilitation is implemented
- Waste water seepage mitigation measures are implemented
- Monitoring and evaluation processes are established and implemented

It must be noted that throughout a mining operation, rehabilitation and mitigation should be implemented as a means to address impacts whilst operations are still underway. The decommissioning phase would be a process to integrate the existing efforts with post-closure mitigation. This would obviously require financial planning and provisioning to ensure an effective decommissioning process for both pre- and post-closure.

3.10 Current shortcomings in the laws, application processes and co-operative governance around mining

There are several fundamental problems in the implementation of the South African legislation around mining and the protection of environmental resources. They have been frequently voiced in Ministerial speeches, reports of the auditor general, scientific reports and publications, the media as well as by members of the public, industry and government departments.

3.10.1 Weaknesses in the legislative process and co-operative governance

Rewriting of outdated legislation is an essential process for countries undergoing change, but it also brings with it the challenge of court interpretation and deliberation of new laws such as the MPRDA and NEMA (as well as their 2008 amendments). This process is lengthy, complex and at times confusing, until such time as a precedent has been set.

This complexity may contribute to the fact that government departments associated with mining have undertaken very few prosecutions despite clear infringements of legislation, and have only imposed token penalties. Other factors that have been invoked are a lack of capacity and political will to prosecute, or speculation that retribution will be swayed by the political power of the mining companies under scrutiny.

Amendments were made to both the MPRDA and the NEMA in 2010 to deal with these gaps but they have not yet been translated into practice.

Although inter-departmental cooperation has supposedly been adopted by all government departments, the DMR is often criticized because it is perceived to have the final say on any PR and MR application. Even under the amendments, the DMR still remains the lead authority for assessing environmental submissions and providing environmental authorisations. The full control of DMR over environmental authorisations creates a conflict of interest, as it is the responsibility of the DEA to take care of the sustainable development and conservation of the country's natural resources. This disempowers government departments that are entrusted with protecting natural resources and leaves room for DMR to exploit natural resources at the expense of sustainable practices.

3.10.2 Weakness in the application process

The imbalance of power can be seen in the application process when provincial conservation authorities make valid objections and statements, only to discover that a right has been awarded. In some cases it has even been awarded within proclaimed protected areas – an action that is illegal. The DEA and DWA say they do not have equal say as DMR when asked to provide comment on EMPs. Failure to comment within a certain timeline results in DMR deeming this to be an indication of "no objection", thus providing additional motivation for the DMR to award the right. Equally, a frequent complaint by the DMR against the DEA and DWA is that these other government departments frequently fail to respond in time, delaying the application process.

Legally, mining operations can only start once both the DMR and the DWA have issued the relevant authorisations[67]. There is an overt problem in the parallel environmental application procedures under the MPRDA, the NEMA and the NWA. The EIA submission process under the MPRDA takes 30 to 180 days to complete, while the EIA process under the NEMA takes between 12 and 18 months. Applicants for mining-related rights or permits often have not yet completed their NEMA EIA but have to submit it under the MRPDA timeframes. This has led to much frustration among applicants.

Another cause for frustration has been that the DMR has issued mining rights to more than one party for the same geographic location. Such double-applications were meant to be sorted out with the help of the online application process, but applicants are concerned that the online application process is chaotic, leading to more double-applications than before.

Variswave – automated online system failing those who try to comply

The new DMR automated system has not been without it problems. Emerging coal mining houses have revealed serious problems within the system in that authorisations have been granted online for applicants to pursue prospecting rights only to find out that the properties over which they are seeking rights already have rights over them. In certain instances, this discovery has come only after the applicants have already spent resources on developing the basic EMP and begun stakeholder engagement. It is ironic that the very system designed to support and streamline applications is also causing costly problems for applicants who appear to have no recourse once the problem has been discovered. This highlights a need for the DMR to further refine and improve their online application system not only from an environmental screening perspective but at a basic functional level.

The requirement for co-operative governance is often hindered by a complex hierarchy of responsibilities at national, regional, provincial and municipal levels. Co-ordination of activities between and within these levels requires a full understanding of the respective responsibilities and power. In reality this is often unclear. A lack of human resources and lack of capacity are often attributed to bad communication among departments, high levels of staff turnover, backlogs and the lack of experience to adequately deal with applications[67].

3.10.3 Weakness in enforcing regulations

The lack of human resources affects the ability to monitor mining operations and their adherence to legislation. Inspectors are often young and lack the experience to either evaluate the level of impact at mines or to counter well-versed mining officials who are experienced in upholding their companies' primary interest of profitability.

A water-use license is required by law but it seems common practice to commence operations without one. There are over 100 examples of mining operations around South Africa that are operating without any water use license. When this is brought to the attention of DWA, in most cases, the mine is allowed to apply for one but operations continue. Clearly there is a need for enforcement of this legal requirement as a means to ensure compliance with associated legislation (such as the Water Act referred to in section A.6 of an EMP). The issue of Water Use Licenses is less applicable to prospecting but still relevant in some instances yet it is highly doubtful that any water use license has been awarded for prospecting in South Africa when an EMP indicates ones is required. The relevant Catchment Management Agency (CMA) is the responsible authority to ensure that the water user in question complies. In case of a failure to comply, the CMA must take "reasonable measures" to remedy or eliminate the effects and source of pollution and the polluter is responsible for the incurred costs[127] [Section 19(3-7)]. In reality the impacts of AMD are insufficiently managed and often the CMAs are not yet functioning at full capacity. So the responsibility falls upon the regional DWA office, despite their typical understaffing and lack of capacity[68].

Despite the shortcomings in enforcement, there are examples of good practice in coal mining. Legislative changes have created a paradigm shift among the mining industry in the past 30 years, so that mine water is now integrally considered in the mining process[87]. This has culminated in good practice like the eMalahleni water purification plant which turns mine effluent into a usable resource. The technical and financial efforts that go into such examples are significant, and require willingness among mining companies to prove good practice in the long term. Some smaller mining companies do not necessarily have the same long term commitment to manage their environmental impacts or the financial stability to ensure funding. Full wastewater recycling is still the exception rather than the rule.

3.10.4 Weaknesses in EMP application processes

Over 30 EMPs were scrutinized and the following weaknesses were found in prospecting EMPs

The EMP template intended for use by non-professionals (i.e. unqualified laypersons), thus opening up the process for abuse. Section A4 of any EMP sums up this approach clearly and thereby exposes an inherent weakness in the integrity of the document from the outset.

A4 USE OF THE DOCUMENT:

This document is designed for use by non-professionals and newcomers to the environmental management industry and it incorporates a very simple Environmental Impact Assessment (EIA). The EIA is contained in Section C of this document and was designed specifically with the target sectors of the mining industry (described in A.2 above) in mind.

The aim is ultimately to (a) gather information from applicants themselves; (b) to assess the impact of the operation based on that information and then (c) to guide the applicant to mitigate environmental impacts to limit damage to the environment.

Based on Section A4 it appears the EMP exercise is a mere “tick box” process, implemented to fulfil the basic environmental requirements, as set by the DMR.

- There is no clear standard set for EMPs within DMR and so, the standard EMPs varies greatly. Numerous contradictions, errors of fact and in some instances, apparent misinformation, are evident.
- There are many examples of copying from one EMP and pasting into another, so that seemingly little or no attention is given to actual environmental/social issues in the target area.
- Typically, only fleeting attention is given to hydrological issues, despite the fact that impacts on water resources are among the most long-lasting.
- Very often it is evident that there were incomplete, limited or even non-existent attempts at notifying and consulting with interested and affected parties (IAPs).

Despite such grave shortcomings, DMR authorisation is typically still given.

The following critiques are given for mining EIAs and EMPRs:

- As with the prospecting applications, the EIA processes lack quality standards, resulting in some thorough applications while others barely fulfil the most basic requirements.
- Although an EIA and management programme have been completed, the management of most sites does not fully comply with and adhere to the EMPR.
- Mine managers appear to be under-qualified at many of the smaller mining sites.
- Very little attention is given to proper mitigation of hydrological issues.
- Valid objections to any EMPs, EIAs and EMPRs are often responded to by suggesting an engineering solution which is seldom implemented once operations are underway.

There is thus often a disparity between what is contained in the authorising documentation and how this is translated into implementation.

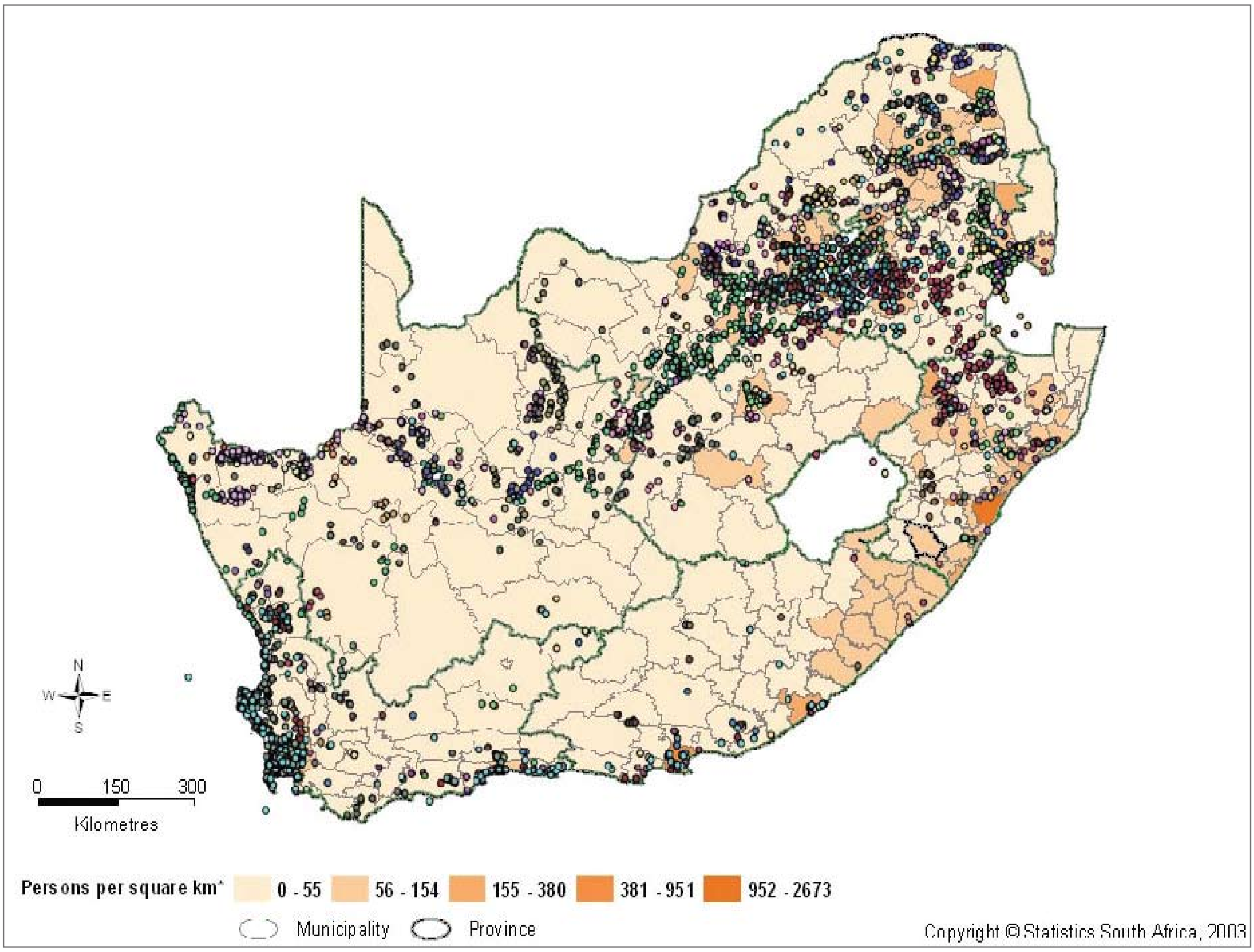
3.10.5 Weaknesses in the decommissioning process

Apparently few if any closure certificates have ever been awarded by the DMR to coal mines – a fact that is of concern. One of the major criticisms of the decommissioning process is that the financial provisions do not cater for the post-closure impact adequately, rendering present rehabilitation/mitigation efforts ineffective over time.

The DMR currently sits with responsibility for 5 906 abandoned mines in South Africa. Their recent strategy was to prioritise asbestos mines and rehabilitate 6 of them. No clear strategy has been developed for the remaining 5 900 mines, a point that was criticized by the Auditor General. The legacy of abandoned mines is discussed more fully below.

An Auditor General Report was compiled in 2009, to investigate the matter of abandoned mines. The report is critical, thorough and clear in its evaluation of shortcomings within the DMR in handling the matter. The report provides evidence that crisis situations are identified and audited within government. Matters were taken further with the establishment of the Inter-Ministerial Technical Committee to address the risks of AMD decanting in the (gold mining areas of the) Witwatersrand. The subsequent report[82] issued by the committee aimed to ensure that science and sound evidence informed and integrated response plan. The report provides a concise action plan with budget and it remains to be seen if this advice can be successfully translated into action in order to start averting the most imminent AMD dangers in South Africa.

Figure 15: Location of abandoned mines in South Africa (Council for Geoscience, 2008) linked to population density (Auditor General report on Abandoned Mines)



3.11 Prosecutions for poor practice

South Africa has sound laws and regulations for coal mining, but the implementation is fraught with complications ranging from lack of institutional capacity, power differences among players and government departments and an imbalanced approach to honouring the multiple national responsibilities of addressing historical inequalities and sustainable practices. The number of prospecting licenses issued in South Africa and the frequent accounts of malpractice and disregard of the environment and IAPs suggests that coal mining governance at present is poorly practiced. Regulatory processes are insufficient and good practice often depends on the decision of individual mines to adhere to internal or industry guidelines on good practice.

Farming community successfully challenges mining company – but DMR does not withdraw

The Luneburg/Wakkerstroom case (southern Mpumalanga) is a useful example of the authorisation of prospecting rights in inappropriate locations. Over a 2.5 year period, a high court application to overturn prospecting rights awarded in one of the most biologically and hydrologically important areas resulted in the rights holder withdrawing, settling out of court and conceding the sensitivity of the area targeted for prospecting. Despite this, the DMR has maintained its stance of objecting to the high court appeal and has therefore not withdrawn. The matter is due to be set down and finalised via the high court shortly and raises the issue of how the DMR can maintain its stance given the obvious environmental sensitivity of the area in question. The situation is further exacerbated in that rights were awarded over two provincial nature reserves (which is illegal). The affected area was proclaimed in 2010 as Mpumalanga's first protected environment (The 23 600 ha Kwamandlangampisi Protected Environment) further confirming its significant biodiversity value. Many questions about the manner and method of scrutinizing applications in sensitive areas are raised as well as the DMR's response to valid objections. This case clearly brings into question the notion of good governance within the Department.

A watershed court case occurred in 2010 when the 2 500 member strong Bengwenyama community of Limpopo Province went to High Court to contest that they had been improperly consulted during a prospecting process by the Genorah Mining Company (BEE partner of ASX-listed Nkwe Platinum) on their property. The Constitutional Court found that "The community was not treated as required by the Constitution". It also found that the DMR had not acted in accordance with procedural fairness requirements as set out in the Promotion of the Administrative Justice Act (PAJA) (Act 3 of 2000)[69]. This was decided because the community missed the PAJA deadline of 180 days, but that the DMR was at fault, as it had not processed the appeal in time. The court decision emphasizes that the process of consultation during prospecting is essential, as it poses such huge and far-reaching effects on landowners. By law, communal land owners have the first right to apply for mining rights on their own land, a right the community is interested in exercising, although their applications have been unsuccessful to date[70].

The DMR has also faced several lawsuits because it has granted duplicate prospecting and mining rights to applicants. As such, JSE-listed Kumba Iron Ore (Anglo American group) is taking the DMR to court to review a decision to grant prospecting rights to Imperial Crown Trading (BEE company) over 21,4% of the Sishen mine in the Northern Cape. Lonmin is also appealing a DMR's decision that grants chrome rights at their platinum lease area in the North West to BEE Company Keysha[72]. Partially based on the duplicated applications, the DMR placed a moratorium on lodging new prospecting right applications from 30 August 2010 until 31 March 2011, to conduct a clean-up audit and to prepare for the launch of their on-line application process. The moratorium was extended in Mpumalanga until 30 September 2011[71].

Legally, the Department of Water Affairs has the right to stop a mine from using water, but it does not have the power to stop the mining process. For that, it would need the support from the DMR, who do hold such power. There are few cases where mines were temporarily stopped from pumping water out of mine shafts when they were found to seriously pollute rivers in the Vaal catchment. In 1996 DWA and DMR agreed to switch off the pumps of Randgold and Exploration Co. Ltd's Grootvlei mine due to negligent effluent disposal into the Blesbokspruit wetland, a demarcated Ramsar wetland site. Stopping the pumps provided government with sufficient pressure on the mine to arrange more acceptable disposal solutions, because prolonged lack of pumping causes flooding and closure of mine shafts the loss of many jobs[72].

Within the DWA, the division of Water Quality and Management that deals with mining application licenses up to the point of license issue. Thereafter, internal responsibility is handed over to the enforcement team from the Resource Protection and Waste Division, called the 'Blue Scorpions'. The team does get involved in gross environmental violations as happened at Grootvlei in 2010[73]. One of the stumbling blocks for DWA is its institutional capacity. DWA has enough young and keen junior staff, but training opportunities are limited and staff are trained only through practical experience while on site inspections. The inexperienced staff are often no match for their opponents – well experienced and well-versed mining managers.

In 2010 the Grootvlei mine was once again under scrutiny after its new company, Aurora Empowerment Systems, was found pumping untreated effluent into the Blesbokspruit during a time of financial difficulty. The Minister of DWA has issued warnings and the site was visited by the Blue Scorpions (DWA law enforcement) to collect evidence of malpractice. Media reported that the company founders could face fines up to R10 million or prison sentences, but it was speculated that the company founders, were unlikely to get prosecuted[75]. The DWA instituted legal action based on the malpractice, and the matter remains under investigation. Other media reports stated that treatment was temporarily resumed[74], but this has once again failed. Pumping has since ceased and the underground pumping station has been flooded[86]. The water level continues to rise and surface decants are anticipated in the town of Nigel within five years.

Another recent DWA warning was issued to the Shanduka coal mine for polluting public roads and operating without a water use license. Further warnings were extended regarding the lack of a proper waste management policy, as it could lead to health risks for nearby communities as well as impacts on a nearby forest[75].

Equally, there are accounts of DMR auditing its licensees, after it became evident that several coal companies have operated under the pretext of supplying Eskom and have exported it instead, making use of increasing demand for the low grade coal that has historically been reserved for Eskom. If found guilty, such companies could lose their mining rights[76]. This issue forms part of much larger tensions in the coal industry between Eskom, government and mining companies. The cause for tensions lies in increased overseas demand for lower-grade coal, the right to a free market that allows mining companies to sell coal to the highest bidder and national needs to ensure a large enough coal supply to cover energy demands and Eskom's future expansion plans[34].

3.12 History of mine abandonment in RSA

South Africa's history includes more than a century of mining. Legislation from as early as 1903 until the 1990s inadequately addressed environmental and social responsibilities of mining and mining closure. Mine owners were fully responsible for mining impacts until they had obtained a certificate of closure, but instead many owners abandoned mines due to bankruptcy, death or to avoid responsibility. In order to address this, the 'Fanie Botha Accord' was signed in 1975 whereby the Department of Water Affairs and Chamber of Mines took joint responsibility of mines, abandoned up to 1976[76]. Government responsibility was halved for abandoned mines in the period 1976 to 1986, again making mine owners partially responsible. After 1986 all responsibility was placed back on mine owners.

Following the major changes in legislation in the 1990s, a mine is only regarded as closed once a closure certificate has been issued in terms of Section 43 of the Minerals and Petroleum Resources Development Act (No. 28 of 2002)[62]. Until then, the owner remains responsible and according to Sections 41 and 43 of the MPRD Act the owner has to financially provide for all the environmental liabilities that are related to the mine.

A mine is proclaimed as abandoned according to Section 46 of the MPRDA, if no closure certificate has been issued and no responsible owner can be traced. Then it becomes the responsibility of DMR to rehabilitate. By 2008 a total of 5906 mines were considered ownerless and derelict, becoming the full responsibility of the government[91]. Most of them had gained that status prior to 2002 when the MPRDA came into being.

A recent audit by the Auditor General was performed on abandoned mines. The process ranked 1730 of the 5906 mines as high-risk. This ranking was done based on levels of air pollution from wind-blown dust or combustion, on contamination of surrounding water resources by AMD and on physical hazards presented by open shafts and unstable slopes[91]. The audit found that the DMR had exclusively focussed on asbestos mines, rehabilitating five of the 5906 mines in the last three years. This lack of performance was evaluated and by 2008 the DMR was found:

- Not to have an approved national strategy for the rehabilitation of abandoned mines;
- Not to have an integrated information system to record and report on mine status, making is difficult to target and prioritise mine rehabilitation;
- Not to have policies, procedures or organisational structure to budget for rehabilitation projects;
- Not to have an approved strategic or business plan for mine rehabilitation;
- Not to have communication systems defined to promote service delivery.

