DEVELOPING A MULTI-SECTORAL INTEGRATIVE LICENSING AND MONITORING FRAMEWORK TO ALIGN AND INTEGRATE BIODIVERSITY AND ENVIRONMENTAL WATER QUALITY IN THE COAL MINING DEVELOPMENT LIFE-CYCLE

Report to the

Water Research Commission

by

Munnik, V., Humby, T., Van der Waals, J., Houdet, J., Thomson, G., Keighley T., Cobbing, B., and Palmer, C.G.

Rhodes University

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Water Research Commission
Private Bag X03
Gezina, 0031

orders@wrc.org.za or download from www.wrc.org.za

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PREAMBLE

The story of this project – an easy read.

If you drive through South Africa's Highveld grassland landscapes, you will encounter a network of small streams and slightly larger rivers, and you will see the reeds and rushes and sometimes a gleam of water, characteristic of wetlands. The grasslands will be dotted with livestock; there will be mealie fields and a little irrigation. These grasslands form a hub of agricultural production. You will also see evidence of coal mining. Great piles of earth and coal, and a skyline with the silhouettes of coal-fired power stations represent the "engine room" of South African industry.

In this kind of landscape, this project was born, out of a new event. A court fined a mine for destroying a wetland, and made provisions that the fine must be spent on research into the interconnections between coal, cows, people and the natural environment.

This is the research we have done - also in a new way. "We" are a research team comprising academic specialists, students, and people knowledgeable of the case study place. We have woven a story of the interconnected threads of story. As we began, we found ourselves mired in a knot of laws. It was very difficult to find a coherent thread – so we took on two approaches: 1) understanding the purpose and direction of the laws that govern mining and the protection of landscapes; and 2) unravelling the legal requirements of mining, from prospecting to mine closure.

At the time, other team members investigated the wetlands that are so much part of the water network running and seeping through the grasslands. Ever since Noel Hynes wrote *"the stream and its valley"* in 1975, people have realised that water bodies in a landscape reflect the activities of the landscape – so water ecosystems are often the basis of ecological "health" monitoring. Traditionally two kinds of living organism are used to indicate the heath of watery ecosystem: plants and 'bugs' (mainly the insects and their larvae that live in water). So, we braved bumpy fields and farm tracks (with kind permissions) and slooshed about in water and mud, collecting plants and bugs in wetlands. We also sat on rocky sandstone sills and hill-slopes, looking out across the veld to see road and weirs, gullies and bare ground, and the places where wetlands connected with streams.

Why wetlands? They are places where coals seams come close to the surface, and they are also actively used by livestock – agriculture and mining are local (competing) economic drivers.

As we talked to people in Carolina – the town in the case study area - where the town water supply turned acid in 2012 - we found people who were angry, anxious, and sometimes confused. We met miners who were defensive of their best efforts to be "clean and responsible", farmers with a threatened future, residents with memories of acid water streaming out their taps, and government officials who were being questioned about their effectiveness. The blame game thrived.

We also found a group of people committed to understanding their local place, and committed to working towards a more harmonious future. They belonged to all kinds of groups of people, and included civil society activists, farmers, miners, mining consultants, residents, and government officials. Their mechanism of influence was the Upper Komati Catchment Management Forum (UKCMF). They formed an acid mine drainage working group, and agreed to work with the research team in unravelling the coal and natural ecosystem story.

After a while it became clear that the "bugs and plants" could only tell us part of the coal mining impact story – with a small indication of such impacts. We then encountered a passionate hydropedologist who provided a "missing link". The geology and sub-surface soils are layered – with water seeping horizontally over impermeable layers, into the wetlands and streams. Mining punctures the layers and water seeps vertically downwards, with much less feeding the wetland. Mining causes the landscape to leak.

In the meantime, the legal researchers could tell us that the law is complex and fragmented, but that there is evidence of progress towards more integrated legislation with better legal protection for wetlands – one hope being SPLUMA (the spatial planning and land-use act). The mining lifecycle laws were organised into a flow diagram of actions required by mines, and points where the process could be checked on, and where local people and other stakeholders could be involved.

By then the forum members had jointly learned from each other and from visiting specialists more about their place, and the legislated steps. This meant that together we could build a resource to empower them to interact proactively with mining processes. We also looked at the reality of how mines followed the step-wise process, and identified gaps in mining practice.

Throughout the three-year dialogue with the forum working group, we exposed power struggles between various groups – including between national government departments. These struggles meant, among other things, gaps in representation at forum working group meetings, and mismatches of regulatory activities.

At the start of this story we wrote of the economic interests of farming and mining. The "economics" of the natural world are more complex. It is a great trap to put a monetary value of the functions of ecosystems – so we looked at the multi-faceted *value* of wetlands.

Finally, at the end of three years, the forum working group had knowledge about the law, about the health of their ecosystem (including some evidence of ecological impact; the water flow being interrupted by mining; and the limitations of conventional rehabilitation - the sub-surface layers are not reconstructed). The UKCMF had collectively developed a 10-step process for oversight of mining operations based on a clear understanding of regulations. The government institutions understood their roles and responsibilities. The absence of some players indicated the limitations of formal regulation and the overall contribution is an alternative, parallel regulatory process.