The stagnation of the national strategy for rehabilitating abandoned mines beyond its draft format has led to the overall stagnation of rehabilitation. No new rehabilitation projects were started between 2008 and 2009 and none were planned for 2009 and 2010[91].

The holder of a mining-related right is allowed by law to obtain written consent from the Minister of Mineral Resources to transfer and outsource the handling of environmental liabilities and responsibilities to a better-qualified entity. The outsourcing would be based on liabilities as identified in the environmental management report and as prescribed in a closure plan [RSA 2002, Section 43(2)] and be allowed as long as financial provision is in place to compensate the external entity for its services. This is an important clause that could potentially open avenues of dealing with abandoned mines as well as post-mining situations. In a future in which water resources become more scarce and costly, it may become financially viable treat mine water and sell it as a resource.

3.13 Consequences of abandoned coal mines

One of the obvious consequences of abandoned mines is the exponential cost to government of meeting its legal responsibilities. The DMR is estimated to require R30 billion to rehabilitate the 5 906 mines. However, this estimate does not include long-term treatment of AMD and the construction and operating cost of treatment plants (the eMalahleni plant alone cost R300 million). It is estimated that plant construction costs will be about R5 billion and operational costs of several million will be required annually[91]. In the last decade, the Department of Water Affairs has invested over R120 million to deal with mining wastewater. In the last five years, DMR so far has spent approximately R42 million on rehabilitating five of the 5 906 mines[91]. Australia, in comparison spends an estimated $ 80 million annually on AMD[117].

The vast discrepancy between rehabilitation requirements and the rate of government response shows that government is incapable of dealing with the growing problem of abandoned mines. Coal mines currently remain unaddressed, as the focus lies with asbestos mines and the imminent threat of decanting gold mines[91]. It means that acid water, of a quality similar to what was described in the Olifants catchment (Figure 16), is going to become more and more common as the list of abandoned mines grows and the rehabilitation backlog remains. The affected river systems will continue to deteriorate until these mines are adequately rehabilitated.

3.14 Guidance for best practice in the coal mining sector

Guidance is given by SANBI and DWA on mitigating the impacts of mining on the natural environment and water resources.

SANBI advise restrictions on mining activities under relevant laws linked to conservation areas as described in the table below. Protected areas, world heritage sites, and endangered ecosystems are protected under law and mining is restricted in these areas. Ramsar sites and Freshwater Ecosystem Priority Areas (FEPAs) are not currently restricted by law, but SANBI recommends that mining should not happen in these areas. SANBI also recommend that Biodiversity Priority Areas (BPAs)

Figure 16: Pictures of (a) acid mine drainage decant and (b) manual pH control, Kromdraaispruit, Olifants catchment

Source: P. Oberholster, 2011)

should include buffers around protected areas and national parks, estuarine functional zones, critical biodiversity areas defined in provincial conservation plans, trans-frontier conservation areas and high water yield areas[77].

Table 13: Biodiversity Priority Areas in which mining is or should be prohibited (no-go areas)

SANBI Mining and Biodiversity Guidelines, Draft, 2011

Biodiversity Priority Area	Rationale for it being a 'No-Go' area (including relevant legislation)	Information source
Protected areas	Reserved in terms of the Protected Areas Act and includes Special Nature Reserves, National Parks and Provincial and Local Nature Reserves; Protected Environments; World Heritage Sites (including proclaimed buffers); Marine Protected Areas; Specially Protected Forest Areas; Mountain Catchment Areas. **Legislation:** Protected Areas Act (57 of 2003); Marine Living Resources Act[1] (18 of 1998); NFA (84 of 1998)[2]; MCAA (63 of 1970)[3]	**Source:** National Coverage (2010) developed for the National Protected Area Expansion Strategy and available on http://bgis.sanbi.org for download
World Heritage Sites and their buffers	Reserved in terms of the World Heritage Convention Act (Act 49 of 1999). WHS are recognised as protected areas in the Protected Areas Act (57 of 2003) **Legislation:** Protected Areas Act (57 of 2003); WHCA (49 of 1999)	
Ramsar Sites	Ramsar sites are designated by the Ramsar Convention on the conservation of wetland habitats and species. Many Ramsar sites are provincial nature reserves. **Legislation:** n/a	
Terrestrial and Marine Critically Endangered and Endangered ecosystems[4]	We are in danger of losing the last remaining natural examples of Critically Endangered and Endangered ecosystem types. Any further loss of natural habitat or deterioration in condition of the remaining healthy examples of these ecosystem types must be avoided, and the remaining healthy examples should be the focus of urgent conservation action. **Legislation:** Section 52 of the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004)	**Source:** Currently viewable on http://bgis.sanbi.org
River and wetland Freshwater Ecosystem Priority Areas (FEPAs), and 1km buffer of river and wetland FEPAs	National network of strategic spatial priorities for conserving freshwater ecosystems and associated biodiversity produced by the National Freshwater Ecosystem Priority Areas project and incorporated in the 2011 National Biodiversity Assessment. FEPAs are often tributaries and wetlands that support hard-working mainstem rivers, and are an essential part of an equitable and sustainable water resource strategy. FEPAs need to stay in a good condition to conserve and manage freshwater ecosystems, and protect water resources for human use[5]. It is recommended that mining activity not be permitted in river or wetland FEPAs or within 1km thereof. **Legislation:** n/a	**Source:** 2011 National Biodiversity Assessment

1 Marine Living Resources Act (Act 18 of 1998)

2 National Forests Act (Act 84 of 1998)

3 Mountain Catchment Areas Act (Act 63 of 1970)

4 This reflects Ecosystem Threat status throughout South Africa and also informs the National Biodiversity Assessment 2011. For the purpose of this Guideline the Ecosystem Threat Status of freshwater ecosystems has not been included.

5 This does not mean that FEPAs need to be fenced off from human use, but rather that they should be supported by good planning, decision-making and management to ensure that human use does not impact on the condition of the ecosystem. The current and recommended condition for all river FEPAs is A or B ecological category.

DWA published a series of –"Best practice guidelines for water resource protection in the South African Mining Industry" between 2006 and 2008. These are available from DWA and from the Chamber of Mines.

RESOURCE PROTECTION AND WASTE MANAGEMENT HIERARCHY

Step 1: Pollution Prevention

↓

Step 2: Minimisation of Impacts
Water reuse & reclamation
Water treatment

↓

Step 3: Discharge or disposal of waste and/or waste water
Site specific risk based approach
Polluter pays principle

The documentation describing **Water Resource Protection and Waste Management** in South Africa is being developed at a number of different levels, as described and illustrated in the schematic diagram below.

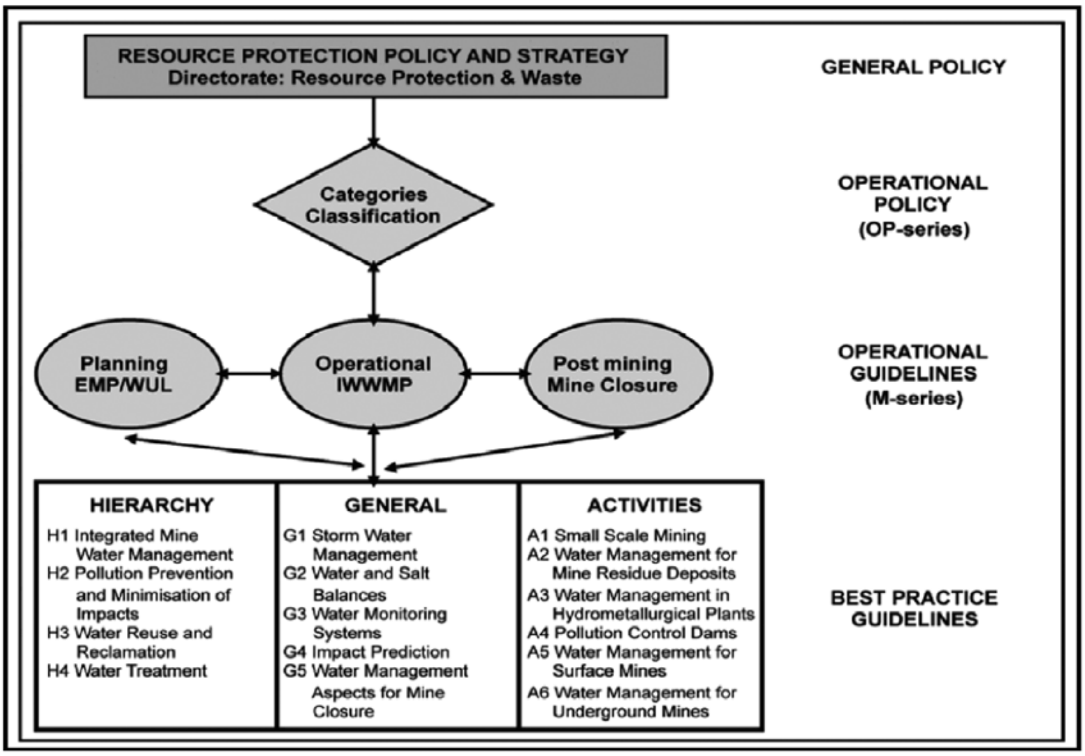
The overall Resource Protection and Waste Management Policy sets out the interpretation of policy and legal principles as well as functional and organisational arrangements for resource protection and waste management in South Africa.

Operational policies describe the rules applicable to different categories and aspects relating to waste discharge and disposal activities. Such activities from the mining sector are categorised and classified based on their potential risks to the water environment.

Operational Guidelines contain the requirements for specific documents e.g. water use authorisation application reports.

Best Practice Guidelines (BPG's) define and document best practices for water and waste management.

Schematic Diagram of the Mining Sector Resource Protection and Waste Management Strategy



4. COAL MINING IMPACTS ON WATER RESOURCES

The most direct impact of coal mining on water resources stems from acid mine drainage (AMD). Acid mine drainage, also referred to as acid rock drainage (ARD), is a phenomenon that has been associated with mining as far back as 2000 years ago in mining regions like the 'Rio Tinto' (Red River) in Spain[78,79]. In South Africa, the three valuable mineral commodities of coal, copper and gold are all either in a sulphide form (gold and copper) and/or are associated with sulphide bearing strata that are linked to the formation of AMD. When these sulphide minerals (especially pyrite or 'fool's gold') come into contact with water and oxygen, they oxidise via several possible chemical reaction pathways to form sulphuric acid and iron. This in turn leaches other metals from the materials in which it forms[80] and the process also leads to elevated concentrations of salts (mostly sulphates) and a decline in pH values.

Under natural weathering conditions the oxidation processes also occur, but at such slow rates that the acid produced is readily neutralised by alkaline materials in the rock. During the mining process the rock mass is extensively fragmented, rapidly increasing the overall surface area on which the oxidation processes can occur. Oxygenated water (from rainwater or surface flow) can then come into contact with the newly exposed surfaces of the broken-up material, starting the acidification process and reducing the pH to below 3 at times[81]. This acidic water will flow into the groundwater resources and ultimately discharge into streams and rivers[82]. The subsurface AMD flow is of particular concern, because the extent of its polluting plume is concealed and the timeframe between initial acid formation and visible decant into surface waters often spans years or decades[83].

The potential and severity of AMD generation in coal mines can vary and depends on many factors[83,85] including:

- The geochemistry and mineral composition of the coal strata
- The presence and abundance of sulphide-bearing materials within or located nearby the coal-bearing reserves
- Carbonate-bearing rocks or organic matter in the mining and/or receiving environment can neutralise the acidification process, even rendering water alkaline (i.e., pH >7); and
- Climate and rainfall - mines in wetter regions will generate greater volumes of AMD than mines in drier regions

The mine's setting in the geomorphological landscape also has an influence:

- An elevated location will lead to drainage of contaminated water away from the mine, whereas
- A basin-like setting will lead to the local collection of contaminated water

A mine located in the headwaters of a catchment will threaten a more of a water resource, and thus its users, than a location in the lower catchment.

Weathering processes may vary –

- In wetter climates chemical weathering processes promote the mobility of contaminants due to there being more water available to act as both solvent and transport medium; and
- In drier regions mechanical weathering processes dominate, as temperature

extremes often promote the physical breakdown of strata, and contaminants tend to move relatively slowly in groundwater

4.1 The pollution of water resources by coal mining

Mining processes and their impacts on water resources are different for the prospecting, active mining and post-mining stages.

4.1.1 Prospecting

During a typical prospecting process roads are created in order to move between the prospecting boreholes that are drilled on-site (sometimes over 100 per site) during the process. The Environmental Management Plan (EMP), prepared by the prospector prior to proceeding, stipulates that prospectors have the responsibility to rehabilitate any roads, pits or boreholes created as part of the prospecting activities, unless the landowner decides to keep the structures in place. Prospectors typically follow a standard rehabilitation approach, which is often not suitable to several vegetation types. Grasslands such as those in Enkangala, for example, are very sensitive to disturbance and the rehabilitation efforts often produce inadequate results. The Enkangala area has numerous prospecting scars that have never reverted back to their original state (Figure 17). Others have reverted back to a functional state, which is not comparable to the original state.

South Africa has sound policies, laws and regulations around mining, the environment and water matters, but co-operative governance and policy implementation are weak[50]. Some small mining firms have been seen to illegally start mining of shallow coal resources that they excavated during the prospecting activity. Typically, digging is done by hand or with small machines and coal is transported by light vehicles. In this way, the prospecting site is turned into an illegal, mini-opencast mine[84]. Any such digging will of course discontinue once the legal processes have caught up with the misused prospecting license. Such malpractices leave behind the exposed pits in which water can freely accumulate and acidify.

4.1.2 Active mining

Roughly half of all South African coal mining operations today are conducted underground, while the rest are open-cast[50]. The diagrams in Figure 18 show the differences in the mining methods. The chosen methods are obviously related to the depth of the mined deposits, but from a profitability perspective, the opencast method is preferred, because it maximises the quantity of coal that can be extracted from a seam.

Underground mining allows only partial extraction of the coal material, because support pillars need to be left in place to prevent the mine ceiling from collapsing. Underground mining is more labour intensive and poses greater risks of accidents, but it is also less environmentally damaging than opencast mining, because of the

Figure 17: From left to right: pictures of (a) natural grassland, (b) prospecting road scarring the landscape, (c) improperly capped prospecting borehole from 1980s leaking methane, showing reversal to basal, but not natural grasscover

Source: A. Burns / WWF-SA

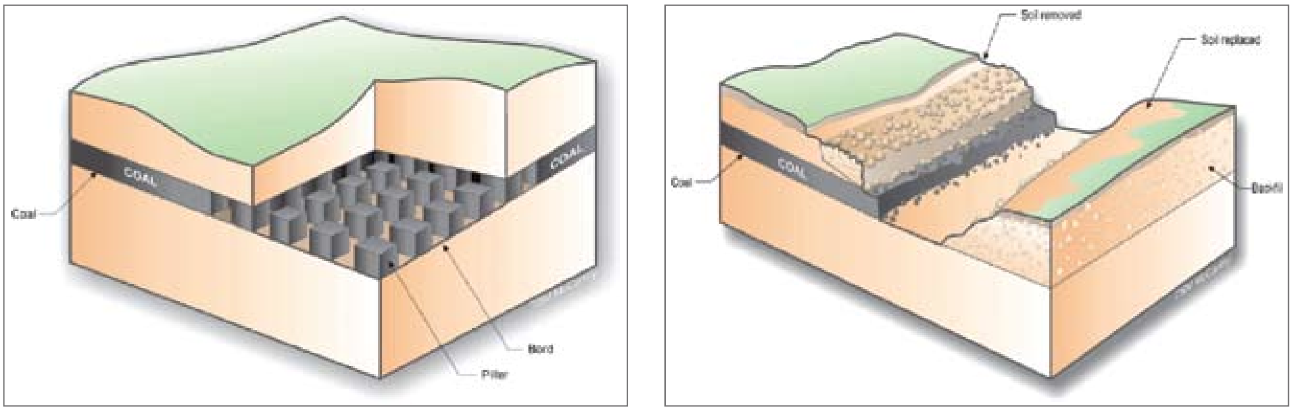


Figure 18: Graphic depiction of (1) an underground pillar mine and (2) an opencast coal mine

Source: Mc Carthy (unpublished)

limited disturbance of the mined material. In opencast mines, the surface soils are blasted and removed by drag-lines to expose the coal seam. After successful removal of the coal seam, a new excavation is commenced adjacent to the old one and the soil that is removed is used to start filling up the front-end of the mine[84]. However, there is seldom sufficient soil to fill the final void left by the last dragline at the end of the mine operation and this fills up with acidic water[83].

It is almost always necessary to dewater the active mine to remove seepage water (Figure 19). The excess water is pumped into surface dams to first allow suspended solids to settle out and then the water is released into the environment before acid can form[86,85].

In the case of existing licenses from DWA and the compliance of the mine to such licensing, the effluent quality is regularly checked and treated to ensure that the effluent adheres to stipulated water quality standards. In this way, pollution from active mines is managed and partially treated. Any mines that do not comply with the conditions of their licenses or best practice guidelines are likely to start the AMD process during the active mining phase.

Figure 19: Picture of water collecting next to an active mine in the Western Basin

Source: C. Wright, (2011)

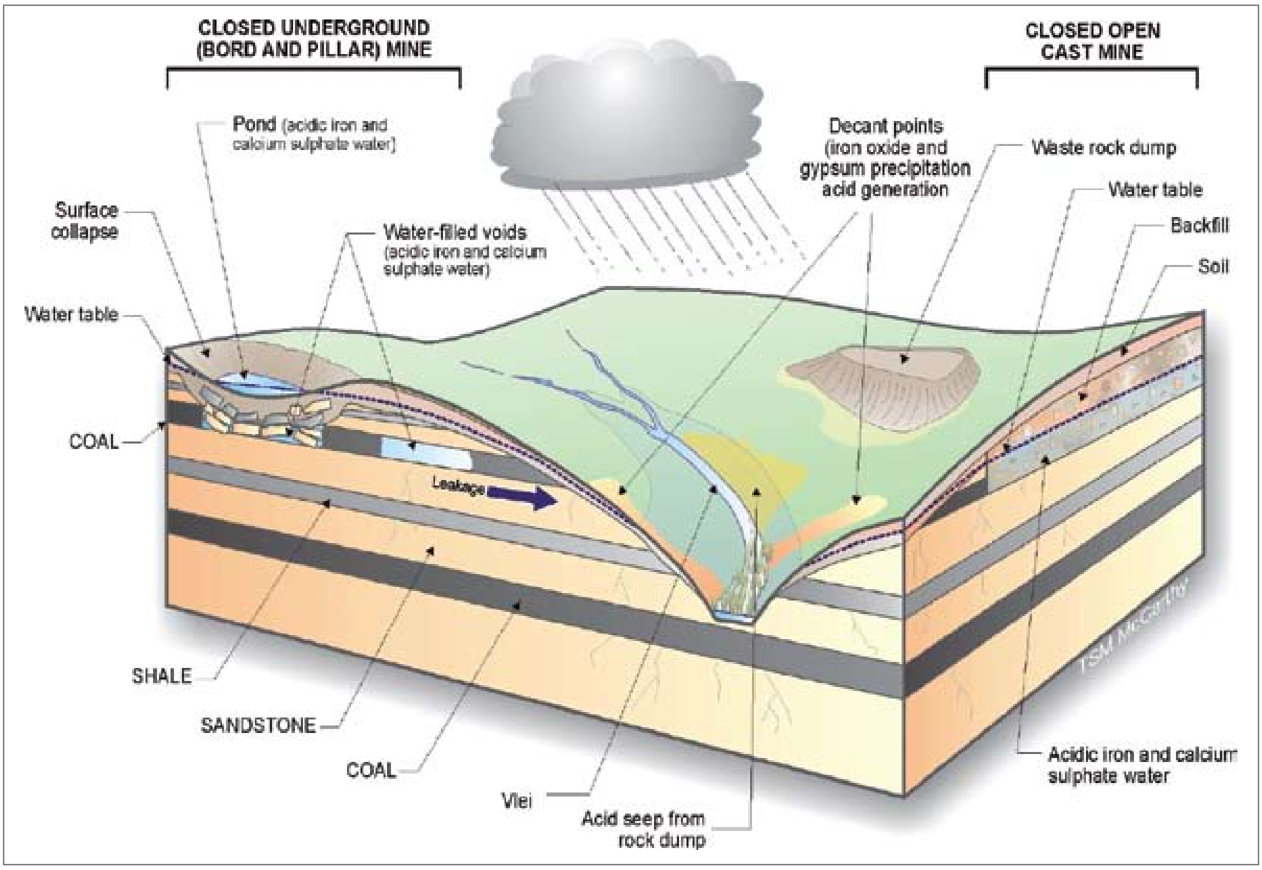


Figure 20: Schematic depiction of AMD processes at defunct underground and opencast mines

Source: Mc Carthy (unpublished)

4.1.3 Post-mining

The high-risk period for water contamination from coal mines occurs in the post-mining phase, when water pumping and treatment ceases and the closed or abandoned mines are left to flood and decant. It may take years or decades for a new hydrological cycle to re-establish at the mine site, and by the time AMD decant occurs the mine operators and regulators are often no longer monitoring.

Underground mine voids fill with water over time, setting in motion the AMD process below the surface. Decanting eventually occurs from the lowest opening (Figure 20). Shallow underground mines are also at risk of collapsing, causing the overlying rock strata to subside. An artificial surface indentation is created where more water can collect, seep into the mine cavity and acidify.

When mining stops, opencast mines are backfilled with the previously excavated rock fragments, which are covered by soil and landscaped to various degrees (Figure 20). The backfilled material is fragmented and mixed and no longer resembles the natural pre-mining structure and layering. The original layering of soil and harder materials previously controlled the surface water-groundwater interactions. After mining, rainwater freely penetrates into the backfill to acidify groundwater resources and/or to decant at the surface.

The slow filling of mining voids and backfill materials with water means that visible decant only commences years or decades after mining ceases[84,86]. AMD will stop once the oxidisation process in a mine has been completed. However, while it is difficult to estimate how long this process will take, it is likely to persist for decades or even centuries[84]. The severity of the potential impact that coal mining processes typically have on water resources can be summarised as follows (Table 14).

Table 14: Summary table of potential impacts (low, medium, high) on water resources

Low impact

Medium impact

High impact

Source: based on SANBI Mining and Biodiversity Guideline draft documents (2011)[87]

Potential impacts	Exploration, drilling and road construction	Construction phase	Active mining	Post-mining
Altered hydrological regimes	Low	Medium	High	Medium
Altered geohydrological regimes	Low	Low	High	High
Increased acidity, heavy metals and salts	Low	Low	Medium	High
Increased turbidity	Low	Medium	High	Low
Risk of surrounding water contamination	Low	Low	Medium	High

4.2 Differences between coal and gold Acid Mine Drainage

In South Africa the dangers of AMD are better-known from abandoned gold mines, rather than from coal mines[82]. The basic chemical processes in AMD generation from gold and coal mining are the same, because the host material for both minerals contains pyrite[43]. Differences lie in the geology of the host materials as well as the extraction methods.

Coal layers, up to several metres thick, occur within sedimentary rocks of the Karoo Supergroup, while gold occurs in thin strips or layers inside conglomerates which form part of the sedimentary rocks of the Witwatersrand Supergroup. Only in localised places do the conglomerates hold gold in economically recoverable quantities[90]. Gold mining involves extracting the gold-bearing conglomerate layer, bringing it to the surface and crushing the material for gold extraction. After extraction, the remaining crushed rock is piled onto tailings dumps. Rainwater falling onto this dump will oxidise the pyrite that is present (approximately three per cent) and an AMD contamination plume typically emanates from the base of the dump to enter groundwater and adjacent streams[88].

Furthermore, water continually seeps into gold mine shafts from surrounding groundwater. During mining, this water is pumped out, treated (if required) and discharged into streams. When mining stops, pumping stops and the old mine shafts slowly fill with water, allowing for the acidification process to commence. Once the mine void is filled, the rising water decants from the lowest-lying opening of the mine[49].

4.3 Water resource contaminants associated with coal mining

Coal mining directly pollutes surface and groundwater with acid, salts and metals generated during the AMD process[89].

The acidification of water increases the solubility, mobility and bio-availability of metals, often raising the concentration of these to unacceptable or toxic levels. Metals known to respond to a low pH from AMD processes are aluminium, beryllium, cadmium, copper, cobalt, chromium, mercury, manganese, nickel, lead, vanadium and zinc[42,90,91,92]. The higher concentrations of sulphate typically found in AMD increase the solubility of arsenic, cobalt, iron, magnesium, nickel and uranium[93]. This does not mean that all AMD causes the leaching of the metals listed above, but rather that the

Figure 21: Pictures of ferric hydroxide precipitate, or 'iron boy' in Tweelopiesspruit, tributary to the Vaal in the Western Basin

Source: M. Steyn, (2011)

altered pH and sulphate content has the capacity to leach these metals should any of them occur in the mined materials or rock formations with which the water comes into contact.

A common visual impact of metal-related AMD pollution is the precipitation of ferric hydroxide [$Fe(OH_3)$] and oxyhydroxide complexes FeO(OH). These form a yellow or orange coating in stream channels (called 'iron boy'), which can smother aquatic biota, or even clog streambeds due to the formation of a hard crust[85] (Figure 21). The precipitated iron also consumes dissolved oxygen in the water, leading to asphyxiation of biota that rely on dissolved oxygen for survival[94].

The acidification of water, especially below the threshold pH of 4.2, has severe impacts on aquatic ecosystems. The drop in pH (in some areas AMD water can reach a pH of less than three[83]) leads to the conversion of all dissolved carbonates and bicarbonates into carbonic acid, which dissociates to carbon dioxide and water. This process nullifies the bicarbonate buffer system of water, and then water no longer has a natural control system to resist pH changes[83].

Plants depend on bicarbonates as an inorganic carbon source, and acidification limits or destroys their ability to photosynthesise[95]. Other organisms are killed through the destruction of ionic balances or the damage to cell components or carbonate exoskeletons[83,97]. An affected stream also loses its capacity to decompose dead matter, thus hampering natural nutrient cycling and disrupting the natural foodchain[96].

Elevated levels of aluminium have deleterious effects on benthic insects and lead to neuromuscular dysfunction in fish[96,96,97]. Increased levels of salinisation generally lead to changes in the community structure of aquatic biota, because some species are salinity tolerant while others are not[96,98].

4.4 Consequences of water pollution by coal mining for human health, livestock and crop productivity

The consequences of AMD polluted waters extend beyond the aquatic habitat into the realms of human and animal health and crop production.

Increased salinisation – especially through increased sulphate concentrations – disturbs the normal metabolism and nutrient uptake of plants and soil biota. High concentrations of dissolved salts in plants lead to plasmolysis, or cell shrinking and collapse. The plant species and individual plant properties (e.g. structure and depth of the root system) will determine the concentration of soil-salt levels at which a crop or plants will succumb to salinisation. Some crops such as apples, lemons, oranges and potatoes are particularly intolerant. The process of soil salinisation is hard to reverse and almost totally irreversible in the case of heavy-textured soils with high levels of swelling clay. Although a combination of efficient drainage and flushing of the soil by water is often used, the leaching of salts from the soil profile is rarely effective[99].

When crops are irrigated with AMD-polluted waters, the metals can be found in agricultural soils and in the roots and shoots of plants100. Increased concentrations of certain metals may be phytotoxic to plants. Aluminium (Al), for example, is an important metal associated with AMD and acidification. Below a pH of 5, Al is toxic to plants and acts as an important growth-limiting factor for crops, causing cell damage and limited nutrient uptake[101,102]. Hence acidification and consequent release of Al in AMD affected areas can lead to significant losses in plant biomass and crop yields (the severity depends on the kind of crop, its genotype and its tolerance levels)[62,103]. Aluminium toxicity in shallow soils can be countered by increasing the pH of the soil with lime treatment, and nutrient deficiencies can be addressed by applying more phosphates[104]. Ammonium-based inorganic nitrogen fertilizers on the other hand would add to the acidification problem[104]. However, liming and phosphate additions are only feasible for shallow-rooted crops and their expense creates a financial burden to farmers. In turn, the use of phosphates adds to the eutrophication crisis in South Africa, where currently data from 88% of the national water quality monitoring sites indicate that the waters already exceed the Resource Water Quality Objectives[104,105].

Metals such as aluminium, copper, zinc and arsenic can concentrate in plant tissue when plants are exposed to elevated concentrations of these metals in the vicinity of mining activities[106]. If such plants are consumed by animals and humans, the metal concentrations may be carried along in the food chain. Animals that drink contaminated water and/or feed on contaminated plants have been shown to accumulate metals in their tissue or in their milk[107].

Human exposure to AMD pollutants can occur through ingestion of contaminated water, food or through dermal absorption via water or air. There are many, thorough studies summarising the exposure risks of humans and animals to individual metals[108,109]. While such reports provide good summaries of health risks associated with individual metal exposure, they do not provide an overview of any cumulative effects that multiple pollutants (as found in AMD) can have on human health. Individual chemicals present at safe levels can become harmful when they occur in a mixture of pollutants[110]. Since AMD has the potential to release a complex mix of pollutants, this lack of knowledge is a cause for significant concern. Research is currently underway to address the health risks associated with AMD in South Africa[111].

There are some known health risks associated with exposure to chronic and toxic levels of the individual pollutants that are commonly associated with water-borne pollutants from coal mines:

- **Aluminium:** Respiratory and neurological problems. Potential causal link to Alzheimer's disease, neurotoxic effects and bone diseases in renal patients[110]
- **Manganese:** neurotoxic – risk of uptake greater from food than from water[111]
- **Sulphates:** Diarrhoea[112]

Other studies have looked at health effects in coal mining communities and found that community members have a 70% greater risk of developing kidney disease and a 64% greater risk of developing chronic obstructive pulmonary disease (COPD) such as emphysema. They are also 30% more likely to report high blood pressure (hypertension)[113]. The latter two health effects are, however, not linked to water, but rather to airborne pollution and stress, aspects that are beyond the focus of this report.

5. A CASE STUDY OF HISTORICAL COAL MINING IMPACTS: THE OLIFANTS CATCHMENT

The Olifants river catchment is known to be one of South Africa's most degraded rivers because of impacts from coal mines, abandoned mines, agriculture, industry and sewage pollution. Coal mining in this catchment started in the 1890s[87] and by 2004 an estimated 50 000 m³ of mine water was discharged into the Olifants River daily, as well as 64 000 m³/day from closed and abandoned mines[41,114,115]. In 2001, mine water use in the catchment amounted to an average 4.6 %, but it contributed about 78% of the total sulphate load[116]. Such pollution levels have impacted downstream users, including people living in the catchment as well as tourists and wildlife of the Kruger National Park[85].

Most industrial activities and their associated pollution occur in the upper Olifants catchment in the Witbank and Middelburg areas. Some of the pollution is captured and accumulated in the Witbank and Middelburg Dams (Figure 22). Both dams showed an increase in sulphate and TDS concentrations from as early as 1986[84,87], mainly as a result of coal mining activities. Sulphate concentrations of 120 – 160 mg/l are still commonly measured in the dams, whereas it is estimated that these levels would have been much lower at 20 – 40 mg/l if mining activities were not present[118]. A controlled discharge scheme was introduced for the Witbank Dam area in 1997, to ensure that waste released from mines and power stations coincided with high flow volumes. Effluent releases are increased during high-flows when the river's dilution capacity is at its highest and releases are restricted during low flows[117]. This was paired with significant investments by industry to improve the drainage, storage and treatment systems used for effluent water. These combined efforts have almost halved the sulphate concentrations in Witbank Dam, providing some relief from mining impacts in this upper part of the catchment[117]. However, concentrations regularly still exceed drinking water guidelines. Eskom requires good-quality water to operate their coal-fired power stations near Witbank and they import clean water from the eastern escarpment rather than carrying the costs associated with the purification of Witbank Dam water[84].

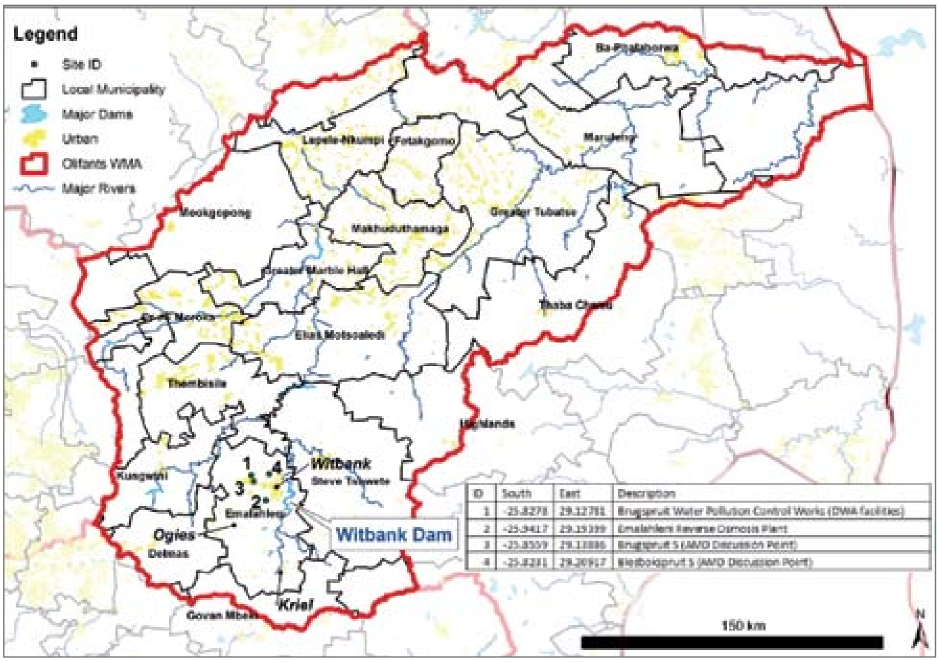


Figure 22: Map of Olifants catchment with locations of dams and relevant case study example locations

Source: WR2005, CSIR data

Determinand	Blesbokspruit Water quality Average mg/L (1990 – 1996)	SA drinking water quality guidelines[73] mg/L Target	SA drinking water quality guidelines[73] mg/L Short term (poss. chronic effects or symptoms in sensitive users)	SA Agriculture Water Quality Guidelines[73] mg/L Target	SA Agriculture Water Quality Guidelines[73] mg/L Max acceptable (short term)
TDS	3 091.7	0 – 450	2000	220	1 485 – 2 970 (mod salt tolerant)
pH	2.7	6 – 9	4.0 – 11.0	6.5 – 8.5	< 6.5
Sulphate (SO4)	2 292.9	0 – 200	400 – 600		
Magnesium (Mg)	62.2	0 – 30	70 – 100		
Iron (Fe)	162.8	0 – 0.1	1 – 10	5	20
Manganese (Mn)	14.2	0 – 0.05	14 – 20	0.02	10
Aluminium (Al)	104.5	0 – 0.15	0.5	5	20

Table 15: Water quality of undiluted AMD spilling into Blesbokspruit

Source: adapted from Bell et al. (2002)[83]

Many cases of AMD spillage as well as AMD management efforts are found near Witbank Dam. Two neighbouring streams, the Brugspruit and the Blesbokspruit are both recipients of AMD from abandoned underground mines in the area. The Middelburg Steam Coal Mine operated from 1908 until an underground fire began in 1947, forcing official mining to halt. The abandoned underground mine started decanting mine water in 1991, which is 44 years after mining was abandoned. Seepage from the mined area spills into the Blesbokspruit at a rate between 20 000 and 120 000 m^3 per month, depending on rainfall and season[85].

Decanted water spilling into the Blesbokspruit between 1990 and 1996[85] far exceeds both the drinking water guidelines as well as agricultural water quality guidelines (Table 15).

Similarly, AMD seepage from the burning mine flows into the Brugspruit tributary, which divides the abandoned mining area from rapidly expanding urban settlements. Neither the old mining area nor the recipient river is cordoned off and the neighbouring communities are fully exposed to the effluent (Figure 23).

5.1 Costs of cleaning up AMD from coal mining

The Department of Water Affairs and Forestry has taken responsibility for the abandoned mine in the Brugspruit area and in 1997 constructed a Water Pollution Control Works at a cost of R26.5 million. It has a capacity of 10 000m^3/day and protects Loskop Dam from the impacts of this particular AMD spillage. At the treatment works the water is treated with sodium hydroxide, to counter acidity[117] and soda ash is added to the final effluent in order to increase the buffering capacity of the treated water[118]. When fully functioning, the treatment works thus has the capacity to improve effluent acidity and consequent metal concentrations, but the sulphate concentrations remain unaddressed. The plant has also failed because of stolen

Figure 23: (a) Children playing in the warm AMD decant from an underground burning and abandoned coal mine in the Witbank area, (b) cattle drinking AMD polluted water in the Brugspruit area (c) AMD seepage precipitates on soil adjacent to Brugspruit river

Source: (a) M. Lieferink, (b) CSIR (2010), (c) K. Schachtschneider (2010)

electricity cables and insufficient maintenance, during which time acidity regulation did not occur and the untreated decant flowed into the Brugspruit[117].

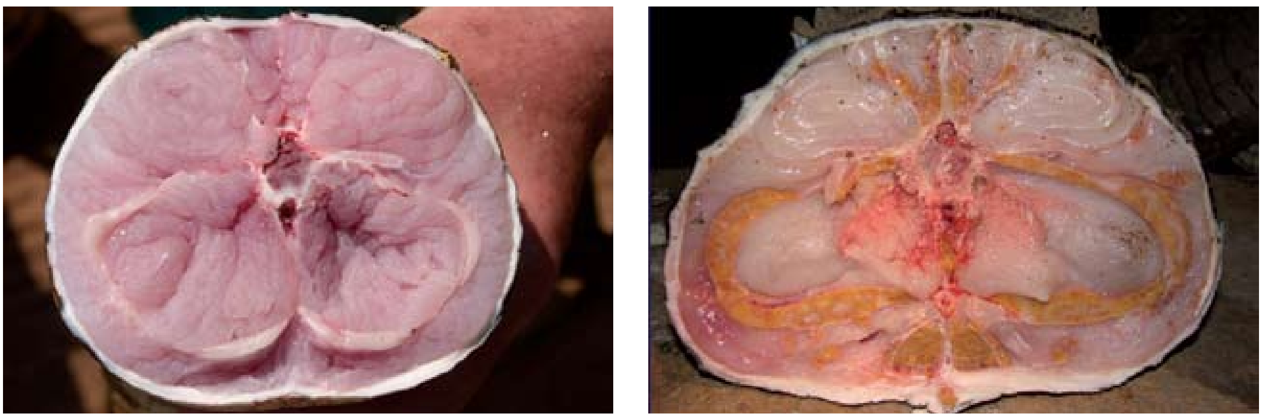
The eMalahleni Water Reclamation Plant is another example of expensive clean-up. This plant uses reverse osmosis to turn 25 000 m^3 of mining effluent into potable drinking water each day. The costly initiative (almost R300 million) was implemented by Anglo Coal and BHP Billiton and is showcased as an example of best practice and minimal impacts in social and environmental mine water management. The eMalahleni municipality covers its chronic water shortage by using over 70% of the reclaimed water to supply its consumers. The environment is also spared further effluent release because the plant operates at 99% recovery from four coal mines in the area[119]. The long-term economic sustainability of this operation is still uncertain, because the treated water that is sold to eMalahleni is heavily subsidised and it is unclear what will happen once the operating mines reach closure. eMalahleni is an example of one of South Africa's best practice in terms of wastewater treatment and holistic addressing of all pollutants, including sulphates. However, this will require a long term commitment and stable relationship between capacitated mining houses with secure funding and local government. We cannot expect to resolve all AMD issues in this way.

5.2 Loskop Dam impacts from AMD

Further downstream in the Olifants catchment lies Loskop Dam, receiving the full flow from the upper catchment[85,117]. Similar to Witbank and Middelburg dams, Loskop Dam also has sulphate concentrations that exceed target drinking water standards around its inflow areas[114,120]. The Loskop Dam provides water to the second-largest irrigation scheme in South Africa, irrigating about 16 000 hectares of crops that include sunflowers, soya, wheat, vegetables, tobacco, peanuts, cotton and citrus fruit[121]. Farmers here depend on a reasonable water quality in order to comply with crop production and export standards. Citrus, vegetables, sunflowers and peanuts are the common crops and all moderately sensitive to salinisation[114]. The dam itself is located in a proclaimed nature reserve and it used to contain a thriving population of fish and Nile crocodiles[122,123]. Over the last 18 years several incidents of fish mortality have occurred, culminating in a massive fish die-off in 2007 and the crash of the crocodile population from 30 animals to a total of six in 2008[122]. The cause of death for both crocodiles and fish is pansteatitis, a hardening of the fatty tissue that leads to immobility and death[122,124]. Pansteatitis is thought to be linked to heavy metal pollution and acidification of the system through pollution sources like AMD and acid rain[125]. This link and the potential influences of other pollutants from agriculture and urban areas are still under investigation.

Figure 24: Photos of normal crocodile tail section and crocodile tail section (right) suffering from pansteatitis, a hardening of the fatty tissue, from Loskop Dam.