This kind of multi-stranded research, embedded in local knowledge and empowerment is uncommon, and not well understood. This narrative hopes you find the details to follow written in research language, easier to understand. We also hope the outcomes takes everyone closer to sustainable and equitable natural resource protection and use.

the research team

EXECUTIVE SUMMARY

Background

This research report emanates from a fine, which was paid and then transferred to the Water Research Commission for purposes of research. As a result of a plea bargain, an agreement was reached in the Ermelo regional court (Mpumalanga) in 2009 (Case no ESH 82/11: Ermelo CAS 462/07/2009), the summary outcome of which is described below.

- Imposition of a suspended fine.
- Rehabilitation report for the affected area, to be compiled and to which the perpetrators would have to comply.
- As compensation, R1 million was to be paid (for the purpose of the proper execution of their mandated duties) to each of the following entities: WRC; Mpumalanga Department of Economic Development, Environment and Tourism, and Lydenburg Aquatic Services Office (Mpumalanga Tourism and Parks Agency).

The court order specified that these funds "may only be utilised for environmental research, awareness, protection, and training within Mpumalanga". It was also specified that the money would be used to achieve the objectives outlined below:

1. Developing standard methods for ground-truthing and refining the current NFEPA data layers relating to the extent, distribution, and type of freshwater ecosystems in the Mpumalanga Highveld coal belt, to support informed and consistent decision-making by regulators dealing with water-energy-food issues.
2. Incorporating these revised data layers into the atlas of high-risk freshwater ecosystems and guidelines for wetlands offsets, currently being developed by SANBI, to improve the scientific robustness of these tools.
3. Supporting the uptake and development of necessary capacity to apply the data, atlas and guidelines by regulators and the coal mining industry to facilitate improved quality during their planning and decision-making process.
4. That regulatory authorities and mining companies will incorporate data on freshwater ecosystems and resources into their planning and decision-making processes.
5. That decision-making relating to mining, especially when this involves trade-offs with water security and biodiversity, will be consistent and based on accurate and comprehensive baseline data on the type, condition and value of the ecosystems and associated goods and services that will be affected by such decisions.
6. The full social and environmental costs of any permanent, residual wetland loss will be internalised in mining project balance sheets, to ensure no net loss of wetland functions at a landscape scale.

The first three objectives were covered in the WRC project K5/2281 "*Supporting better decision-making around coal mining in the Mpumalanga Highveld through the development of mapping tools and refinement of spatial data on wetlands"* (Mbona et al., 2015).

The current project supports improved decision-making relating to coal mining in the Mpumalanga Highveld, responding to the court's final three objectives: moving from providing high quality information to decision makers, to confronting the broad challenges of integrating biodiversity and environmental water quality into the mining life-cycle. Objective 6 met resistance from the mining community who withheld information essential for a monetary estimate. A value of wetlands was estimated. Ensuring "internalisation" of costs has to be a regulatory function.

Rationale

The mining sector is a traditional economic driver in South Africa whose activities impact on water resources, wetlands, waste disposal and generally result in landscape alteration. As a result, coal mining in particular is one of the most contentious water users in South Africa.

This project addresses growing concerns that the impacts of mining on biodiversity and environmental water quality are not sufficiently taken into account by the current coal mining life-cycle provisions, and ultimately result in negative impacts. Two cases where such impacts have occurred were used as starting points in the current research programme, as outlined below.

- The Golfview mining case of 2009 in the Ermelo regional court, which provided the source of funding for this research.
- The Carolina acid mine drainage event of 2012 and its aftermath, which included a seven-month period when no drinking water was available, and social unrest. These events prompted the team to choose Carolina as a case study site. The Ermelo court directed the WRC to fund "environmental research, awareness, protection and training within Mpumalanga".

This project broke new ground in that it identified contested biodiversity and mining goals and linked these to the development of robust processes for the negotiation of appropriate controls and mitigation measures. As a result, we make recommendations for identified areas to preclude mining activities, and for serious consideration of a range of land-use agendas that include sustainability and economic transformation.

The research broadened the scope of sustainable landscape decision-making to include considerations such as the functioning of wetlands, water resources and biodiversity in the mining-related decision-making process. Inclusive steps incorporating sustainability concerns, relate to future land use, climate change, and the growing carbon constraints associated with coal mining and the future use of coal.

Objectives and aims

The project aims were defined as:

- **Aim 1:** Conduct an analysis of available resource and catchment-based tools aimed at sustainable development of water resources and management.
- **Aim 2: I**nvestigate and evaluate the decision-making processes followed in issuing mining authorisation.
- **Aim 3:** Determine the relationship between licensing processes and ecological infrastructure from a landscape and connectivity perspective.

- **Aim 4:** Propose an integrative decision-making process and institutional arrangement required to support licensing for sustainable use of natural capital.

- **Aim 5:** Develop guidelines necessary to understand the socio-economic value of selected wetlands, demonstrating their importance to society.

- **Aim 6:** Develop and test a multi-sectoral integrative monitoring framework linked to a decision support system that will cater for bio-physical, economic and societal needs.

- **Aim 7:** Develop appropriate capacity for officials involved in licensing, business, and affected communities.