Source:Oberholster et al, 2010



6. CURRENT STATE OF WATER RESOURCES IN ENKANGALA

Rivers in the Enkangala area are currently in a good condition. Some impacts are seen in rivers downstream of the Enkangala area, in heavily transformed catchments and where municipal waste water treatment plants (WWTPs) are not working properly. Overall, however, water quality in the Enkangala headwaters is good with ideal levels for pH, TDS, and sulphates. Unacceptable levels have been monitored for phosphates, probably linked to farming and poor quality sewage effluent (at Memel).

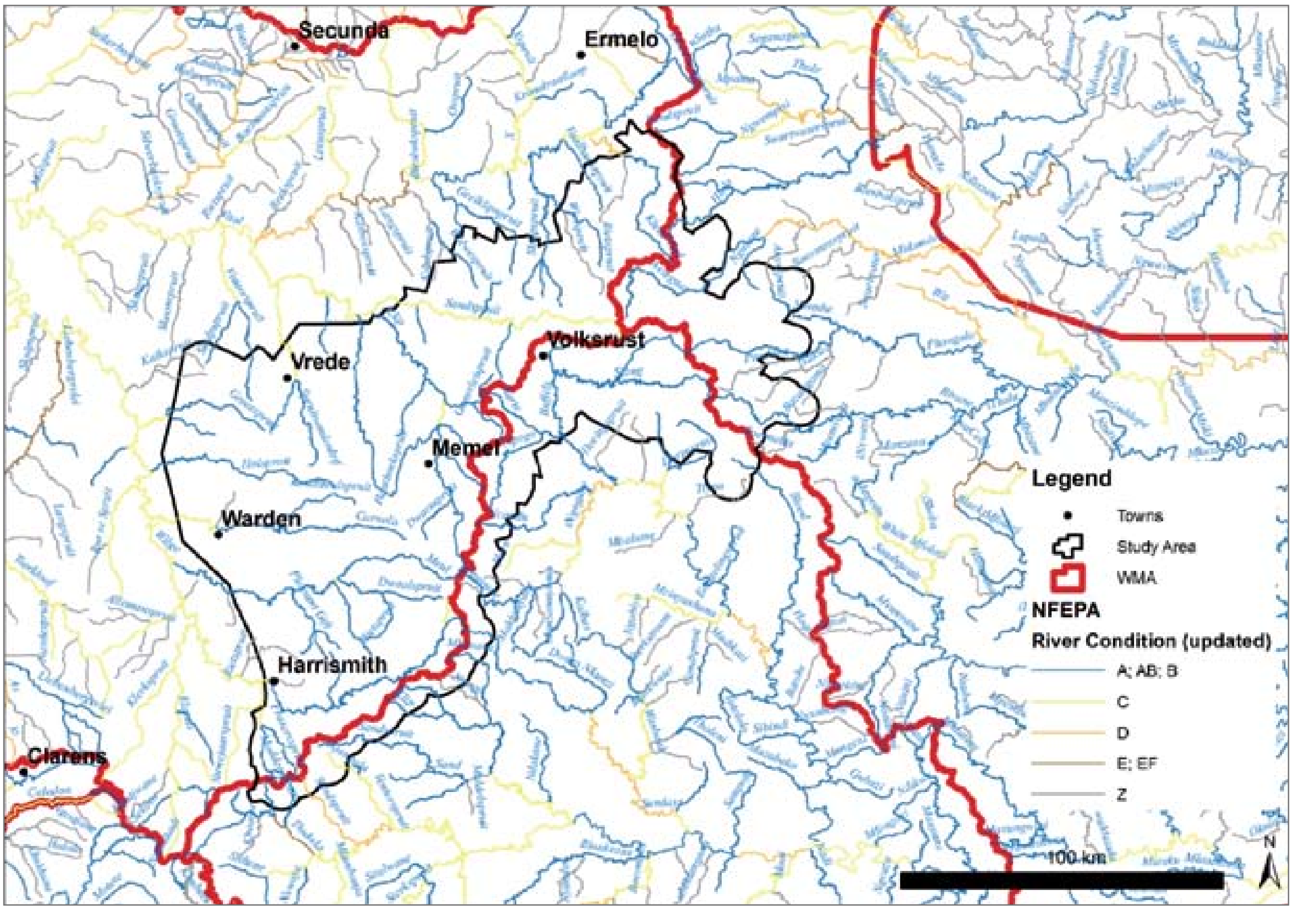
6.1 Present ecological status of rivers

National Freshwater Ecosystem Priority Areas project (NFEPA) map products[32] provide strategic spatial priorities for conserving South Africa's freshwater ecosystems and supporting sustainable use of water resources. These strategic spatial priorities are known as Freshwater Ecosystem Priority Areas, or FEPAs.

FEPAs were determined through a process of systematic biodiversity planning and involved collaboration of over 100 freshwater researchers and practitioners. FEPAs were identified based on a range of criteria dealing with the maintenance of key ecological processes, and the conservation of ecosystem types and species associated with rivers, wetlands and estuaries. The maps provide guidance on how many rivers, wetlands and estuaries, and which ones, should remain in a natural or near-natural condition to support the water resource protection goals of the National Water Act of 1998[125].

Figure 25: NFEPA map for the rivers in the Enkangala region

Source: NFEPA (2011)



The NFEPA data for the Enkangala region shows that the rivers in most of the catchments are in good condition (Figure 25), save for the Sandspruit river in C13, which was moderately modified. The Witspruit (C11), Rietspruit (C81), Tsakwe, Bozargoma, and the Pawkahe (W42) were classified as condition Z, not good, based on land cover reports, but this has not been verified with field monitoring of water quality parameters.

6.2 Water quality in major rivers downstream of Enkangala

The catchment water quality of the three water management areas originating in the Enkangala region were described by the Department of Water Affairs and Forestry Water Management Reports[25,26,41] and briefly summarised for the Enkangala region in the Enkangala Hydrology and Landuse Management Report[23].

6.2.1 Upper Vaal

Water quality in the Grootdraai sub-catchment, and specifically the Grootdraai Dam, is dominated by the impacts of coal mining, synthetic fuel industry and gold mining[41]. There are several operational and abandoned mines in the Ermelo area of the sub-catchment and mines in the Leeuspruit sub-catchment with continued explorations. Further deterioration of the water quality in the dam will have significant cost and water requirement implications for Sasol Secunda and the power stations supplied from the dam[41].

Nutrient and sediment loads in the river system are also thought to be affected by agriculture, further contributing to eutrophication processes.

There are also some local eutrophication problems associated with the management of waste water treatment plants and landfill sites in the sub-catchment. These are related to discharges from waste water treatment plants, poorly managed sewage systems, irrigation return flows and stormwater run-off particularly from dense urban settlements[41]. None of the water service authorities (WSAs) located in or adjacent to Enkangala, and within the Upper Vaal WMA, obtained Blue Drop or Green Drop Status during the various assessments in 2010[126] indicating that there are numerous water quality management challenges in the area. These municipalities utilise water resources for both water supply and the discharge of waste water and as a result, have the potential to affect the water quality within the Enkangala region.

By contrast, water quality in the Klip (Free State) and Wilge River sub-catchments of the Upper Vaal is fairly good although the measured TDS concentrations are increasing as a result of atmospheric deposition[41].

6.2.2 Upper Thukela

The Thukela WMA is divided into four sub-areas; the Upper and Lower Thukela, the Buffalo and Sundays. A number of water quality issues have been documented for the Upper Thukela area. The effluent from the industrial area, and untreated sewerage from the Ezakheni complex outside Ladysmith, has resulted in poor water quality flowing down the Klip River and entering the Thukela River. There are severe overgrazing and soil erosion problems in the Driefontein Block and Matiwaneskop areas to the north-west and north of Ladysmith[5].

High rural population densities in many of the communal areas have resulted in occasional high phosphate concentrations in the Sundays River and Wasbankspruit. There are two dormant and six closed coal mines in this area which, together with natural drainage of geological formations, also contribute to elevated levels of nitrates and phosphates. Salt deposition in the Upper Sundays River, probably as a result of mining, has also been observed[25].

The upper Buffalo River is the most impacted tributary in the Thukela and the water quality is reported to be poor down to its confluence with the Thukela[25]. Pollutants generated by industrial activity around Newcastle and acid mine drainage from numerous operating and abandoned mines are the main causes.

The Green Drop and Blue Drop Assessments for the Water Services Authorities in the catchment indicate a general lack of compliance with national drinking water quality standards and poorly performing waste-water works. This is likely to negatively affect water quality in the region.

Waste water management also is problematic and some municipalities failed to provide the relevant information for the assessment. The Blue and Green drop scores reveal that poorly performing WSAs are likely to negatively affect the water quality in the area.

6.2.3 Pongola/Usutu

The water quality in the Pongola and Usutu catchments is naturally good and considered relatively undisturbed, save for a couple of exceptions. Large-scale irrigation upstream of the Pongolapoort Dam has resulted in seasonal return flows of saline and nutrient enriched water to the Pongola River. The Assegaai River in the Usutu catchment was polluted with industrial effluent from a tannery located near Piet Retief. Groundwater in the lower reaches is also highly saline as a result of the marine source of the sediments underlying the Makathini flats[26].

6.2.4 Assessment of current water quality of the Klip, Sandspruit and Bivane Rivers

The Klip, Sandspruit and Bivane Rivers were evaluated to create a baseline and establish the current water quality conditions of the rivers in Enkangala. The Klip River is upstream of most mining activities and the water quality of this river will determine its dilution capacity further downstream. The Sandspruit River is the only river in the region classified at a NFEPA level B condition. Both the Sandspruit and the Bivane River traverse areas that are under prospecting for coal mining (Figure 26).

The parameters used for the water quality review for these areas were limited to sulphate concentrations, electrical conductivity, chloride and phosphate concentrations, and pH.

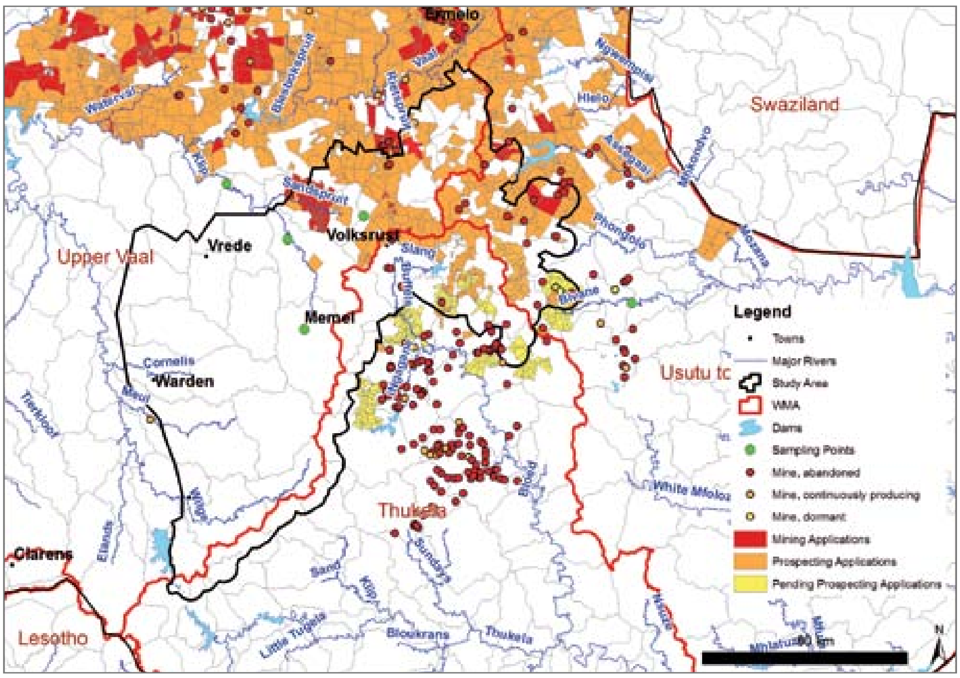


Figure 26: Depicting the three studied rivers and chosen sample points

Table 16: Generic RWQOs for the review and comparison of the Bivane, Klip and Sandspruit Rivers.

Source: DWA(2011)[107]

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
Sulphate	mg/L	≤ 80	>80 and ≤ 165	>165 and ≤ 250	>250
Electrical Conductivity	mS/m	≤30	>30 and ≤ 50	>50 and ≤ 85	>85
pH		≥6.5 and ≤8	>6.5 and <8.4		<6.5 and >8.4
Chloride	mg/L	≤40	>40 and ≤120	>120 and ≤175	>175
Phosphate	mg/L	≤0.005	>0.005 and ≤0.015	>0.015 and ≤0.025	>0.025
Heavy metals		Varies according to metal			

The Electrical Conductivity (EC) is an indicator of the salinisation of the water resources. Sulphate concentrations and pH are the strongest indicators of the impacts of mining activities and the extent of AMD pollution[127]. Unlike trace metals such as iron, sulphate is conservative at the concentrations and pH levels in river systems, and is not removed from the stream through precipitation or chemical reactions with other components.

Chloride concentrations serve as an indicator to establish the extent of agricultural impact, sewage effluent discharges and industrial impacts.

Phosphate concentrations provide a measure of the degree of waste water and sewage effluent contribution to the nutrient enrichment of a given water resource. Eutrophication has become an increasing concern in many river systems in South Africa.

The water quality measurements and data were obtained from the Department of Water Affairs and spanned from 2005 to 2009. A generic set of Resource Water Quality Objectives (RWQOs) for the country's surface water resources was used to determine the water quality trends for the Klip, Sandspruit and Bivane Rivers in the Enkangala region (Table 16). The RWQOs Model (version 4)[128] used for the water quality review is based on the South African Water quality Guidelines[114], Quality of Domestic Water Supplies: Assessment Guide, Volume 1[129] and Methods for determining the Water Quality Component of the Reserve[130] and are based on the strictest water user criteria.

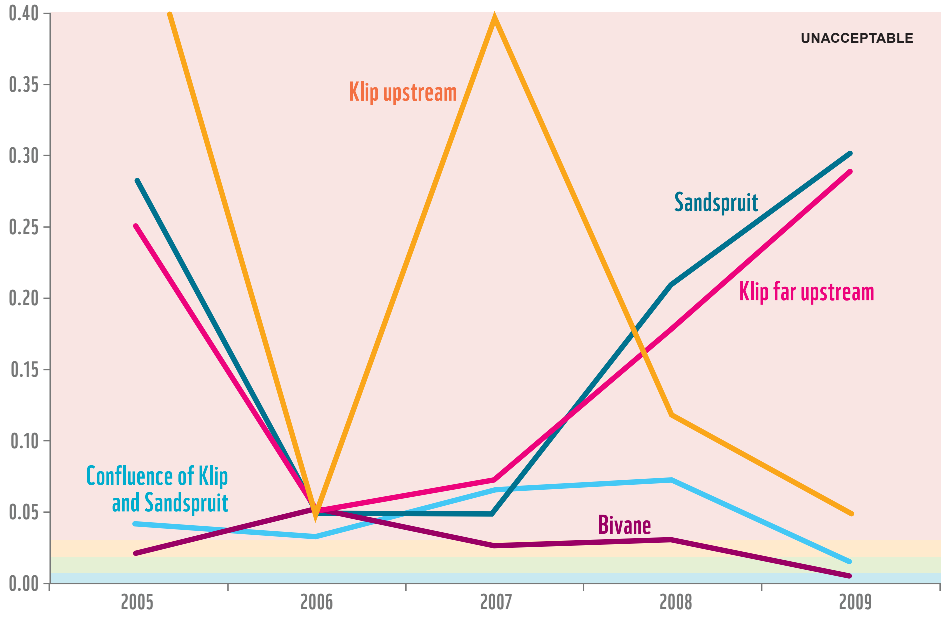


Figure 27: Phosphate concentrations in the Sandspruit, Klip and Bivane Rivers in the Enkangala region.

Source: RWQ database, DWA

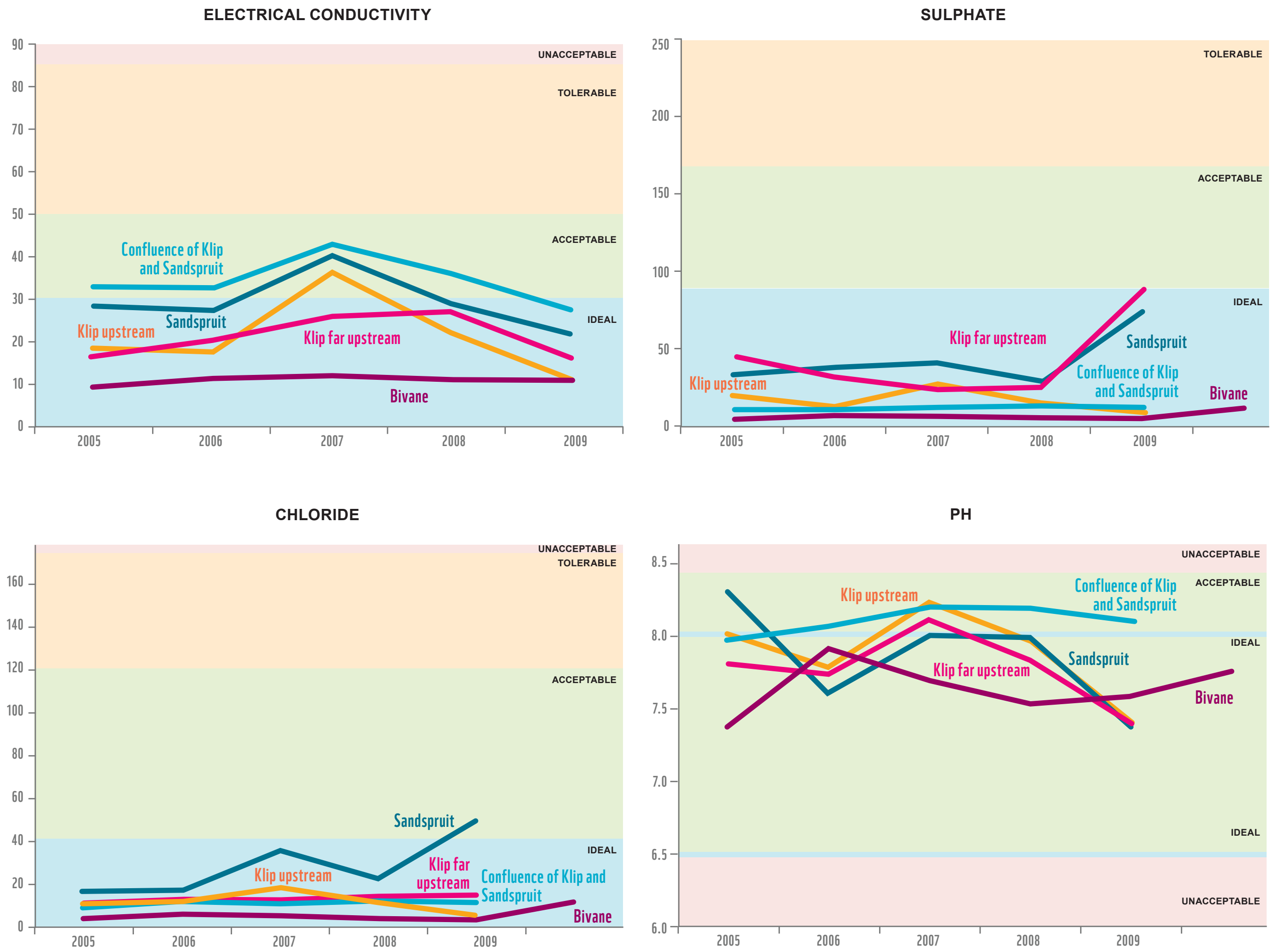


Figure 28: Water quality trends for the Klip, Sandspruit and Bivane Rivers.

Source: RWQ database, DWA

The water quality parameters for each of the sites measured well within the ideal and acceptable levels, save for PO_4-P concentrations (Figure 27 and Figure 28). The unacceptable levels reported for PO_4-P are based on toxic effects in aquatic ecosystems. To date, levels of PO_4-P concentrations for safe domestic consumption have not yet been established in South Africa. The elevated PO_4-P concentrations are attributed to the agricultural activities in the Enkangala region as well as the unmonitored discharge of wastewater stations in the various main catchments as discussed in the previous sections.

The acceptable levels of sulphate and chloride concentrations, electrical conductivity and pH values support the NFEPA evaluations that these rivers are currently relatively undisturbed and have good water quality conditions.

6.3 Potential sources of cumulative impact on water resources in the area

The water flowing from the upstream Enkangala areas is good quality and the inflows are important for diluting contaminants further downstream. The only cumulative impact of the Sandspruit and Klip Rivers on the Upper Vaal system is the elevated phosphate levels which contribute to the overall eutrophication of the catchment further downstream. Elevated nutrient levels are typically associated with agricultural practices, and the land cover map (Figure 9) shows that the entire area is heavily cultivated and partially degraded. There are also small-scale urban areas, the largest one being Memel. High phosphate levels can also stem from inadequate sewage treatment from municipal wastewater treatment plants in towns adjacent to the affected rivers. Memel is in the headwaters of the Klip River, and its Green Drop score was below 80% compliance. The waste water treatment works have not monitored their effluent quality to date and are operating at 50% above the design capacity, so the treatment is almost certain to be inadequate[131]. Therefore it is highly likely that the high phosphate levels can be attributed to a combination of runoff from cultivated lands and sewage effluent from urban areas.

The polluters could be identified more accurately by assessing the water quality of the Memel wastewater works (as a point-source pollution), as well as establishing the kinds, quantities and times of fertilizers being applied on the cultivated fields. However, this investigation is beyond the scope of this report.

7. ALTERNATIVE FUTURES FOR DEVELOPMENT IN ENKANGALA

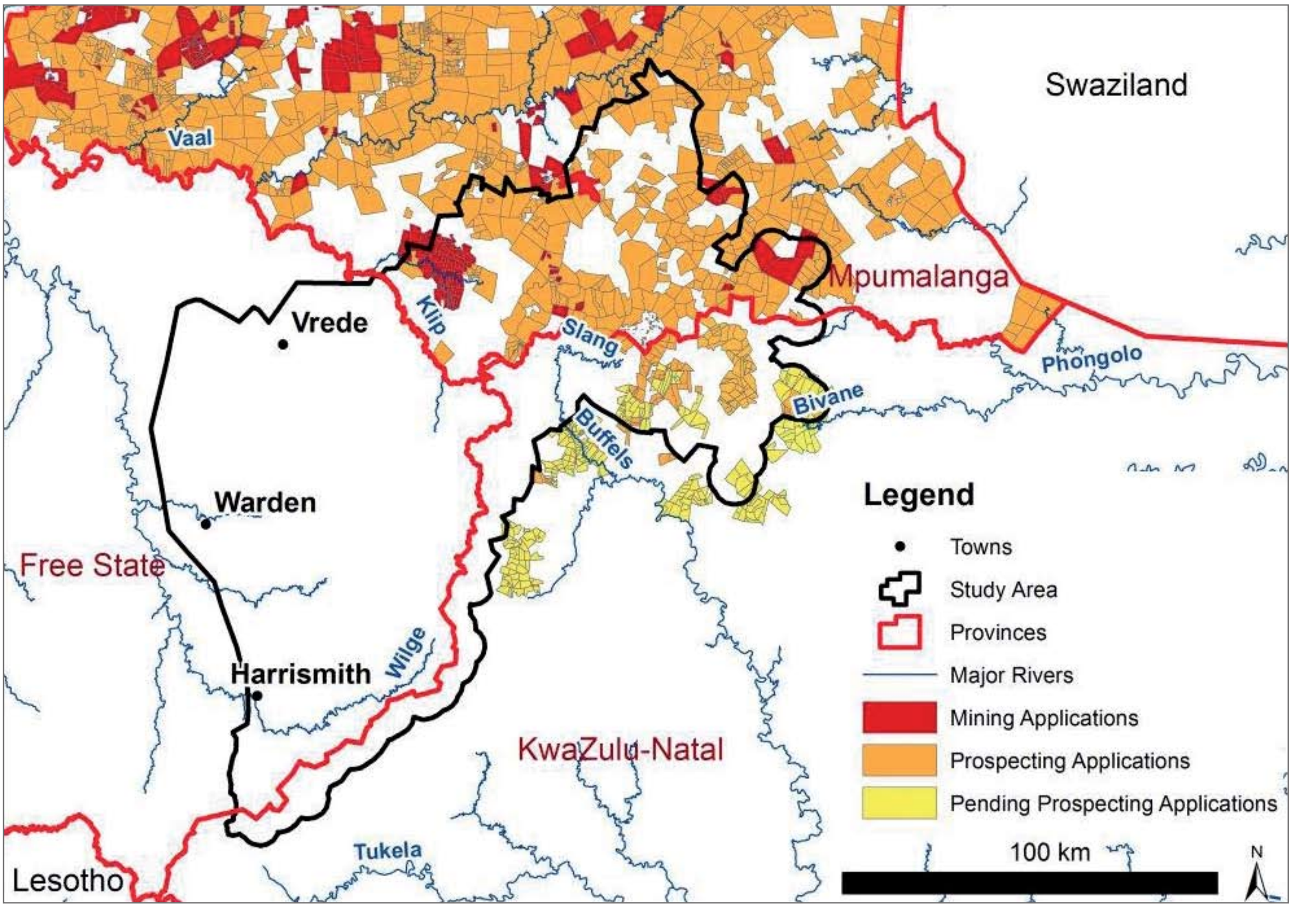
7.1 A Future with extensive coal mining

South Africa has seen a flurry of prospecting rights handed out in the last six years. Minister Susan Shabango of the DMR stated that the Ministry had processed 26 000 applications since the inception of the MPRDA (approximately 2 889 applications annually)[132]. Successful applications are recorded for Mpumalanga but others, like KwaZulu-Natal and the Free State are not well documented. Between 2005 and 2010 approximately 13.7% of Mpumalanga was already under mining rights applications and 40.3% of Mpumalanga was under prospecting applications – making a total of 54% of the province under some form of planned mining activity. A member of the Chamber of Mines gave the average success rate of applications at around 10%, according to which Mpumalanga could see a 4% increase in coal mining following the 2005 and 2010 applications. A more realistic assessment of the future extent of mining would be to look at mining applications in any given area, rather than prospecting licenses. However, such information is not available from the DMR or other sources.

Depending on the data source, between 0.01% and 2% of the Enkangala area is currently being mined. Mpumalanga prospecting data (2005 – 2010) and post 2010 prospecting data suggest that currently 20% of farms in Enkangala are affected by prospecting applications. This excludes any applications in the Free State and does not include all applications in KZN (Figure 29). The prospecting licenses are particularly focussed on the northern parts of Enkangala, where the main coal resources in the

Figure 29: Extent of mining, prospecting, exploration rights in Mpumalanga (2005 – 2010 orange) and post 2010 applications (yellow) in and around Enkangala. No data was obtainable for the Free State or Southern parts of Enkangala.

Sources: MTPA, WWF



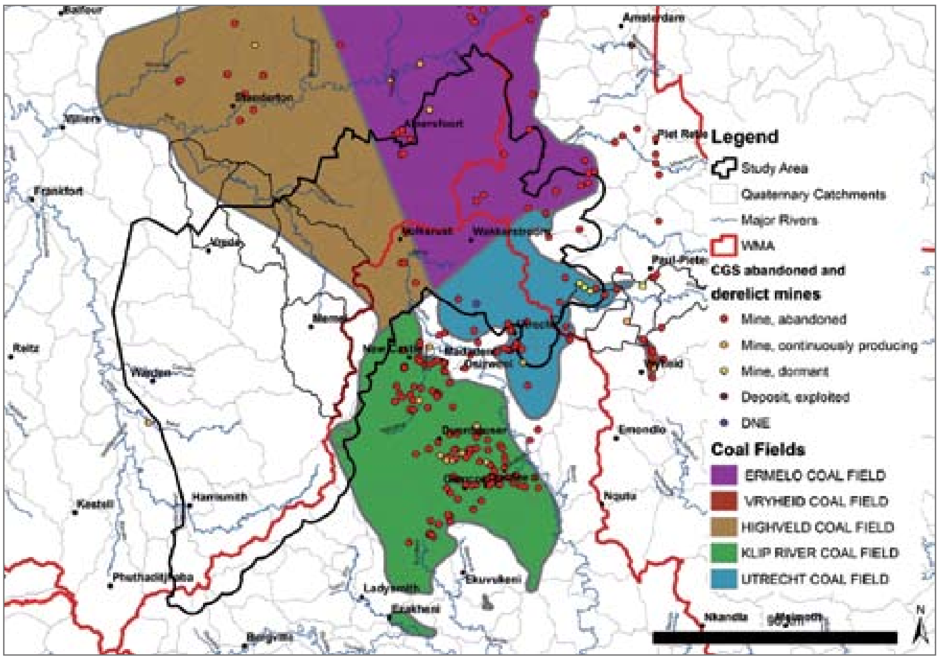


Figure 30: Map depicting mining activities and abandoned mines in Enkangala

Source: CGS (2007)

Ermelo and Highveld coal fields are situated. The Free State part of Enkangala does not hold major coal resources, so the extent of prospecting is probably lower, although this could not be confirmed.

Data from the Council for Geoscience shows that there are 25 abandoned mines in the Ekangala area, as well as three dormant and two operating mines (Figure 30). The mines are mainly found in the Utrecht and the Ermelo coal fields, with only three abandoned mines in the Highveld coal fields. Abandoned mines in the Klip River coal fields are concentrated outside Ekangala.

7.2 Food and job security in Enkangala

The general household survey (GHS) of 2010 indicated that 23.1 percent of households in South Africa had inadequate or severely inadequate access to food. Both KwaZulu-Natal and Free State were above the national average, while inadequate access to food was lowest for Mpumalanga[133]. The government expects demand for basic food products in South Africa to grow by between 1.12 and 4.19% by 2020, and this will exceed current production by between 22 and 88%[134]. A viable agricultural sector in South Africa is critical to meeting these future demands.

The total multiplier effect of formal sector agricultural employment in the local municipalities in the study area amounts to 33% of the total economically active population. A relatively high share of black households are involved in commercial agriculture in the Enkangala study area. For the Free State portion of the study area, between 43 and 56% of black households in the district municipality are involved with commercial agriculture. In the Mpumalanga district municipality, black households involved with commercial agriculture range between 29 and 42%, while in the KwaZulu-Natal district municipality this drops to between 15 and 28%[135]. Many of these are backyard or small scale farmers. It is clear from these numbers that agriculture is currently an important sector in the everyday life of many people in Enkangala.

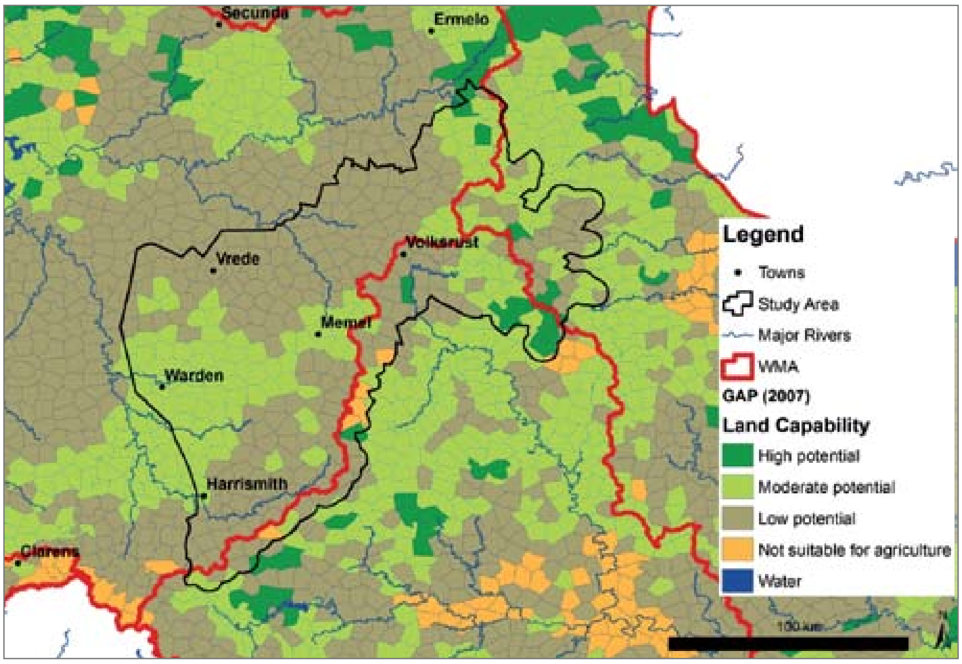


Figure 31: Land capability map for Enkangala, in terms of agricultural crop potential

Source: NLC, (2009)

7.2.1 High productivity soils in the area for crop production

The soil types are dominated by sandy loam, with areas in the northwest having a relatively higher clay content, while soils close to the escarpment are more loamy[22]. Deeper soils occur in the western section of Enkangala, while shallower soils occur closer to and along the escarpment.

High land capability areas, in terms of crop production, are uncommon (4%) in Enkangala (Figure 31) but greater areas have moderate potential (37%). Most of moderate potential areas fall within the Free State and the Upper Vaal sub-catchment. The north-eastern parts of Enkangala hold the remaining proportion of moderate to high potential lands, which fall into the Ususu/Mhlatuze and Upper Thukela catchments. The remaining areas (59%) have poor cropping potential, but these areas still form valuable livestock grazing areas. Rangeland farming, including conservation and game farming, has been identified as the grassland use most compatible with sustaining ecosystem functioning and faunal biodiversity. When implemented and managed correctly there are some impacts on floral diversity which are currently researched.

7.2.2 Subsistence agriculture in the area and land-claims

Land claims in the Enkangala area could not be comprehensively collated as there are differences in data capture among the provinces.

Based on personal observation, communal land ownership is widely scattered in Enkangala and currently makes up a relatively small percentage of the area (probably less than 15%). However, the percentage of land reform beneficiaries and communal land owners is slowly increasing.

The primary subsistence agricultural activity is rangeland farming (livestock – mainly cattle with some sheep and goat farming). Around many of the homesteads are small ploughed areas for subsistence cultivation (primarily maize and some vegetable production). In some isolated cases, community food gardens are evident but their footprint is generally limited to a few hectares.

Figure 32: Traditional dancing performed by the community at the signing of the first biodiversity agreement with the Mgundeni Community and EKZNW.

Source: A. Burns / WWF-SA

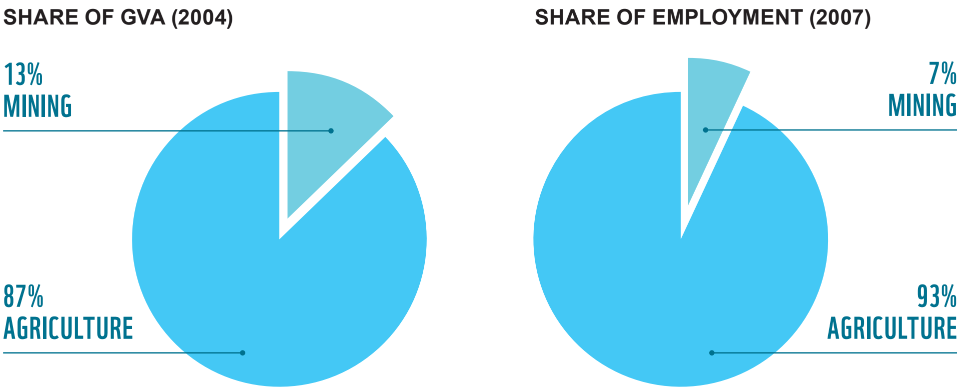
Land reform is a key political means of addressing historical inequalities in access to land. However, the reform process is frequently overruled by prospecting and mining applications, where commercial and communal farmers equally are faced with the risk of having mining activities proclaimed on their land, permanently changing their way of living and generating income. The recent successful court case of the Bengwenyama community over a mining company in Limpopo shows that consultation with landowners is taken very seriously, and that it is especially important when it comes to landowning communities[72]. However, the Bengwenyama community themselves plan to exercise their legal privilege to apply for mining rights. The question remains what communities do if they are not interested in mining?

Mgundeni land reform beneficiaries:

The Mgundeni land reform beneficiaries (approximately 30 households) located in Northern KZN have been committed to conserving their wetlands since they gained ownership of it. In 1999, they sent letters to Ezemvelo KZN Wildlife requesting support for conservation initiatives on their land and shortly thereafter, in partnership with WWF, the community entered into a formal relationship with the provincial conservation authority. A few years later, they signed the first Biodiversity Agreement between land reform beneficiaries and Ezemvelo KZN Wildlife, and an extensive capacity development programme began with support from WWF. After being trained in fire management and invasive alien weed control, the community began implementing best management practices. In addition, a feasibility study was conducted to ascertain the best possible income generators for the community into the future. In 2011, they learned that a prospecting right had been awarded on their land. Apparently the right was awarded a few years back but none of the community had been consulted. Given that their land forms part of the Pongola River headwaters (and includes substantial wetlands which they rely on for their drinking water needs), and given that the community (who are cattle farmers) are opposed to the proposition of any mining on their land, what does the future hold for this community? Through a hard-won victory, their land was returned via land reform only to be “taken away” by proposed mining activities that would effectively devastate their sensitive wetland covered land if viable coal reserves were discovered. How does the DMR embody good governance by authorizing rights in such areas without considering the social and environmental consequences of proposed mining activities?

Figure 33: Relative share of mining and agriculture in Enkangala – Gross Value Added (2004) and Employment (2007)

Source: NSDP (2006); Stats SA (2011b)[38]



7.3 Economic scenarios of potential future developments in Enkangala

This report outlined the current economic and employment situation in Enkangala in the agricultural and coal mining sectors. Currently, agriculture produces 87% of GVA as compared to 13% from mining. Likewise, the proportion employed in agriculture (93%) is significantly larger than in coal mining (7%) at present (Figure 33).

As there are substantial coal resources in the area, as well as the extensive prospecting, we did an economic analysis and modelling exercise which focused on coal mining and agriculture. National and provincial data were used and downscaled via simple abstraction methods to illustrate the economic benefits and costs for Enkangala. The lack of fine-scale information on coal reserves, coal mining operations and agricultural activity in the study area necessitated the use of a limited and disaggregated dataset. The calculations and conclusions of this section are very sensitive to the values in these datasets and may thus differ with when more refined data become available.

A future research need: Economic methods can be too simplistic if they are applied without taking into account the complexity of natural resources. This section is based on national economic averages and it does not include the water component at present. This should be addressed in future research, as this approach would assess the agricultural value both of Enkangala and the agriculture downstream that depends on the provision of adequate and unpolluted water from Enkangala.

7.4 Scenarios depicting economic value of new coal mining

Three different scenarios were modelled to describe the economic potential of future coal mining in the Enkangala area. They are a baseline scenario, a restricted mining scenario and an ‘internalising externalities’ scenario:

- **The baseline scenario is based on 20 years of data on local South African prices and assumes ‘business as usual’**. It assumes that local prices continue to rise in real terms at the long term average of 3% per annum, and production increases to meet demand. Exports continue to decline, although at a slow rate. Unit prices for water treatment costs are assumed to remain constant in real terms, but total water treatment costs will increase as a result of the increased wastewater generated through domestic production.
- **The restricted mining scenario assumes that coal production decreases by 40% over 60 years**. All the other parameters are the same as for the baseline.
- **Internalizing externalities equates to a ‘polluter pays’ scenario**, in which the mines pay the wastewater treatment costs that make up 5% of the total producer value over 60 years.

7.4.1 Net Present Values for coal mining

The baseline and restricted mining scenarios are depicted at discount rates of two, four and eight percent respectively. A discount rate reflects the social preference of mining in terms of whether mining income is wanted at present or further into the future. In the baseline scenario, coal mining net present values (NPVs) range between R31 and R182 billion over 60 years. Under the reduced mining scenario, NPVs range between R25 and R138 billion. External costs of wastewater generation are less under the restricted scenario than under the baseline case. The welfare gain in terms of the reduction in external costs from the restricted mining scenario is significantly less than the private losses of the mining companies, leading to a net societal loss of between R5 billion and R44 billion depending on the discount rates used (Table 17).

Table 17: Changes in welfare under the restricted mining scenario

Source: Own analysis

Net Present Values (over 60year period)	Discount rate		
	2%	4%	8%
Baseline:			
Mining value (Rm)	R 182 471	R 89 556	R 30 778
External cost (Rm)	R 2 228	R 1 369	R 690
Restricted mining:			
Mining value (Rm)	R 137 969	R 69 521	R 25 400
External cost (Rm)	R 1 367	R 926	R 535
(Private) mining production gain/(loss) (Rm)	(R 44 503)	(R 20 035)	(R 5 380)
Social welfare gain/(loss) – water (Rm)	R 861	R 442	R 156
Net societal gain/(loss) (Rm)	(R 43 641)	(R 19 593)	(R 5 223)

Based on the analysis and a purely economic perspective, a restricted coal mining scenario would lead to high net social welfare losses, and a ‘polluter pays’ or cost internalisation strategy would be a preferred way forward. The coal mining sector does appear to be a candidate for cost internalisation, but the broader institutional and regulatory frameworks need to be considered, together with implications for small scale mining companies.

7.5 Scenarios depicting economic value of agriculture

Again, the agricultural scenarios are based on best available current information and the actual price fluctuations cannot be accurately predicted. A deeper understanding of the production system in the study area, and the cost of production, is required before more realistic simulations can be constructed.