Notes on outcomes in respect of aims

Breaking new ground

- the use of a **research approach** and methodology that is trans-disciplinary and multi-disciplinary, engaged, participatory, and action-focused;

- the recognition of the problem of controlling the environment impacts of coal mining as a **complex or "wicked" problem;** and therefore

- viewing the case study catchment as a **complex social-ecological system.**

Innovative outcomes

- identification of agriculture and mining as the two main enterprises that **both** generate employment, income **and** impose environmental impacts;

- provision of clear evidence that **mining** has long-term, **practically irreparable**, environmental impact, while **agriculture** has impacts amenable to effective remediation, and **long-term income and employment.**

- Clarifying and **synthesising the mining life cycle** with an analysis of the many legal sources of regulation;

- Provision of a detailed **legal analysis** of current and possible future, legal approaches to mining regulation with progress towards greater integration;

- Recognising **power imbalances** at several levels, but most importantly between the responsible National Departments, rendering **formal regulation largely ineffective**;

- Recognition of the non-statutory – but legally recognised – integrated water resource management institution – the Catchment Management Forum (CMF) as the **most effective intervention point** in **multi-sectoral** coal mining regulation;

- Development of a knowledge-based **framework for intervention** by a coal mining, regulatory "watch dog", that is a multi-sectoral, community of practice (the Upper Komati CMF (UKCMF) Acid Mine Drainage working group)

- Identification of limitations to traditional **wetland delineation**, and identification of hydropedology as an additional approach.

Methodology

The Carolina quaternary catchment X11B was chosen as a case study site for a number of reasons: The site is close to the site that resulted in the fine used to fund the research. Carolina was also affected by a damaging AMD event. The Upper Komati Catchment Forum has representative participation stakeholders, and is well supported by the Inkomati Usuthu Catchment Management Agency (IUCMA). The research team was therefore able to use catchment management principles to investigate decision-making concerned with coal mining and impacts on water and biodiversity. The Carolina AMD event has been well studied, providing a foundation for studying this complex social-ecological system (C-SES). The project worked on both a **multi-disciplinary** level (using the best methods of individual disciplines to understand a complex problem) and a **transdisciplinary** level (transcending disciplinary boundaries) to resolve aspects of the wicked problem of AMD is a C-SES.

Multidisciplinary investigations included a concise, integrated account of the coal mining life-cycle, including mine regulation and decision-making, and clarifying whether regulatory processes protect green infrastructure. Wetland assessments began with conventional qualitative wetland-focussed catchment assessments which were followed by a quantitative, multivariate, biodiversity assessment and a hydropedology study. A qualitative, interview-based exploration of social responses to hydro-connectivity, biodiversity, ecosystem services and ecological infrastructure was undertaken. A resource-economic perspective on wetland value took into account the serious limitations of monetary approaches.

The transdisciplinary work took the information from the disciplinary studies and integrated them throughout a three-year dialogue process with the Upper Komati Catchment Management Forum (UKCMF). Interactions were based on principles to encourage social learning. A multi-sectoral integrative monitoring framework was co-developed and linked to a decision support system to be used by participants. These included officials from various departments, mining managers and consultants, regulators from DWS and the IUCMA and a wide range of community participants. Materials developed included the handbook "*How to engage with coal mines through a catchment management forum*" (Appendix D) and a set of maps and planning instruments that were developed collaboratively and tested with participants. Appropriate levels of technology available to participants were taken into account.

Results and Discussion

Aim 1

The biophysical report identified two widely used qualitative methods to assess wetlands in a catchment context. When these provided limited results, the approach was augmented by applying established quantitative bio-physical assessment methods, and hydropedology. The legal report contains an analysis of 50 relevant instruments (Appendix A), analyses the new streamlined decision-making system; and a working group evaluation of processes.

Aim 2

The decision-making process was investigated by adopting the following approaches: a legal analysis; an analysis of requirements from the perspective of a mine manager applying for a license, interviews with mine managers, consultants, regulators; and discussions (involving a participatory action research process) with the UKCMF working group, which included information dissemination (mirroring back) on research findings. Information on the background to contestations between coal mining and other land uses was also provided.

Aim 3

The legal analysis interrogated legal provisions for coal mining regulation in relation to ecological infrastructure; in the context of social connectivity.

Aim 4

This integrated decision-making process was developed through a series of dialogues and other co-creating knowledge exercises with the UKCMF working group. Knowledge inputs were based on desktop research, specialist research, and feedback. A ten-step process provided an integrative decision-making process, rooted in the participatory catchment forum.

Aim 5

Draft guidelines, based on existing law and best practice, co-created by the research team and the UKCMF, for different users of wetlands were compiled and presented to the UKCMF, with the suggestion that these be developed further, as different rules apply to different activities. Draft guidelines referred to existing guidelines, supported by wetland assessments and a land-use economics study (Chapters 4 and 5).

Aim 6

An agreed, co-created multi-sectoral integrative monitoring framework, linked to a decision support system was developed with the UKCMF. (This is more accurately a knowledge system consonant with social learning principles.) It addresses bio-physical, economic and societal needs. This framework and decision-making support system form the bulk of the recommendations.

Aim 7

The three-year dialogue process enabled the project to encourage the growth of a community of practice, in the form of a multi-stakeholder, open working group of the UKCMF. In a “trust space”, participants shared experiences and understandings of coal mining and its impacts. Participants listened, and debated issues – arriving at consensus. At the end of the study the UKCMF AMD working group were informed about ecological infrastructure value, and competent to intervene appropriate in the mining life cycle, calling mining water users to account. Competence was built on local knowledge, particularly local geology (confirmed by the hydropedology study).