The scenarios used for agriculture are focused on maize as it is one of the larger crops in Enkangala and it is important from a food security perspective:

- **Baseline scenario, where business continues as usual**. It is assumed that maize yields increase by 5 tonnes over 50 years, or 1 tonne every 10 years. Monthly international maize prices over nine years (1990 to 2009) grew at an average rate of 0.24% (based on FAO Cereals Price Index) and this figure was used as a baseline.
- **Impacts on agriculture by climate change** Following existing data[136] the area planted is assumed to decline by 1.28% per annum.

For these assumptions, producer values of maize under the business as usual (BAU) and climate change (CC) scenarios increase, external costs decline under BAU, but increase under CC. External costs increase because production is assumed to increase, and therefore wastewater generation increases. External costs are higher over the long term under the climate change scenario.

Internalising externalities, or 'Polluter Pays': it will be possible for maize farmers to internalise wastewater externalities in a long-term scenario of steadily increasing maize prices (assuming no real increase in production costs). Under both scenarios, producer values increase and wastewater costs as a percentage of production values decrease slightly. Like the mining scenario, future externality costs are predicted to make up a small share of agricultural values.

7.5.1 Net Present Values for maize

Although the effect of climate change has the effect of increasing social welfare through the increased maize production, these values decrease with increased discount rates (Table 18). In reality social discount rates for food production could be much higher since society places a higher time preference for current consumption over future consumption, thereby reducing the present value net societal gain.

Table 18: Simulated changes in welfare as a result of climate change impacts on maize

Source: Own analysis

Net Present Values (60 years)	Discount rate		
	2%	4%	8%
Baseline			
Maize value (Rm)	R 16 519	R 11 299	R 6 603
External cost (Rm)	R 456	R 315	R 187
Climate change			
Maize value (Rm)	R 25 030	R 15 933	R 8 410
External cost (Rm)	R 685	R 442	R 237
Agricultural production gain (Rm)	R 8 511	R 4 634	R 1 807
Social welfare gain/(loss) - water (Rm)	(R 229)	(R 126)	(R 50)
Net societal gain/(loss) – climate change (Rm)	R 8 282	R 4 508	R 1 757

7.6 Scenario discussion and conclusion

In the current South African context agriculture makes an important contribution to food security, whereas coal mining makes its most important contribution to energy security. The Enkangala simulation results indicate that agriculture's contribution is currently greater in Enkangala, but it is expected to grow marginally or even decline in future. Mining activities are relatively small at present, but they have the potential to grow significantly due to the existing, untapped coal reserves in the area. Agriculture is more likely to have a more significant impact in the Free State portion of the study area over the long term, where known coal reserves are thought to be not substantial. The portion of the area that is most likely to experience significant mining pressure in the future is KwaZulu-Natal, since coal production is still relatively low in relation to reserves. Overall reserves are also lowest in this province, but mining in sectors other than coal may compound this effect. The Mpumalanga portion of the study area has the highest proportion of coal reserves, signifying potential for future coal mining.

The external costs of both wastewater (WW) and greenhouse gas (GHG) impacts were investigated. The costs of water pollution externalities for both mining and agriculture are relatively low in relation to their economic contribution but the estimated direct external costs of wastewater are obviously higher for coal than for agriculture. However, external costs of wastewater from coal mines could not be modelled for post-closure of mines and hence the wastewater costs of coal mines are anticipated to be much higher.

Greenhouse gas emissions for agriculture are measured as direct external costs through enteric fermentation and manure management, and as such, agriculture has the highest direct external costs for GHG emissions. The main GHG impacts of coal occur during combustion. This occurs either in another country (due to exports), or via Eskom's coal-fired power stations. Due to the technicality that coal combustion occurs away from the mining locality and by other organizations, the GHG impacts are considered an indirect external cost for coal mining. The results show that the direct external costs of both WW and GHGs for agriculture and coal are more than ten times lower than the indirect GHG costs of coal combustion.

The Enkangala simulations are based on national data and thus reflect the national figures whereby the contribution of mines to 'Gross Value Added' (GVA) is 3.5 times more than agriculture, but mining employment contributes 50% less than agriculture nationally (Stats SA).

Discussions with mining representatives while writing this report suggest that Enkangala is not viewed as a sustainable mining area by larger players. However, it is attractive to smaller concerns that see value in smaller profit margins. The fact that Enkangala is being prospected almost exclusively by small mining companies raises concerns about the financial and skills and ability internalize wastewater costs, and to mitigate impacts over the required timescale. Employment is another discussion point, as small mining concerns often operate on shorter timeframes than large companies – raising the question whether mining is can create viable jobs in Enkangala, when compared to agricultural employment that spans generations.

7.7 The potential impact of new mining on the water yield and water quality in the Enkangala area

Looking at the current water users in the three main catchments, mining plays a minor role in water consumption. Most industrial water use in the Upper Vaal, Thukela and Usutu catchment is by Eskom for power generation, especially for cooling coal-fired power stations. The actual coal mining process has less of an impact on the quantity of water used than the secondary use of coal for power generation. The primary impact on water of coal mining is on water quality.

7.7.1 Predicting impacts of potentially acid-forming coal mining on water quality

The potential impact downstream of a mine is determined by the water quality (pH, metals, sulphates) that arises from mining operations, which can be predicted from the local and regional geology, geochemical analysis of rocks, and the water quality and quantity of the receiving system[137]. The first step is to collate existing information on the hydrogeology, water quality and ecological status of any waterways that may receive mine drainage discharge. This information is then used in a model to determine the potential impacts of the discharge. This type of assessment is essential and should be done by suitably qualified specialists. It cannot form part of a standard one-site mining application.

There are several key chemical factors to consider in an assessment of baseline water quality. These include:

- Natural sources and concentrations of alkalinity
- Natural sources of acid rock drainage

- Background or baseline physiochemical properties (pH, EC, Dissolved oxygen etc.) and concentrations of sulphate, dissolved Fe an Al, and other dissolved trace elements such as As and Zn
- Existing sources of mine drainage

The sampling strategy and analyses required to characterize a site prior to mining are site specific and experienced water quality scientists should be consulted to determine the location, number of samples and types of analyses.

Prediction of acidity from rocks disturbed by mining is a key piece of information required to determine water quality downstream of proposed mines. As such, rocks that are disturbed by mining are separated into two groups: potentially acid-forming rocks and non-acid-forming rocks. The acid-forming potential of rocks disturbed by mining is highly variable and can be predicted qualitatively and quantitatively by evaluation of background information and standardised laboratory procedures on fresh rock samples.

Site hydrogeology and background water quality information is integrated with information on mine drainage to predict downstream water quality using reactive transport modelling (Figure 34). Reactive components include:

- Alkalinity and pH
- Dissolved oxygen
- Dissolved Fe^{2+} and Fe^{3+}, Al
- Fine-grained (colloidal) particulate Fe^{3+} and Al minerals
- Trace elements

Reactive transport modelling requires specialist knowledge and should be undertaken by appropriately qualified and experienced personnel.

Site hydrogeological data for predicting downstream water quality are similar to those used for determining baseline hydrogeology, but include a projected volume of mine drainage. The volume of mine drainage relates to the type of mining (opencast vs underground), mine scheduling, the area disturbed, as well as hydrogeological models that include calculations of the amount of rainfall that contributes to surface flows vs groundwater. These models should only be used by a suitably qualified specialist and are often developed and refined during the life of a mine.

Figure 34: Basic process for determining water quality downstream of a mine

Source: Cavanagh et al. (2010)[111]

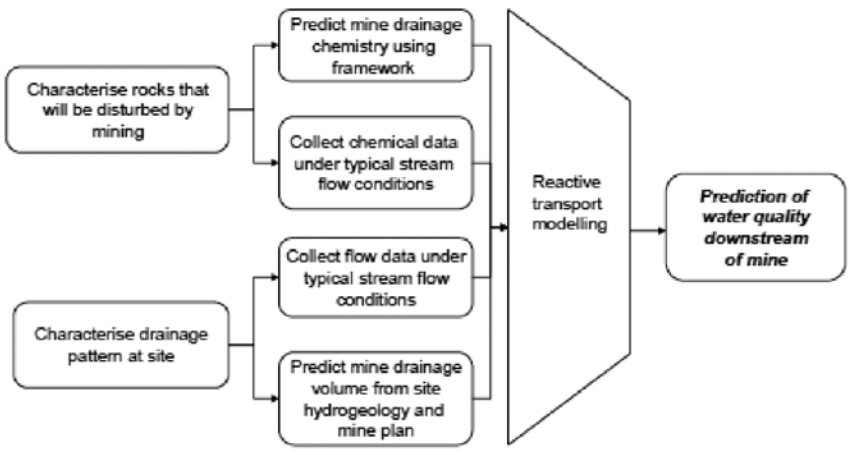
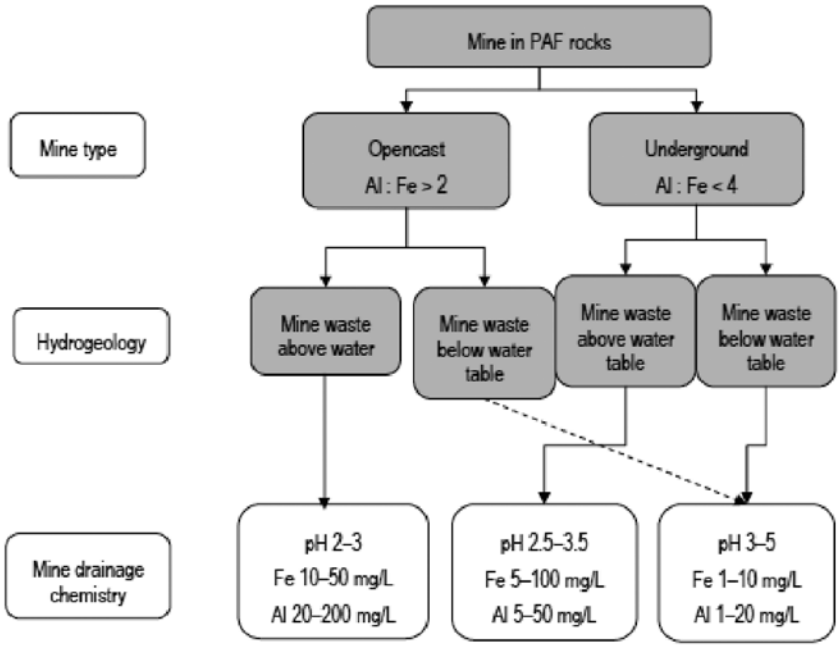


Figure 35: Potential water chemistry from potentially acid-forming coal measures

Source: Cavanagh et al. (2010)[111]



A conservative mine drainage flow at an opencast mine could be calculated by assuming that 100% of rainfall or stream flow over the disturbed area becomes mine drainage.

Based on the AMD investigations done on the Brunner Coal Measures (New Zealand), the following parameters influence the AMD chemistry[111]:

- Mine type (open cast or underground)
- Hydrogeology (above or below the water table)
- Local variations in rock type (mudstone or sandstone)
- Using these parameters as a guide, the sequences in Figure 35 could be predicted.

7.7.3 Anticipated water quality impacts based on Olifants catchment experience

It is difficult to predict the probable impacts of coal mining on the water quality of the Enkangala region without detailed study of historical data and hydrogeological mapping. However, it is clear that AMD is the primary concern for the area. This report presents three possible AMD scenarios, based on water quality examples from the Olifants and the lower reaches of the Vaal.

Scenario 1: non acid-forming coal mining
This scenario assumes that water quality will remain the same as it is currently in Enkangala (*likely to occur in a no-mining scenario, or very limited mining adhering to best practices throughout mining and post-mining process for several decades*)

Scenario 2: medium AMD impact – based on data from Grootvlei mine on discharged mining effluent into Blesbokspruit in the Vaal catchment (Grootvlei) (note, this is AMD from a gold mine and hence not as concentrated as would typically be expected from coal mines) (*likely to occur during mining practices and limited water management*)

Scenario 3: acid-forming coal mining – AMD of a quality equivalent to effluent entering the Olifants catchment in the Blesbokspruit from an abandoned coal mine (Witbank) (likely to happen in the case of improper water management post-mining and mine abandonment)

In this case scenarios 1 and 2 were grouped together, as neither have significant pH impacts on a water source, do not cause secondary metal leaching from soil and the contaminants are mostly from the mining process itself.

The average sulphate and chloride concentrations as well as the pH and EC values determined for a period of five years for each of the sampling sites (Figure 36). The data for the Enkangala sites and for the Blesbokspruit downstream of Grootvlei mine spanned from 2005 to 2010 and was obtained from the Department of Water Affairs. Water quality measurements for the Blesbokspruit downstream of the Witbank Coalfields in the Olifants River, were taken from 1990 to 1996[44]. For comparison, the average values over 5 years were taken for each of the sampling areas.

The water quality at both Grootvlei and Witbank was severely compromised, with coal mining clearly having a much larger impact on water quality than gold mining operations (Figure 36). As gold mining activities have far less acid mine drainage, the sulphate concentrations and EC values of Grootvlei are in the unacceptable region, but are still two to three fold lower when compared to Witbank. By comparison the rivers in the Enkangala are still undisturbed and relatively pristine.

Historical data on the water quality within the Enkangala region (if available) will have to be combined with hydrogeological maps and modelled to make predictions on whether or not coal mining in this region would produce AMD, and to what degree. Brief surveys of the typical coal deposits for coal mining in Free State, Mpumalanga and KwaZulu-Natal show they occur in sedimentary strata of the Karoo Supergroup with relatively low pyrite contents. The pyrite content is however enough to generate sufficient AMD to be a concern.

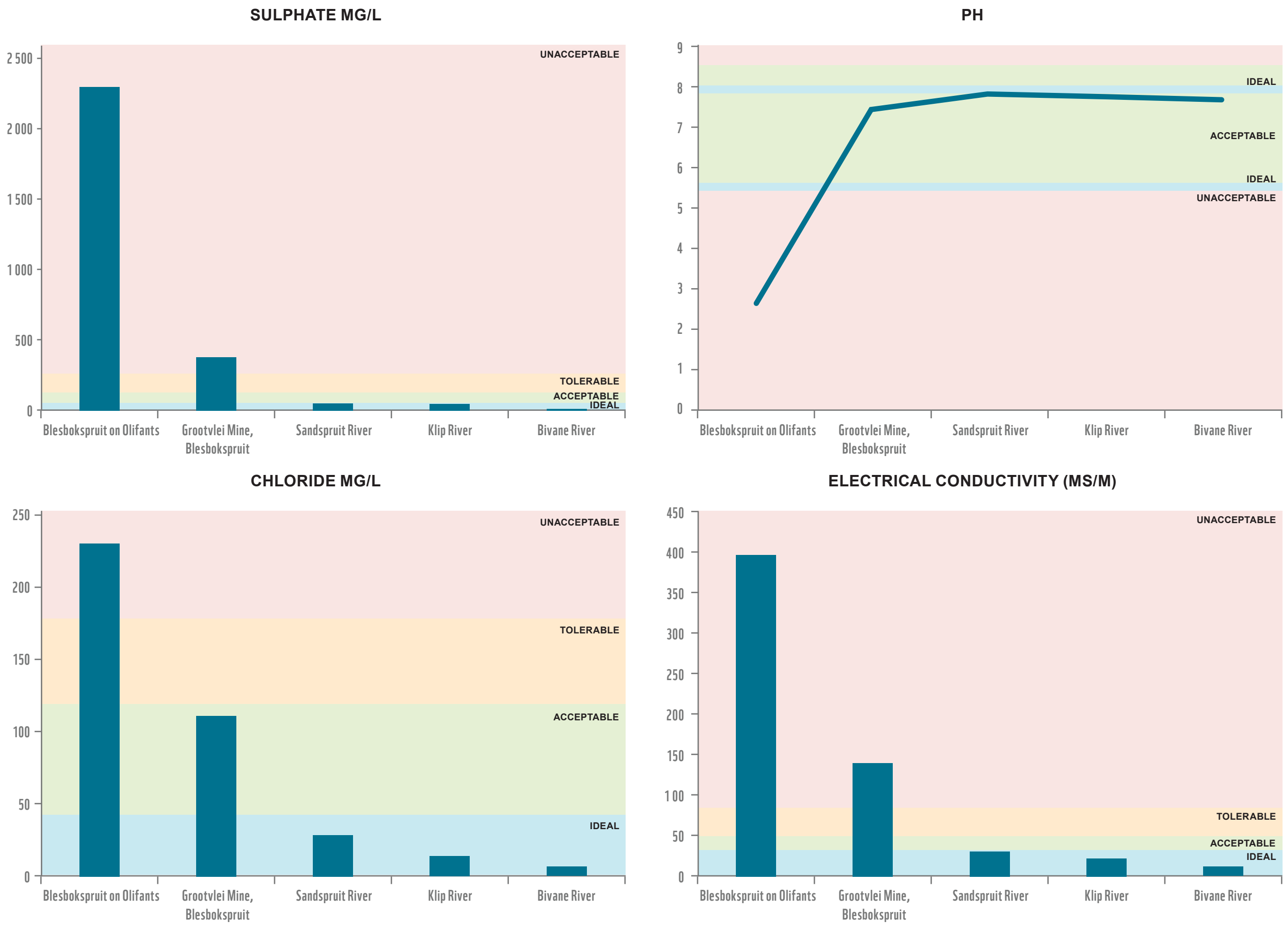


Figure 36: Water quality data for the Klip, Sandspruit and Bivane Rivers in the Enkangala region compared to those in the Blesbokspruit downstream of the Witbank coalfields and the Blesbokspruit downstream of the Grootvlei mine

Source: RWQ database, DWA; Bell et al., (2002)[83] Based on the two scenarios presented on the individual Blesbokspruits and the snapshot description of the coal deposits in the various provinces included in the Enkangala region, there is a moderate to high probability of producing AMD which will affect downstream water quality.

The coals are associated with non-marine terrestrial clastic sedimentary sequences, most commonly mudrock and sandstones, assigned to the Karoo Supergroup. The strata consist primarily of sandstone, carbonaceous siltstone, shale, minor conglomerate and several coal seams. In coal mines, the minerals pyrite and marcasite (FeS_2) are largely responsible for any AMD problems. The mineral matter in South African coals is dominated by clay minerals, mainly kaolinite and illite, followed by quartz and then the carbonates calcite, dolomite and siderite[138]. A range of carbonate minerals is present in Highveld coal samples, including calcite, dolomite and siderite. These carbonates can neutralize some of the acidity brought about by the oxidation of pyrite in aqueous environments.

7.7.4 Estimated water quality impacts with increased mining

The most common and likely method of mining in Enkangala is opencast mining. This mining method is likely to change the water balance of the region because it changes the permeability of the soils and underlying rocks and the vegetation cover Water balances are very important for determining changes in water flows and the potential for pollution from mines. This varies from mine to mine and depends on controlling factors such as surface hydrology, the mining method and the mining depth. High extraction methods, such as opencast mining disturb the overlying strata the most, leading to the largest changes in percentage influx of rainfall into the mines (Table 198). Studies in the Mpumalanga coalfield suggest that the typical mining methods will lead to the following:

Table 19: Percentage influx to be expected for typical mining methods.

Source: Vermeulen (2011)[139]

Mining method	% influx of the rainfall into mines
Shallow Board and pillar	5 – 10%
Deep Board and pillar without subsidence	1%
Opencast	14 – 20%

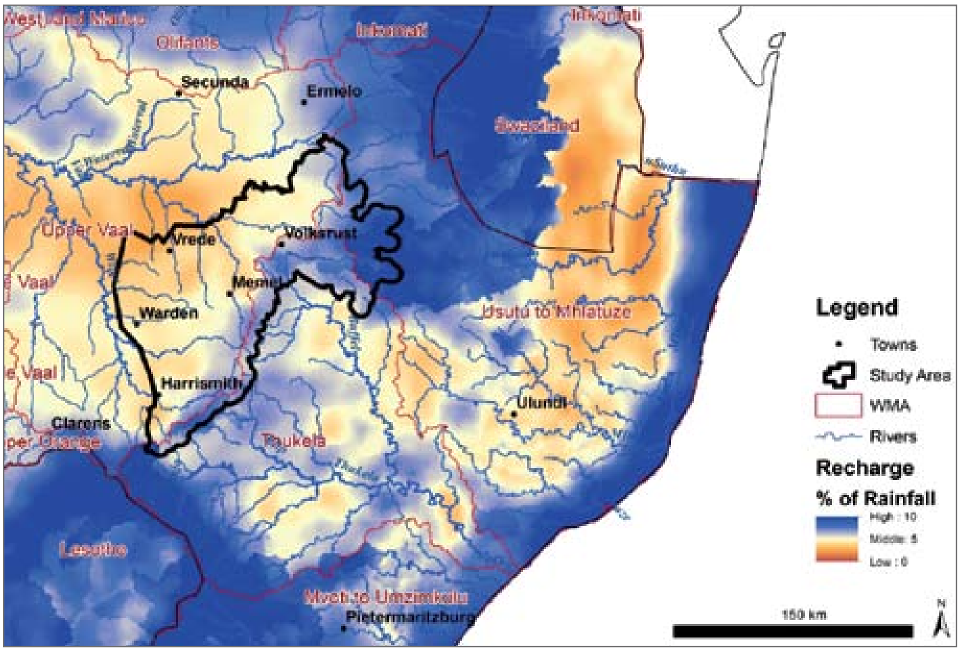
In a natural state, the percentage recharge of rain into the subsurface water resources ranges between 3 and 13%, but with opencast mining this is likely to increase to recharge amounts between 14 and 20%[113] (Figure 37). This means that greater volumes of water will pass through the mined material near and around mining sites, recharge subsurface waters at a greater rate than under natural conditions and become contaminated . This contaminated plume of water will flow underground beyond the mining areas to contaminate aquifers, springs or rivers away from the actual mining site. The extent of such contamination will depend on the slope of the area, the geochemistry, and the nature of the subsurface terrain.