Local farmers felt vindicated as specialist knowledge was shared, and contributed to the wetland value assessment. The absence of the Department of Mineral Resources (DMR) from the project, and especially from UKCMF meetings, was remarked upon by participants. They felt that this reflected a general lack of consultation among regulators of other land uses, including agriculture and water and sanitation. In that sense, this project provided an opportunity for forum groups, who feel excluded from current decision-making, to envision alternative means of communication.

General

Decision-making concerning coal mining, environmental water quality and biodiversity, in a **C-SES** is an overall umbrella concept. The specific and distinguishing feature of this particular research, in this particular C-SES, is that it engages with the **current** process of decision-making in the case-study catchment, based in **participants' immediate and practical** experience in their participation in the UKCMF AMD working group, and the co-learning and sharing of reliable knowledge that resulted in:

- An in-depth legal analysis, from regulators, mining managers, mining consultants, activists and impacted communities;
- Analysis of contestation from a perspective of political ecology;
- Detailed understanding of wetlands as key elements of ecological infrastructure;

- A hydropedological understanding of hydro-connectivity;
- An analysis of the translation of biodiversity and EWQ into the language of ecological infrastructure;
- Co-creation of knowledge resources at different levels of accessibility to support the envisioned inclusive decision-making process.

Conclusions

Policy recommendations are presented under several headings:

Policy recommendations: General

1. Use the results to request a review of the decision-making and monitoring processes associated with coal mining and its impacts on water resources and biodiversity.

2. Call for the participation of government departments **including** the DMR, and that important that inter-governmental inputs are taken seriously and influence decision-making. It is particularly important that mining should not commence without water-use licences.

3. Improve regulations: regular inspections on environmental impacts take place; that regulation is transparent, being reported regularly and fully to the CMFs.

4. Consolidate, align and enable easy public access to local government, provincial and national plans for land use, within an appreciation of the ecological infrastructure as a basis for decisions making.

5. Encourage dialogue on future land use options — including (but not limited to) coal mining and the drivers of economic transformation, land reform and historical redress. Encourage this in an effort to reach consensus, or at least a situation where basic and more complex situations are clear to all participants, and trade-offs are possible or can at least be put into words. This needs to be a dialogue in which all voices are heard and long-term options are considered.

6. Formulate long term development trajectories in terms of the National Development Plan, including options (and resources needed) for a transition to a low carbon, Green Economy.

7. Assess coal mining options in terms of benefits to national and local economies, in relation to impacts on hydro-eco-infrastructure. Take account of land becoming functionally damaged, and preventing competing uses and development options, as a result of coal mining. Internalise costs of functionally effective rehabilitation and restoration of land (eco-infrastructure).

8. Make decisions about whether, and where, to mine coal on the basis of long-term sustainable use of landscapes, in terms of their sustainable use and impacts on eco-infrastructure, future land use and development options, benefits and costs, and socio-economic needs.

9. Catchment management forums, with the support of Catchment Management Agencies and other government departments, empowered to monitor the use of mining and related rights enabled by free access to legal instruments: for example, water use licences, mining authorisations, Social and Labour Plans, etc.

10. Streamline the decision-making and monitoring system in terms of a principled pragmatic approach to IWRM, the aim being to produce documents that are concise, accessible and honest.

11. The need for relevant government departments to participate in citizen monitoring processes through offering specialist knowledge, sharing and considering inputs, and supporting participation through capacity building, particularly for historically-disadvantaged groups.

12. With water being the central consideration of most of the land use options, the emerging Catchment Management system needs to be strengthened by providing opportunities for co-operative governance, and clear role descriptions and integration of land use plans. Processes to develop, update and extend Catchment Management Strategies are ideal opportunities for fulfilling this function (Rogers and Luton, 2011).

Policy recommendations: approach to wetlands

1. The water resource management recommendation is to make use of hydropedology mapping to identify wetlands in the Highveld grassland ecosystem **that are still hydrologically connected.** Thereafter, a moratorium should be put in place on implementation of any aspect of the coal mining life cycle (Chapters 2 and 3 and Appendices A, B and F)) within the perimeter of the still-connected wetland systems.

2. Key biophysical data and the hydropedology study indicated that the conventional wetland delineation of the first two wetland assessments would not reveal wetland impacts until it was too late for remediation action. Hydropedological and hydrological connectivity studies are thus essential for identifying areas where puncturing of the sandstone layers (due to mining activities) may cause wetlands to "leak away". Similarly, there is a need to map unpunctured landscape units and proclaim such areas as "no mining zones". Without such planning, the Highveld wetlands will continue to be at risk.

3. Publish the limitations of the delineation approach in the widely-used WET Health and WET ecosystem services assessments, in enabling an early warning of wetland impact from coal mining. Therefore, make use of hydropedology to delineate Highveld wetlands for the purpose of identifying intact wetland connectivity and lobbying for effective wetland protection.

4. The DWS, DEA and DMR to engage at the highest political and administrative levels to address impunity problems in coal mining regulation and co-operative government and governance. Until such action is taken, water activism will continue to be the most effective avenue for wetland protection.