One of the typical impacts of coal mining in a catchment is a gradual increase in sulphate levels because mine water is typically treated to adjust its pH, but sulphate levels remain expensive to address. This has been shown in the Olifants catchment[43], as well as the lower Vaal system[49].

Most of the prospecting applications received in the Enkangala area stem from small-scale mines. Such mines often lack experience and finances and have less concern about reputational risk than larger mining companies. Hence the risks of inadequate environmental protection, inadequate water treatment (during and after operation), minimal post-closure management, and even abandonment of mines, is greater than if the Enkangala region was mined by larger companies. Larger companies are not prospecting in the area as they do not consider the coal reserves

Figure 37: Percentage recharge of rainfall in the Enkangala area

Source: GRAII



viable. South Africa already has a national responsibility of dealing with roughly 6000 abandoned mines, a task that the responsible departments are struggling to address. Coal mining in the Enkangala region is likely to produce several examples akin to the Blesbokspruit and the Brugspruit rivers in the Olifants catchment. The difference lies in the fact that Enkangala is situated in the headwaters of three important catchments, the location and slope of the area will allow for a wider distribution of contaminated water, and the downstream water is already impacted, preventing further dilution. This will have particular consequences for water quality in dams like the Vaal Dam, as well as for Eskom which requires good-quality water for cooling its power stations. Downstream users will be forced to pre-treat water prior to usage, transferring the cost of treatment downstream and onto other sectors than coal mines.

7.8 The potential impacts of coal mining on the economy, vulnerable communities and ecological systems

The Enkangala study area is an important agricultural region, with a number of farming activities taking place. Field crops include maize, sugar cane, wheat, hay, sunflower seed, tobacco and groundnuts. Significant horticultural crops include: deciduous fruit, viticulture and sub-tropical fruit production, although these make up a relatively small share of total production. Livestock production makes up the main agricultural land use for the area and this includes cattle, poultry, goats and sheep. Animal products include fresh milk, eggs and livestock for slaughter.

Agriculture will be the most affected by the increases in mining and the effluent it generates. A recent report for the Olifants catchment showed that riparian wetland plants (such as *Phragmites australis*, *Typha capensis*, several sedge species and aquatics) contain root, as well as shoot concentrations of aluminium and manganese exceed concentrations considered healthy for human consumption[140]. It is understood that plant species accumulate metals differently and that detailed studies need to be conducted with individual crops. The initial screening in the Olifants does however show that a health risk that crops irrigated with contaminated water will absorb metals that can enter the human food chain. This can occur either directly via plant

Figure 38: Pictures of coal mining adjacent to crop production in the Olifants catchment

Source: J. Brown (February 2011)

consumption, or indirectly via consumption of livestock that were exposed to high metal concentrations in the plants they feed on.

The food chain risks of livestock consuming water and/or vegetation grown on contaminated water are currently not well understood. Further research in this field is required in areas where agricultural, mining and industrial processes often occur in close proximity (Figure 38).

The potential increases in mining effluent in the Enkangala area could the risks associated with crop production. The typical crops grown in the area vary in their relative sensitivity to salinity, acidity and metals; aluminium is particularly toxic to plants (Table 20). Salinity and acidity sensitivities are relatively well documented for specific crops, but metal sensitivity (aluminium and manganese) is not easily traced in the literature. Species specific research would be of benefit for South African crops in the future.

Table 20: Crops commonly grown in the area and their salinity and pH sensitivities

Source: DWAF, (1996)[73], Beegle and Lingenfelter, (1996) [141] Jett, (2005)[142], DAEA, (2005)[143]

Agricultural product	Salinity tolerance (TDS)	Acidity tolerance (pH) (*6.5 – 7 = sensitive; 6 – 7 = moderately sensitive; 5.5 – 7 = moderately tolerant)*
Maize	Moderately sensitive	Moderately sensitive
Sugar cane	Moderately sensitive	
Wheat	Moderately tolerant	Moderately sensitive
Hay (Alfalfa)	Moderately sensitive	Sensitive
Sunflower seed	Moderately sensitive	Moderately sensitive
Tobacco		
Groundnuts	Moderately sensitive	
Subtropical fruit	Sensitive to moderately tolerant, depending on crop	Species specific
Deciduous fruit	Sensitive to moderately tolerant, depending on crop	Species specific
Soyabeans	Moderately tolerant	Sensitive

Some land claims in the Enkangala area overlap with prospecting applications. Prospecting pressures on such communities are an important political issue. Communities with land claims are given first opportunity to apply for mining rights, but such mining rights lapse and other parties are then free to continue with

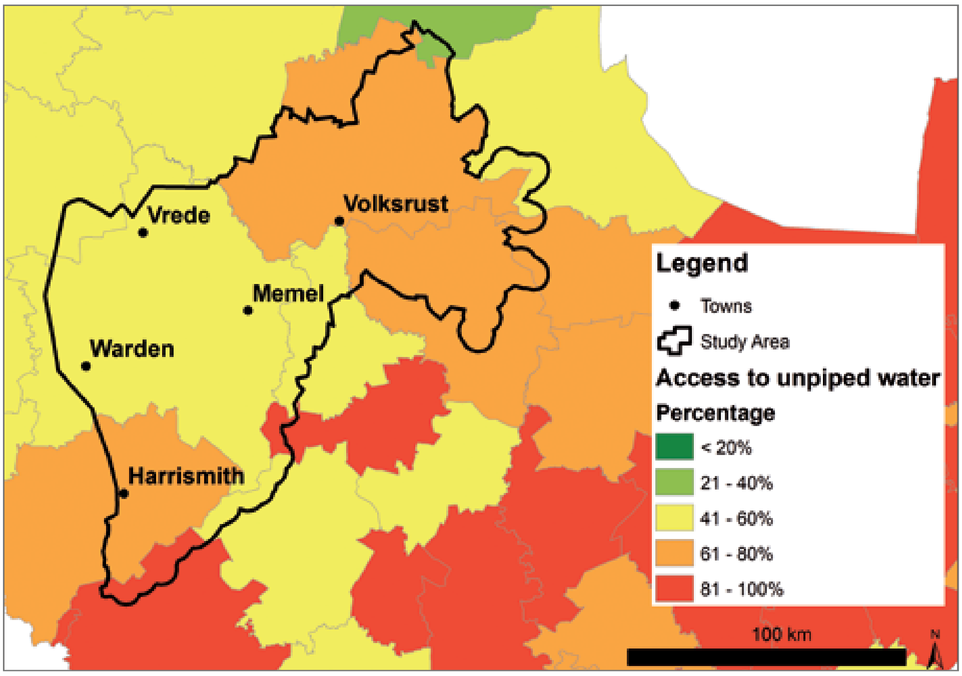


Figure 39: Map of communities depending on untreated water sources in the catchments flowing from the Enkangala area

Source: Stats SA, 2007

the mining process. For communities interested in mining this does provide a good opportunity, but it is not clear what rights communities that want to continue with subsistence agriculture have. Similarly, current title deed holders in the Enkangala area have held farms in families for up to five generations. Prospecting and mining applications are highly emotional issues for farmers, who stand to lose their livelihoods to coal mining.

7.8.1 Communities using natural water resources (unpiped) and untreated

The most vulnerable and voiceless are the poorest of the poor who are living in areas where they do not have access to clean and safe drinking water. They have to rely on natural water sources (e.g. rivers) for drinking water and they would be highly vulnerable to health hazards associated with inadequately treated mine water effluent (Figure 39).

The impacts of defunct coal mines on impoverished communities

An elderly lady recounted how she had to walk many kilometres to collect water from a stream running below a defunct mine near her community. When asked why she took water from what was clearly a polluted water source, she indicated that she had no option because the other sources dried up during the winter months. The location of mines in relation to water sources is an obvious cause for concern but even more so when the only water source for impoverished communities could be affected. The situation could be exacerbated when such mines are abandoned and responsibility falls on the DMR to rehabilitate and mitigate. Sadly, the DMR's track record of rehabilitation for defunct and ownerless mines is not very convincing with increasing examples of communities in the vicinity of such mines consuming polluted water apparently out of desperation. This alarming situation could be avoided if better strategic planning was implemented before prospecting and mining was authorised so that potable water production areas were avoided at the outset.

7.9 Defining no-go areas and applying best practice

7.9.1 Spatial correlations of coal reserves with important water, environmental and land use areas

In order to obtain a better understanding of how coal reserves overlap with crucial environmental, water and agricultural areas in Enkangala, we have run spatial correlations for FEPA river conditions, for FEPA areas, for land capability areas and high runoff areas. All data tables for this section are provided in the Appendix.

The results show that the Ermelo and Highveld coal fields specifically lie beneath 76 and 77% of rivers that are in pristine condition (AB or B). Both the Klip and Utrecht coal fields underlie a smaller proportion of good quality rivers (16 – 17%), while most of the rivers in this coal field area are already 'working rivers' with a 'C' rating (49 – 55%).

Large parts of the four coal fields overlap with FEPA areas (between 42 and 77%) and large parts of the Highveld coal field overlap with FEPA-defined upstream management zones (43%), that have been identified as critical to sustain downstream ecosystem functioning.

The Ermelo coalfield is the one that overlaps the most (40%) with high mean annual runoff areas (>300mm/a), the next-highest one being the Highveld coalfield (13%). None of the Utrecht or Klip River coal fields fall within high MAR areas.

In terms of land capability, the most overlap occurs in the Utrecht coal field (25% high, 39% moderate potential), followed by the Ermelo (5% high, 53% moderate) and Klip coal fields (13% high, 21% moderate). The overlap between the Highveld coal field and areas of important land capability is minimal (2% high, 2% moderate).

The results clearly show that there is overlap between coal resources and key environmental and agricultural areas so mining could potentially affect key river-related habitats and result in the loss of prime agricultural land.

7.9.2 Defining no-go areas for Mining

It is evident that the recent increase in coal prospecting in Enkangala increases the potential for conflicts of interest. Coal is economically important and a prime source of energy in South Africa. Some have seen this as an opportunity to establish new enterprises and diversify the coal mining industry so it is not surprising that prospecting has increased.

The spatial analysis has shown that the coal resources in Enkangala are overlain by large areas that are crucial for water supplies, agricultural land and important river conservation areas. Mining applications in this area should, therefore, be properly assessed right from the outset. However, this has not been the case as was shown by the many cases where applications have been successful despite evidence of the sensitivity and environmental and societal importance of the area. The legislation requires sensitive areas to be given extra scrutiny. The mining application process is meant to ensure that a balance between societal, environmental and economic benefits is maintained. However, in the case of Enkangala, this balance appears to be tipping strongly in favour of immediate economic benefit for the mining companies involved.

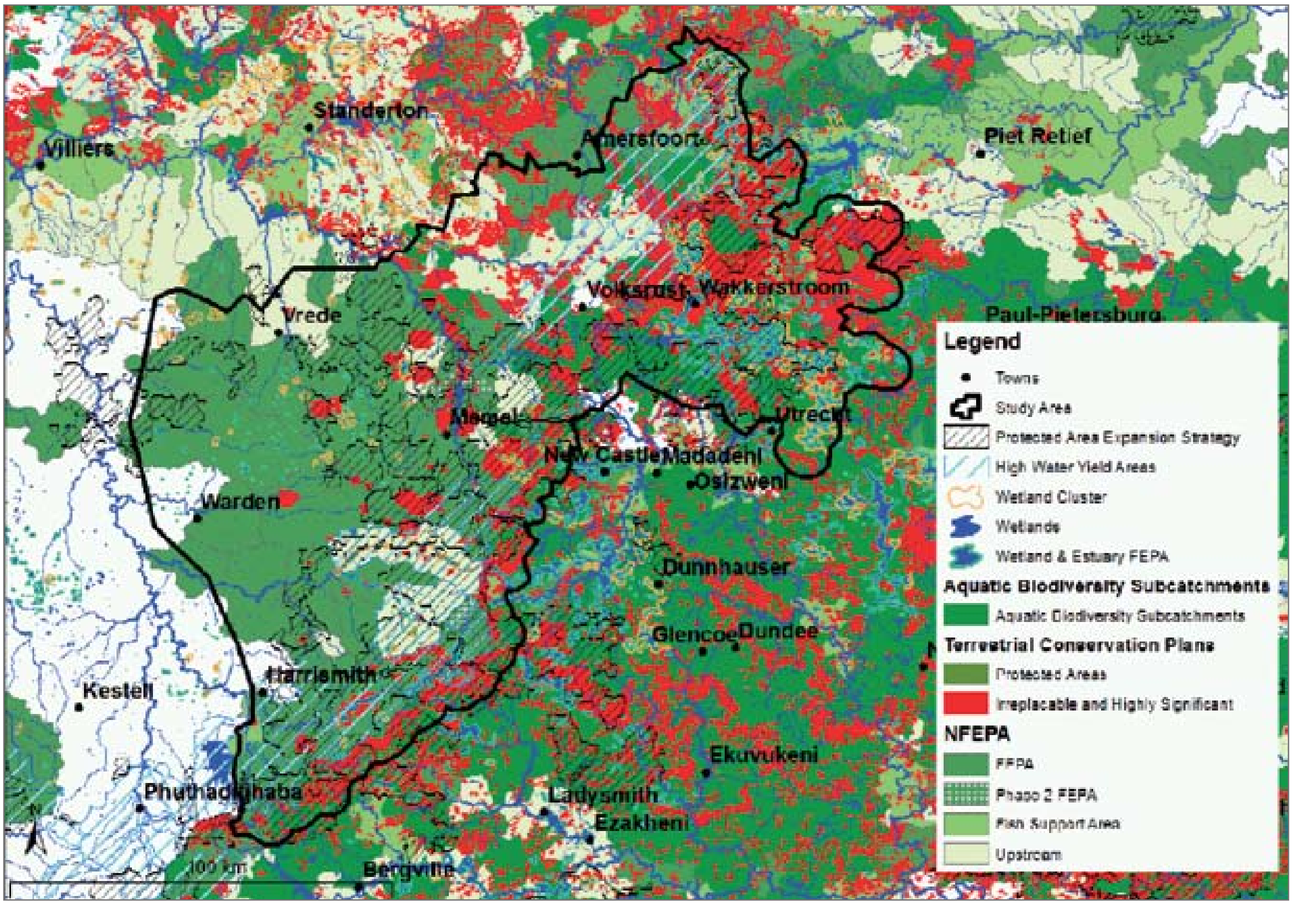
Brightcoal story – Prospecting at the source of river systems – valid environmental concerns, DMR dismissive

Concerns over inappropriate prospecting applications at river headwaters have been recently highlighted with a recent application to the DMR by "The Greater Pongola Catchment Protection Association" (based in Northern KZN) for prospecting rights to be overturned based on serious environmental and social concerns. The Pongola river system is a NFEPA system, provides water for over 150 000 downstream users and is a class A river (as defined by DWA), yet despite obvious biodiversity and hydrological concerns, prospecting rights were awarded in its headwaters. The application to the DMR highlighted serious concerns with regard to lack of consultation, inadequate and even apparently misleading EMPs yet the DMR's response has been entirely dismissive with no attention given to the many merits of the application lodged with them. One of the primary reasons for not considering the appeal was that other departments were approached for comment and having received none, the DMR awarded the rights on the basis of "no objection." The need for the DMR to effectively and meaningfully apply itself to valid concerns raised via such appeals is patently obvious yet, at present, apparently lacking. Additionally, the role of DMR as "gate keeper" and "key master" needs to be questioned because there is little evidence of objectivity in the authorisations they have given in such sensitive areas.

Enkangala is, as described throughout the report, a key area in terms of water and environmental biodiversity (Figure 40). Extensive mining, whether on a single area or on many smaller areas, could cause major local and downstream impacts and applications should be assessed with extra care.

Figure 40: Overlay of NFEPA areas, conservation and protected areas to depict zones in which mining should not occur

Source: NFEPA (2011)



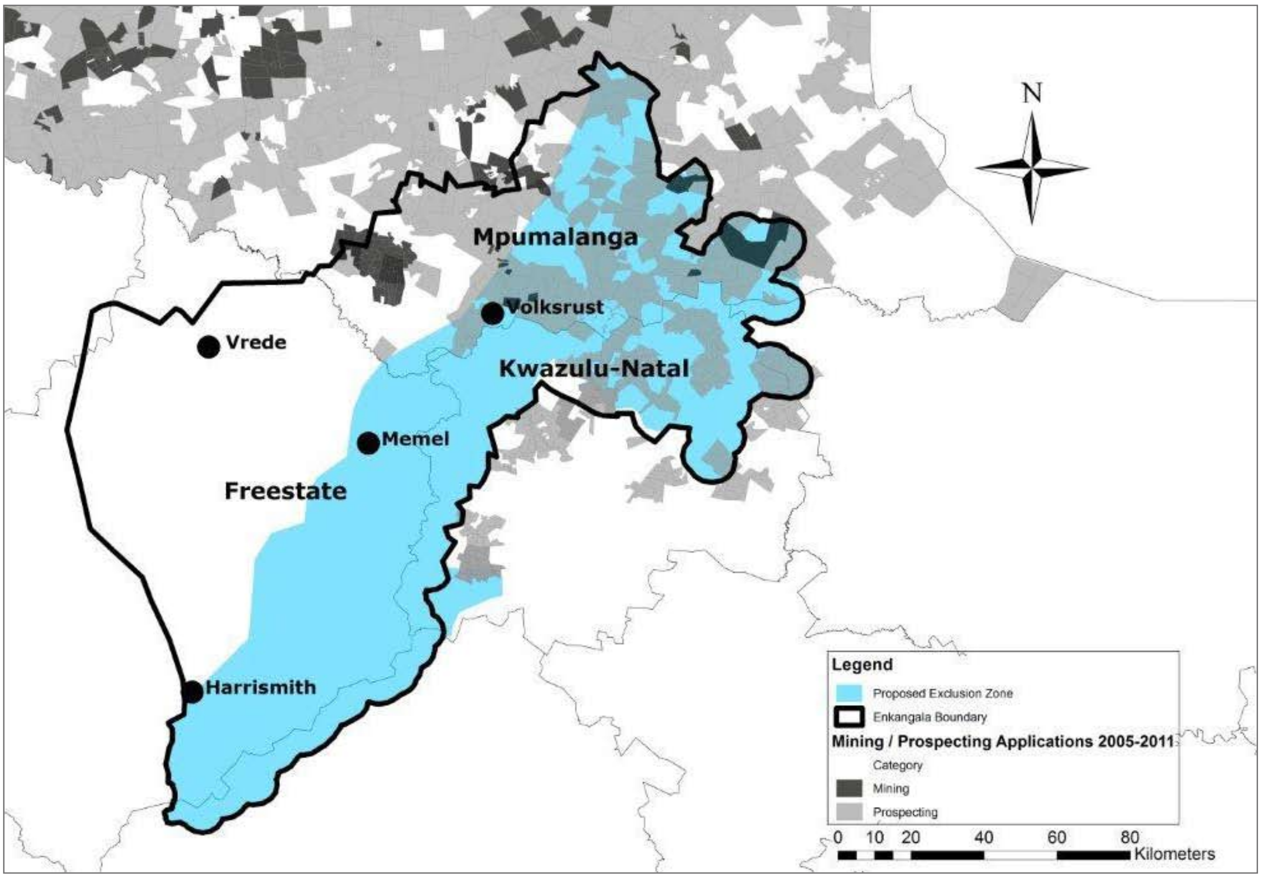


Figure 41: Proposed restricted areas in Enkangala. The blue area indicates a possible restricted mining zone which would protect the most important conservation priority areas and high water yield headwaters.