Policy recommendations: legal aspects

1. There is a need to place certain wetlands, high-value biodiversity areas and important ecological infrastructures beyond the realm of contestation. Such actions will place a greater emphasis on regional and spatial planning tools and how these can contribute to placing certain geographical regions, or particular localities, off limits to mining. Rather than restricting the focus to the licensing process, the nation's conservation, biodiversity, water, spatial planning and agricultural laws must be investigated to ensure that they afford authorities the appropriate forms of power to enable authoritative delineation of land uses that respect ecological limits at the appropriate scale. Whilst conservation plans, biodiversity plans, environmental management frameworks and land use planning schemes abound, the legal status of many such plans is still problematic. The potential for the Spatial Planning and Land Use Management Act (SPLUMA) to protect wetlands, biodiversity and ecological infrastructure is worth further investigation.

2. In addition to determining appropriate uses, authorities must have the power to define thresholds for uses within particular geographical areas. Decisions in this regard must bind mining authorities. The prohibition of environmental or waste management authorisations in particular geographical areas will facilitate such actions, but there may be a need to qualify and refine such powers and to extend it to other authorities (for example to water and agriculture ministries).

3. Revisit criteria for granting prospecting and mining rights, environmental authorisations, water use licences, and waste management licences. Also, to give content to certain criteria applied by the Minister of Mineral Resources when granting prospecting or mining rights (for example, requiring that the grant will not result in 'unacceptable' pollution or ecological degradation). Unacceptability in this case should be unambiguously linked to compliance with the nation's conservation, biodiversity; and probably also food security goals.

4. Revisit timing, assessment protocols and discourses of justification frequently used when conducting site-level EIAs for prospecting and mining projects, recognising that site-level EIAs frequently perform risk management functions other than those associated with management of environmental risks. For example, such EIAs may be important to facilitate the assessment of risk exposure, in which case they will be formulated at a pre-design stage of the project. When finances are granted, any project design changes should initiate the need for an amendment. The justification discourses employed in an application for an environmental authorisation revolve around the activity and its impacts, rather than focusing on ecological infrastructure at risk. Adopting an alternative focus on licensing will enable the use of the ecological infrastructure, rather than licensing the activity, thus requiring applicants to adjust the manner in which they present ecological infrastructure valuation. Valuation should include how the difficult issues are addressed, justifying harm, dealing with substitutability and irreversible impacts, deferring decision-making, and the manner in which they present techniques of observation and care.

5. Strengthening the process for raising the ten objections identified. Where prospecting and mining are allowed to occur, the licensing of such should allow for meaningful contestation in a forum that is transparent and is not biased towards mining interests.

Policy recommendations: resource economics and green economy perspectives

1. The application of concepts and methods from ecological economics, resource economics, and externality studies is at an early stage. Presenting biodiversity and water resources concerns in the language of ecological infrastructure is finding an audience, but comes with the risks associated with conceptualising nature as 'ecological infrastructure'; and thus, commodifying ecosystems. Nevertheless, these considerations remain important for decision-making. Thus, we recommend setting up a WRC Indaba to compare and evaluate different ecosystem evaluation approaches.

2. Developing a perspective of greening the South African economy (Swilling et al., 2016) needs to be taken into account, especially concerning relationships between coal mining and competing land uses.

3. Net impact accounting (i.e. net changes in natural capital stocks and services) to be used as a common shared tool to understand, assess and drive environmental management practices by all land-users. The purpose being to convince key stakeholders to implement policies so as to reach no-net-loss, or even net gains, in key natural capital stocks (wetlands, natural and

improved grasslands) and services (foods, water supply and regulation, waste assimilation and dilution, dust regulation), depending on local context and available resources.

Recommendations for future research

1. Policy framing of the delineation approach to wetlands protection, thus seriously adding to the current delineation approach, which does not pay sufficient attention to the interconnectedness of water in the landscape, thus underplaying the importance of the drivers of wetland systems. Further research into the Leliefontein (Golfview Mining) case study is recommended as the project highlighted serious shortcomings in current rehabilitation approaches.

2. Research and follow-up action on the implementation of proposals of the Golder report on the AMD event in Carolina; co-operation with the UKCMF, the IUCMA, relevant government departments and mining companies, is recommended.

3. As coal mining comes under increasing pressure from climate change regulations and competition from renewable energy, a series of research projects into: (i) closure policy and rehabilitation standards (covering legal, institutional (regulation); (ii) participation and technical aspects of rehabilitation) should be undertaken to ensure that landscapes and water resources are not damaged by current formal and informal coal mining to the extent that their value cannot be recovered.

4. Participatory research, supported by technical research into an array of options that should focus on the healthy use of water and soil in a healthy environment.

5. Participation of CMFs in decision–making systems should continue with respect to coal and other land uses that impact negatively on water resources.

6. Research into appropriate accessible decision-making systems as well as monitoring coal mining and its impacts on water resources, should continue to engage the support and participation of citizens.

Recommendations for a knowledge dissemination strategy

The major ‘dissemination’ or knowledge co-creation process was the three-year UKCMF dialogue process. Additional dissemination steps are proposed, in consultation with the reference group.

1. A contestation dialogue between water protection and coal mining, to improve the quality of decision-making and monitoring within a catchment management framework.

2. Publication of article(s) on results of current research in *SA Water* (academic publication) and the popular-science magazine *Water Wheel*.

3. Printing and distributing the handbook for capacity building in CMFs, “How to engage with coal mines through a catchment management forum”.

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AEV	Acute Effect Values
AMD	Acid Mine Drainage
ASPT	Average Score Per Taxon
BFAP	The Bureau for Food and Agricultural Policy
CCA	Canonical Correspondence Analyses
CER	Centre for Environmental Rights
CEV	Chronic Effect Values
CHAT	Cultural Historical Activity Theory
CMA	Catchment Management Agencies
CMS	Catchment Management Strategy
C-SES	Complex social-ecological systems
CSIR	Council for Scientific and Industrial Research
DAFF	Department of Agriculture, Forestry and Fisheries
DCA	Detrended Correspondence Analysis
DMR	Department of Mineral Resources
DO	Dissolved Oxygen
DWAF	Department of Water Affairs and Forestry
DWEA	Department of Water and Environmental Affairs
DWA	Department of Water Affairs
DWS	Department of Water and Sanitation
EA	Environmental Authorisation
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EMP	Environmental Management Programme
EWQ	Environmental Water Quality
FSE	Foundation for Sustainable Environments
GIS	Geographical Information System
GN704	Regulations on Use of Water for Mining and Related Activities aimed at the Protection of Water Resources (GN704 GG 20119 of 4 June 1999)
HEJN	Highveld Environmental Justice Network
HGM	Hydrogeomorphic
IAS	Invasive Alien Species
ICMA	Inkomati Catchment Management Agency (historic)
IDP	Integrated Development Plan
IUCMA	Inkomati-Usuthu Catchment Management Agency
IWRM	Integrated Water Resource Management
KOSH	Klerksdorp-Orkney-Stilfontein-Hartebeesfontein
MACUA	Mining Affected Communities in Action
MEA	Millennium Ecosystems Assessment
MEC	Member of Executive Committee (provincial minister)
MEC	Minerals Energy Complex
MEJCON	Mining and Environmental Justice Alliance of South Africa
MPRDA	Mineral and Petroleum Resources Development Act 28 of 2002
MSA	Municipal Systems Act 32 of 2000
MTPA	Mpumalanga Tourism and Parks Agency
NDNR	Nooitgedacht Dam Nature Reserve
NEMA	National Environmental Management Act
NEMAQA	National Environmental Management: Air Quality Act, 2004
NEMBA	National Environmental Management: Biodiversity Act 10 of 2004

NEMICMA	National Environmental Management: Integrated Coastal Management Act 24 of 2008
NEMPAA	National Environmental Management Protected Areas Act 57 of 2003
NEMWA	National Environmental Management: Waste Act 59 of 2008
NFEPA	National Freshwater Ecosystem Priority Area
NGO	Non-Governmental Organisation
NHRA	National Heritage Resources Act 25 of 1999
NWA	National Water Act
PCA	Principal Components Analyses
PES	Present Ecological State
PII	Principle of Infinity Intersubstitutability
RDM	Resource Directed Measure
RMDEC	Regional Mining Environment Development Committees
RQOs	Resource Quality Objectives
SAHRA	South African Heritage Resources Agency
SAM	Strategic Adaptive Management
SANBI	South African National Biodiversity Institute
SARS	South African Revenue Service
SASS	South African Scoring System
SCA	Supreme Court of Appeal
SDC	Source Directed Control
SPLUMA	Spatial Planning and Land Use Management Act
TDS	Total Dissolved Solids
TPNP	Towards Practising a New Paradigm
TWQR	Target Quality Ranges
UKCMF	Upper Komati Catchment Management Forum
WatRES	Water-related Ecosystem Services
WMA	Water Management Areas
WRC	Water Research Commission
WWF	World Wide Fund for Nature

1 BACKGROUND AND INTRODUCTION

1.1 General introduction

Problem statement.

Coal mining impacts, land use decision-making, positioning of project in terms of related Water Research Commission and other coal mining and ecological infrastructure research.

The South African mining sector impacts on water resources wetlands, waste disposal, and landscape features. Coal mining is one of the most contentious water users in South Africa (CER, 2016), raising concerns that its impacts on biodiversity and environmental water quality are not sufficiently taken into account by current coal mining decision-making processes if this decision-making process is taken to include monitoring and compliance enforcement as implied in the title of this research report. Two cases where such impacts have occurred provide the starting point for this report: the Golfview mining case of 2009 in the Ermelo regional court (the source of funding for this research) and the Carolina acid mine drainage event of 2012 and its aftermath (Tempelhoff et al., 2012, McCarthy and Humphries, 2013).

The present project addresses the basis of mining-water resource protection policy and provides an opportunity to align biodiversity and mining goals with the development of robust negotiation processes, appropriate controls, mitigation, and decisions to restrict mining.

Catchments can be regarded as complex social ecological systems, the management of which requires transdisciplinary action research (*sensu* Max-Neef 2005, Rogers and Luton 2011) while balancing the needs of water resource protection and water resource use. The present report focuses on wetland conservation and water use licensing in relation to the mining industry as a water user, paying particular attention to abstraction, waste disposal and landscape transformation (including wetland degradation and destruction). The recognition of ecosystem services in relation to ecological infrastructure provided a foundation to decisions relating to land use evaluations, leading to the adoption of a system of weighting against alternative development paths. The concept of hydro-connectivity in a total landscape was encouraged as a focus by the reference group for this project.