The area is a water source for three major river systems so it is critical that coal mining is only permitted by companies that can demonstrate their ability to adhere to 'best practice' standards. Water treatment during all stages of mining (including the post-mining phase that extends beyond the usual 30 year horizon) should include pH adjustment, and metal control and sulphate removal. This level of treatment requires a fully operational desalination which should be a required for every mining operation in Enkangala. Best practice guidelines have been set-out in detail in reports that were prepared by the Department of Water Affairs between 2006 and 2008 (DWA, Best Practice Guidelines, series H1–4[144,145,146,147], G1–4[148,149,150,151] and A1–6[152,153,154,155,156,157])

Areas highlighted as conservation priorities should preferably remain unmined as shown in figure 41. In reality, the definition of restricted areas should involve the relevant departments (DWA, DEA, DMR) and key stakeholders (local and downstream land and water users). Ideally this could happen under the implementation of the Classification of water resources as envisaged in the National Water Resource Classification System. The best practice guidelines should be prescribed, as well as practices recommended in the 'Mining and Biodiversity Guideline' that is currently being drafted by SANBI[89].

8. RECOMMENDATIONS FOR BETTER COAL MINING IN SOUTH AFRICA

Our water resources are under threat and stressed. Acid Mine Drainage is one of the most hazardous threats facing our water resources.

AMD from both coal and gold mining has already bought devastating consequences to impacted areas, such as the Witwatersrand and the Witbank. South African's live with a legacy of nearly 6000 abandoned and ownerless mines. Our government departments are currently not able to ensure that proper licencing provisions are met by active mines and that due diligence is followed to prevent pollution from active and dormant mines. Impact monitoring and enforcement is completely inadequate and under resourced, in a sector which generates significant revenues. No account is taken of the importance of water resources, soil resources and the potential impact on food and job security in areas where prospecting rights are issued.

Given this current state of affairs, and the South African government's stated aim to move towards a new Green Growth path and invest in creating jobs, WWF-SA calls on government and the mining sector to implement far reaching improvements immediately. Better coal mining in South Africa must aim to Mitigate – Manage – and Monitor, to protect water resources, agricultural jobs and down-stream users in our urban hubs.

8.1 Mitigate – strategic planning for a sustainable future for all.

The National Planning Commission and Departments of Water Affairs (DWA), Environmental Affairs (DEA) and Mineral Resources (DMR) must agree at the highest level to restrict mining in critical water source areas in order to mitigate the impacts of water pollution. Spatially explicit development plans are needed at a provincial level that take account of high yield catchment areas, critical biodiversity areas and high value agricultural areas. The water, jobs and food provided by these areas need strategic level protection from mining applications. If we can't afford to clean up our current environmental liability, we must prevent impacts in critical areas.

Minister Susan Shabangu, DMR – 'I do not think I am interested in the gold mines. We do not have the money to pay and we can't fix them. Those who have been mining there for years must take responsibility.'

Sunday Times, 20 November 2011 [*Shabangu pours cold water on nationalisation*]

- *Re-balance the power and responsibility among government departments, to enable co-operative governance (as contemplated in Section 41 of the Constitution of South Africa).* DMR is the Department with full control of mining operations. DWA in comparison does not hold the same power in this sector, yet is held responsible for water matters. Often DWA only becomes involved after operations have begun, leading to reactive solutions, rather than sound proactive ones. For example, a response delay by DWA for a mining application is assumed to be a go-ahead for DMR. This is often not correct as DWA may be incapable of processing the applications in time for institutional reasons.
- *The impact of mining needs to be measured and assessed according to cumulative impact, and not individual impacts.* Water quality impacts from mines extend beyond the spatial and temporal boundaries of the actual mining operations. Evaluating mining impacts at an individual level, with site-specific boundaries and for up to 30 years fails to address the full liability that coal mining creates. This issue is addressed under the Mineral and Petroleum Resources Development Amendment Act (MPRDAA), but it is still unclear if government departments will find the ability to co-operate sufficiently to successfully mitigate cumulative effects. The current rate of license handouts seems to suggest the opposite.

- *The cumulative risks of smaller, or so-called 'bakkie-mining' companies needs to be urgently accounted for.* Given their numbers and preference to operate in marginal areas, they have a cumulative impact that is as profound as that of large mines. It needs to be kept in mind that smaller companies are more likely than well-established companies to have insufficient rehabilitation funds and, thus, of abandoning mines. Abandoned mines create a particularly high risk of polluting water resources[44].
- *The national AMD discussion needs to include both gold and coal mines.* At the moment the South African AMD discussion is focused on gold mines and the imminent dangers of gold mines decanting AMD water into high-risk areas such as the inner city of Gauteng[49]. However, it is essential to begin looking at the cumulative impacts that are occurring in the coal sector and the future risks of AMD from coal mines. Differences in mining techniques between gold and coal mines make AMD from coal mines more difficult to manage because it often involves extensive surface disturbances and the destruction of regolith layers that naturally regulate the surface-groundwater interface. Timely consideration of all AMD may help to address the large-scale consequences South Africa will face from coal mining in the future.
- *South Africa will have to decide on tradeoffs between financial capital made from mining, versus environmental costs.* Foreign exchange is very important and money earned from exports allows the government to afford social support, which represents reinvestments in the economy. Thus decisions about tradeoffs are not simple matters. Still, the government should not allow the high revenues generated by mining to drive unsustainable planning.
- *South Africa has to strike an important balance between the necessity of coal mining and the need to protect the environment and social well-being.* For that, both sides need to have sound arguments, good organization and a strong voice. Coal mines already have the resources and capacity to broadcast their aims and benefits, however the opposition voice needs organization, volume and the right platforms to state their case. The debate needs to address the risks, losses and burdens that befall the poorest of the poor, who often depend on natural resources (e.g. fish from impacted water sources, subsistence farming or polluted drinking water) for survival.
- *It should be of utmost national importance to determine the water (quantity and quality) requirements for food security, human provision and dilution in order to know how much further SA can continue to trade and transfer water.* DWA to date has not yet stipulated which water sources are more important than others from a social point of view or from the concept of the National Water Resource Classification system. The NWA requires the Minister to set a management class and Reserve determination for each significant resource. This would guide spatial development planning and should influence where licences are issued. Where scientific evidence is lacking, a strong argument should be made for the precautionary principle, until such time as science has provided the necessary evidence. South Africa only has few remaining pristine and clean water sources (e.g. Heyshope Dam, Mpumalanga) that play a crucial role in diluting the pollution entering rivers further downstream. These key water source areas should be nationally recognized and remain untouched by mining or other high-risk developments.

8.2 Manage – improved management of the licensing and mining process

Whilst our legislation currently aims to protect water resources, ensure the 'polluter pays' principle and enable sound environmental management – implementation is not coordinated between the necessary government departments. A strategic implementation rethink is required to enable our legislation to become more effective. The Department of Water Affairs licencing process must be properly accommodated within mining licencing and capacity within the Department should be strengthened urgently to enable this.

Water management in South Africa needs to be prioritised. Processes which have almost stalled – such as the formation of Water User Associations, Catchment Management Agencies, and the implementation of the National Water Resource Classification system – must be invigorated and accelerated.

Management of financing for decommissioning within DMR needs to be reviewed and improved. We cannot continue to issue new licences to an increasing number of junior operators when rehabilitation funding mechanisms are so inadequate.

- *The prospecting application process should include an environmental/social sensitivity screening process*, whereby applications get ranked, (e.g.: 1. = no go; 2 = considered; 3 = free for mining). The criteria for such areas need to be backed up by proper science that can convince role players about 'no go' areas or additional costs. Proper valuation of alternatives is essential and should be included in the application processes (e.g. agricultural value of area, water in area).
- *Use of existing data to inform license handouts.* Ultimately the decision to mine is based on the presence of a resource and its economic viability – yet prospecting rights are granted for areas without economically viable deposits. If the prospecting licence issuing was based on existing shared data, it would save resources and conflict and reduce environmental damage from prospecting. Data from the Council for Geosciences could be used to streamline the prospecting license processes. More reliable reserve audits from DMR are needed as well as the strengthening of the role of information from DEA, DWA and other IAPs about protecting sensitive or non-economic areas. The WWF for example, already has spatial data for sensitive areas in Enkangala.
- *The prospecting license application process should be consolidated and streamlined into a single process,* requiring the same timelines and the equal engagement of all responsible departments. One way would be to handle this process via an intergovernmental committee, which meets at regular intervals to jointly process approvals and reach decisions. Such a process would reduce frustration and confusion among all applicants, it would honour intergovernmental co-operation appropriately. Another option would be to align the process in a way that all developments with potential environmental consequences were to be processed under the NEMA regulations, placing the DEA as the single authority to issue an environmental authorisation for all development applications (including mining-related applications). Such environmental authorisation would have to be in place before DRM could issue a mining-related right or permit.
- *Environmental practitioners responsible for Environmental Management Plans need to be held responsible for their quality of work*. This can be achieved by either peer reviewing via external sources, or the EMP should be completed by external experts. Such practices should ensure that the assessment is done rigorously and correctly. Any false representation should hold consequences. Currently EMPs are rife with 'cut and paste' examples. In the past, DEA used to disqualify applicants who were found guilty of 'copy and paste' jobs. Similarly, mining company directors

should be held personally liable for the liabilities they create. The National Scientific Professions Act (1993) should be applied in order to ensure appropriate standards of EMPs. Current EMPs have been simplified to tick box format, enabling a layperson to complete it. However, this allows for erroneous decision making and an EMP process during prospecting should be completed with more diligence, as it can save the mining company a lot of conflict later when an area is found to be sensitive.

- *There is a shortcoming around the implementation of EIAs as part of the Environmental Authorisation process.* EIAs are conducted briefly at the beginning of an operation and are not able to take into account all the developments and challenges that the mining process may encounter during its entire lifetime. It is also unable to take into account seasonal environmental issues because of the timeline for completion. EIAs are also site-specific and do not address impacts beyond the mining site, or what impacts may be happening close-by. EIAs therefore fail to address cumulative impacts at present. Government officials reviewing these documents often lack the experience to assess cumulative impacts. Lastly, EIAs lack focus on technologies that could adequately mitigate negative mining impacts.
- *Strengthen policing of mining, environmental and water legislation.* The most blatant disregard of South Africa's sound laws around mining, water and the environment is shown by several cases in which mining takes place without the required permits and licenses. Government is responsible for dealing with transgressors who mine illegally, but this obligation is not honoured in a predictable way.
- *The lack of synergy between the different departments, policies, implementation and information transparency creates stumbling blocks for smaller mining companies.* Junior mining companies report being frustrated by the difficulty experienced in accessing information that is supposedly available but is difficult and costly to get hold of in reality. Small companies have to be experienced and astute to operate in an aggressive industry where bigger players have more experience and resources.
- *The continued lack of information sharing in the mining industry comes at a cost.* The entire mining sector has a historical legacy of withholding information from the public domain. From a business perspective, it is valid to withhold strategically important information, but information sharing for research purposes and best practices should be encouraged. Equally, government has the responsibility to collect, collate and make available mining information and the conditions of mining licences. This is currently not practiced at DMR and the auditor general found that databases do not meet the required standards. The Council for Geoscience has limited access to data, but it is sold at a price, making it costly to access. Improved information sharing would vastly aid co-operation, save time and costs, prevent repetition of research efforts and level the playing field for junior miners.

8.3 Monitor and enforce – growing jobs in the environmental sector.

The number and competence environmental enforcement practitioners must be strengthened and expanded within DME, DWA and DEA. This will enable the effective harmonisation of licensing procedures within and between departments and strengthen government's ability to monitor and enforce compliance. Monitoring of mining activities and water resources in general is inadequate. There is significant scope for growing a new generation of graduate and matric level environmental officers and placing them in effective systems of cooperative governance.

EMPs and EIAs must be completed by trained environmental practitioners, even during the prospecting phase. EMP scores for the prospecting phase must take provincial and national conservation plans into account.

- *The DMR is in need of institutional improvements.* Staff lack experience, staff turnover is high, and the department is often understaffed. Communication between regional and head offices is often insufficient. The channelling of requests and complaints through the system needs improvement, as well the capture and storage of information on databases. Staff turnover could be addressed by introducing contractually enforceable term limits for government personnel, or by establishing benefit structures that could encourage individuals to stay in government for longer (e.g. delayed bonuses, salary increases, better health coverage with seniority of service).
- *Best practices need to be mainstreamed and enforceable beyond their current role as guidelines.* Both small and big mines should be held accountable to comply with best practices.
- *We need to research the effectiveness of best practices – are they really achieving what they are meant to achieve?* There is insufficient research in this field. A useful approach could be to take an example of a mine that has done everything by the book, from cradle to grave in terms of costs involved. This would assess best practice guidelines and provide an example to smaller companies of what could be involved in taking full responsibility of liabilities. It also guides all coal mining companies in terms of realistic provisions for decommissioning.
- *There is a disconnect between the interpretation of rehabilitation and sustainability of the mining industry and other IAPs.* This needs to be addressed, as rehabilitation efforts by mines are typically regarded as insufficient by other IAPs. Realistic lifetime cost-benefit analyses of mines are essential, including the scale of time in the equation (longer than 30 years) and the scale of impact (beyond the actual mining site).
- *Monitoring good practice in coal mining should influence consumers in procurement decisions* – currently some European consumers may require minimum environmental standards from their mining suppliers. If Eskom and Sasol, as major consumers in the domestic market, also required best practice in terms of environmental management and funding for rehabilitation, from their coal suppliers this could have far reaching effects in the sector. This could reinforce the professional standards of jobs created to ensure environmental compliance.

GLOSSARY

Aeolian: driven or caused by the movement of the wind; thus Aeolian deposits are of wind blown material, for example sand-dunes

Aquifer: a geological formation which has structures or textures that hold water or permit appreciable water movement through them. A saturated stratum which contains intergranular interstices, or a fissure/ fracture or a system of interconnected fissures/ fractures capable of transmitting groundwater rapidly enough to supply a borehole or a spring directly

Biodiversity: a term which encompass the diversity of living organisms in a system, their interactions and their roles maintaining ecological processes and functions. Formally, there are three components (a) Composition: what is there and how abundant it is; (b) Structure: how the units are organized (structured) in space and time; and (c) Function: the roles the different units play in maintaining processes and dynamics. These three components are each represented at four different levels or scales of organization: (i) Genes, (ii) species and/or populations, (iii) communities (habitats) or ecosystems and (iv) landscapes. In conservation planning the terms composition and structure are combined and called biodiversity pattern.

Biome: a broad ecological unit representing major life zones over large areas. In South Africa these are defined mainly by vegetation structure and climate.

Catchment: synonymous with a river basin or watershed; an area of land forming a natural drainage basin which channels all water into a single outflow.

Direct Cost: A price that can be completely attributed to the production of specific goods or services. Direct costs refer to materials, labour and expenses related to the production of a product. (http://www.investopedia.com).

Ecosystem: an interconnected, and interacting system comprising a diverse combination of living organisms that all act as a single unit.

Effluent: water that returns to a natural water source after its use for any activity, such as mining, domestic, industrial and agricultural use.

Geological formation: the fundamental lithostratigraphic unit of an area that may consist of consolidated or unconsolidated material.

Gross Value Added: A productivity metric that measures the difference between output and intermediate consumption. Gross value added provides a monetary value for the amount of goods and services that have been produced, less the cost of all inputs and raw materials that are directly attributable to that production. (http://www.investopedia.com)

Groundwater: in common usage includes all subsurface water (McGraw-Hill, 1978) but in this document the use of this term is restricted to water in the zone of saturation. It flows into boreholes/wells, emerges as springs, seeps out in streambeds or elsewhere in surface catchments and is not bound to rock (particle) surfaces by forces of adhesion and cohesion. Generally used of water contained in aquifers.

Groundwater dependent ecosystem: an ecosystem which depends on groundwater discharging from or contained within an aquifer, and is significantly altered by changes in the groundwater regime.

Hierarchy: a series of ordered groupings of people or things within a system, arranged one above the other (SOED). See http://www.isss.org/hierarchy.htm and Nested hierarchy.

Hydrology: the study of occurrence, properties, circulation and distribution of water on the earth and in the atmosphere (Chambers, 1996).

Indirect cost: costs that are not directly accountable to a cost object (such as a particular function or product). Indirect costs may be either fixed or variable. (http://en.wikipedia.org/wiki/Indirect_costs)

Net Present Value: The total present value of cash flows (revenues and expenses) over time (i.e. the sum of discounted cash flows) (http://ext.wsu.edu/forestry/economagic/glossary/)

Nominal Price: The actual price of something in the year it occurs. (http://ext.wsu.edu/forestry/economagic/glossary/)

Precipitation: technically the word simply refers to the transition of a substance from one phase to another; in the climatic context it is used broadly for all forms of water deposition on the earth's surface (McGraw-Hill, 1978) including dew, mist, rain, snow and hail. Precipitation is measured in units of depth (mm or inches). Precipitation results in the release of energy (termed latent heat). Symbol P or Ppt.

Private Cost: A producer's or supplier's cost of providing goods or services. It includes internal costs incurred for inputs, labor, rent, and depreciation but excludes external costs incurred as environmental damage (unless the producer or supplier is liable to pay for them) (http://www.businessdictionary.com/definition/private-cost.html)

Primary aquifer: an aquifer in which water moves through the primary openings of the geological formation.

Primary openings: interstices that were formed contemporaneously with the formation of the sedimentary deposit or rock that contains them. Synonymous with primary porosity. The ability of water to flow through these interstices is termed primary permeability.

Recharge: see groundwater recharge

Real price: A price that has been adjusted for inflation (http://ext.wsu.edu/forestry/economagic/glossary/)

Regolith: technically a layer or body of weathered, fragmented or unconsolidated rock material, whether residual or transported, of variable character and overlying bedrock (Bates and Jackson, 1980). The mantle of fragmented and loose material of deposited soil and in situ weathered/ decomposed rock. It overlies or covers more solid rock, so-called bedrock.

Reserve: the quality and quantity of water required to supply basic needs of people dependent on that resource, and to protect aquatic ecosystems in order to secure ecologically sustainable development and use of water resources (National Water Act No 36 of 1998)

Riparian: living or growing by rivers or streams (e.g. on the bank, Mc Graw-Hill, 1978). The National Water Act contains the following definition: 'riparian habitat' includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation species with a composition and physical structure distinct from those of adjacent land areas.

Roots: tap, sinker, lateral, etc.- the descending axis or parts of a plant, normally below ground (McGraw-Hill, 1978); functions include anchorage, absorption and conduction of water and minerals, and sometimes food storage; roots lack the nodes and internodes found in stems and branches.

Runoff: the water in a stream after rain (McGraw-Hill, 1978). In hydrology, this refers to all the surface flow of water from a catchment in a stream or river (Ward, 1975); sometimes it includes the sub-surface runoff. It is usually used to refer to the (volume of) surface water that leaves a catchment in a period of time. As most catchments are assumed to have no subsurface flow at the measured point it is generally equivalent to the surface runoff. All forms of runoff are measured in units of volume (m^3 of ft^3) but are sometimes expressed in units of depth. Common symbol is Q.

Run-of-mine production: is the amount of coal that directly comes out of a coal mine, prior to refinement

Secondary aquifer: an aquifer in which water moves through porous areas that were formed by processes that affected the rocks after they were formed.

Seep: slow escape or oozing of water (Chambers, 1996); used of a usually small, diffuse wetland area where interflow and groundwater emerges, usually at a slow rate, to become surface flow.

Social Cost: An actor (business firm, individual, etc.) initiating an action does not necessarily bear all the costs or reap all the benefits of that action. Those that the actor does bear are the private costs; those that the actor does not bear are the external costs. The sum of these two is the social cost. (http://www.coase.org/nieglossary.htm).

Soil: the upper surface layer of the earth comprising decomposed and fragmented rock or unconsolidated, living organisms, organic matter, water and gases with properties attributable to the interaction of its parent material, time, climate, fauna and flora (McGraw-Hill, 1978).

Source area: the saturated zone along an effluent stream which generates streamflow (stormflow and baseflow).

Spring: a place, usually a distinct point or small area, where groundwater emerges (McGraw-Hill, 1978), generally as a result of topographical, lithological or structural controls on groundwater movements.

Water course: a river or a spring; a natural channel in which water flows regularly or intermittently; a wetland, lake or dam into which, or from which water flows; and any collection of water which the Minister may, by notice in the Gazette, declare to be a water course (National Water Act No 36 of 1998).

Water table: also known as the free water surface or ground water level.

Welfare gain: Well-being of society is increased by the introduction of a product or an activity.

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South Africa's Water Resources

We need to protect our water resources if we are to adapt to climate change.

100% RECYCLED

12% OF LAND = 50% OF RIVER FLOW

Headwater catchments receive high levels of rainfall and are the source of our major rivers

84%

Of our aquatic ecosystems are vulnerable or endangered

CLIMATE CHANGE

Will result in more extreme events and flooding in many headwater areas: higher risk of Acid Mine Drainage

32%

Projected increase in water demand between 2006 and 2030

WWF

Why we are here
To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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