This project addressed the contested arena of mining in relation to water resource and biodiversity protection by developing and testing an integrated water resource quality management plan to facilitate streamlining of conservation mandates, minimising duplication of effort, and specifying roles and responsibilities of different authorities assisted by a decision support system (DSS) appropriate to adaptive, participatory and inclusive management.

Lessons from this research, undertaken in the Upper Komati, can be extended to selected parts of the Olifants River catchment where threats are greater and the context more complex. The successful implementation of the decision-making process developed in this project has the potential for other applications, aimed at avoiding unnecessary environmental degradation, while maintaining appropriate benefits that mining offers in terms of economic growth and the streamlining of licensing and other regulatory procedures. The system also supports fair negotiation and decision-participation by catchment residents.

The project resulted in the growth of a strong and open multi-stakeholder working group in the UKCMF (as detailed below). Despite repeated invitations, the Department of Mineral Resources (DMR) did not respond or attend.

This introductory chapter engages with the central problem statement and situates its intellectual and policy contribution in terms of related WRC and other research into coal mining, wetlands, issues of ecological infrastructure and social-ecological hydro-connectivity. It introduces issues addressed in this project, as well as the choice of Carolina as a research site while providing discussion on project objectives and how these were achieved. The final section provides an overview of the report contents and the five Appendices.

1.1.1 Background and project aims

This report emanates from a penalty fine, paid and then transferred to the Water Research Commission for the purposes of research, as a plea bargain agreed to in the regional court for the regional division of Mpumalanga in Ermelo in 2009, case no ESH 82/11 (Ermelo CAS 462/07/2009). The case is available on line at cer.org.za/wp-content/uploads/2013/05/Golfview+Plea+a

The accused (Golfview Mining/Anker Kolen) had pleaded guilty to "contravening Section 28 (14) (a) read with Sections 1, 28(15), 32, 34, 34B, 34C and 34H of the National Environmental Management Act 107 of 1998 and admitted that from March 2009 to August 2010 at Portion 18 Leliefontein 136 IT farm Ermelo (Regional division, Mpumalanga) it had "*wrongfully and negligently committed acts or omissions which are likely to affect the environment in a significant manner*". The contraventions were summarised in three counts:

- On Count 1: the accused admitted to mining "…*within a wetland; and or the diversion of the Holbankspruit as well as an unnamed tributary to the Holbankspruit and or; the inadequate pollution control and evaporation dams on site; and or failure to separate dirty and clean water at the mining site; and or failure to construct an evaporation dam with specific requirements outside the box-cuts according to the EMP; and or constructing and using a washing bay on site on a downslope towards to Holbankspruit; and or failing to deposit the 'run of mine coal' (ROM) within each opencast box-cut areas.*"
- On Count 2, the accused admitted that "*during the period March 2009 to August 2010 at portion 18 of Leliefontein farm 136 IT Ermelo in the Regional division of Mpumalanga, the accused wrongfully and negligently used water otherwise than as permitted under the National Water Act to wit: Impeded or diverted the flow of water in a watercourse in terms of section 21(c); and or altered the bed, banks, course or characteristics of a watercourse in terms of section 21(i)*".
- On Count 3, the accused admitted that "*during the period March 2009 to August 2010 at Portion 18 Leliefontein farm 136 IT Ermelo in the Regional Division of Mpumalanga, the accused wrongfully and negligently commenced with activities listed in terms of section 24(2)(a) and (b) without the Department of Environmental Affairs issuing an environmental authorisation for the activity – to wit:*
    - **<u>Listed activity No 1</u>:** The construction of facilities or infrastructure, including associated structures or infrastructure, for … any purpose in the one in ten year flood line of a river or stream, or within 32 m from the bank of a river or stream where the flood line is unknown, excluding purposes associated with existing residential use, but including canal, channels, bridges, dams and weirs… by temporarily constructing an addition bridge to cross the Holbankspruit; and or by dumping the overburden stockpiling rocks inside the river and or by constructing offices and associated structures within the 1: 10 year flood line of the Holbankspruit and or by constructing canals and or channels.
    - **<u>Listed activity No 12:</u>** "The transformation or removal of indigenous vegetation of 3 hectares or more … by transforming or removing indigenous vegetation of more than 3 hectares due to the mining activities taking place."

The outcome of the plea bargain was that (in summary):

- A suspended fine was imposed

- A rehabilitation report for the affected area would be compiled, and complied with.
- Three amounts of R1 million each were paid to the following entities: The WRC; Mpumalanga Department of Economic Development, Environment and Tourism and the Mpumalanga Tourism and Parks Agency's Lydenburg Aquatic Services office for the purpose of the proper execution of their mandated duties.

The court order specified that these funds "*may only be utilised for environmental research, awareness, protection and training within Mpumalanga*".

The Ermelo court order, based on acceptance of the plea bargain, was described as *"the largest criminal penalty ever imposed for environmental offences in South Africa*" (Mondaq, 2012). Rehabilitation costs were expected to bet between R50 million and R100 million. These penalties were widely regarded as evidence of a reversal in official attitudes towards wetlands. The court specified that the money would be used to achieve objectives that included:

- Developing standardised methods for ground-truthing and refining the current NFEPA data layers of the extent, distribution and type of freshwater ecosystems in the Mpumalanga Highveld coal belt, in order to support informed and consistent decision-making by regulators on water-energy-food issues.
- Incorporating these revised data layers into the atlas of high-risk freshwater ecosystems and guidelines for wetlands offsets, currently being developed by SANBI, to improve the scientific robustness of these tools.
- Supporting the uptake and development of necessary capacity to apply the data, atlas and guidelines by regulators and the coal mining industry in their planning and decisions making process.
- That regulatory authorities and mining companies will incorporate data on freshwater ecosystems and resources into their planning and decision-making processes.
- Decision-making relating to mining, especially when involving trade-offs with water security and biodiversity, will be consistent and based on an accurate and complete set of baseline data on the type, condition and value of the ecosystems and the associated goods and services affected by such decisions.
- The full social and environmental costs of any permanent residual wetland loss will be internalised into the balance sheets of mining projects, to ensure no net loss of wetland functions at a landscape scale.

The first three of these objectives were taken up by the WRC Research project K5/2281, published as "Supporting better decision-making around coal mining in the Mpumalanga Highveld through the development of mapping tools and refinement of spatial data on wetlands" (Mbona et al., 2015).

The current project also supports better decision-making relating to coal mining in the Mpumalanga Highveld, responding to the court's final three objectives (above), moving from the provision of high quality information to decision makers, to confront broader challenges implicit in aligning and integrating biodiversity and environmental water quality into the mining development life-cycle. The project aims are outlined below.

1. Conduct an analysis of available resource- and catchment-based tools aimed at sustainable development of water resources and management.

2. Investigate and evaluate decision-making processes followed in issuing mining authorisation.

3. Determine the relationship between licensing processes and ecological infrastructure from a landscape and connectivity perspective.

4. Propose an integrative decision-making process and institutional arrangements required to support licensing for sustainable use of natural capital.
5. Develop guidelines necessary to understand the socio-economic value of selected wetlands demonstrating their importance to society.
6. Develop and test a multi-sectoral integrative monitoring framework linked to a decision support system that will cater for bio-physical, economic and societal needs.
7. Develop appropriate capacity for officials involved in licensing, business, and affected communities.

To deal with these aims, the research applied its understanding of complexity in social-ecological systems, social learning, political ecology and an adaptive way of dealing with emergence during action research. Of necessity, this meant engaging with issues of power in the political economy while conducting a multi- and transdisciplinary project to deal with a complex social-ecological reality, to achieve this aim, the project engaged with legal, biophysical (wetland assessments and hydropedology), resource economics and political ecology questions. These knowledge inputs supported a process of dialogue, from February 2014 through to September 2016, in an open working group of the Upper Komati Catchment Management Forum (UKCMF) (see Sections 1.4 and 1.5 below).

1.1.2 Related research into coal mining and water issues

As a water-scarce country, South African regulators, decision makers and citizens need to be vigilant concerning impacts of mining on water resources (WRC, 2016), a principal that has been the subject of research for decades. The following review provides an overview of relevant, current research into coal mining and its impacts on water resources and biodiversity, with a focus on wetlands.

Before 1990, most South African mine-water-related research was conducted by the Chamber of Mines Research Organisation. Since 2000 the emphasis has shifted to the development of predictive tools and modelling techniques, with the focus on treatment options shifting to implementation and passive systems. (Burgess, 2009). The WRC's latest contributions include a South African Mine Water Atlas (WRC 2016), a Wetland atlas, and a case study on wetlands offset guidelines (Wetlands in Working Landscapes" series; WRC project K5/2230 "*Limiting and mitigating the impact of coal mines in wetlands*". Coaltech Research Association (established in 1999 as the Coaltech 2020 Research Programme) is a collaborative initiative to develop technology and apply research findings that will enable the South African coal industry to remain competitive, sustainable and safe well into the 21st century. (http://www.coaltech.co.za).

Aquatic ecologists have completed extensive studies on the impact of mining on water resources (e.g. Maree et al., 2000) particularly in the heavily impacted Upper Olifants catchment (Ashton et al., 2001; Dabrowski and De Klerk, 2013, Oberholster et al., 2013). A current focus of work in this area by the Council for Scientific and industrial Resource (CSIR) and the South African National Biodiversity Institute (SANBI) is "exploring mutually acceptable solutions" and building "constructive relationships with the coal mining sector" (Oberholster et al., 2016: 1). An early outcome of this process has been the work of the South African Mining and Biodiversity Forum, a forum facilitated by the Chamber of Mines with participation by mining companies, government departments and conservation organisations, produced the "Mining and Biodiversity Guideline: Mainstreaming biodiversity into the mining sector" (Department of Environmental Affairs et al., 2013).

The guidelines are based on six fundamental principles:

- Apply the law.
- Use the best available biodiversity information.

- Engage stakeholders thoroughly.
- Use best practice environmental impact assessment (EIA) to identify, assess and evaluate impacts on biodiversity.
- Apply mitigation hierarchy in planning any mining-related activities and development robust environmental management programmes (EMPs).
- Ensure effective implementation of the EMP, including adaptive management. (DEA 2013: 4).

The first step in the mitigation hierarchy (DEA et al., 2013: 19) calls on mining projects to avoid or prevent negative impacts on biodiversity, by "*considering options in project location, siting, scale, layout, technology and phasing to avoid impacts on biodiversity*." but also states that "*This … option …is not always possible. Where environmental and social factors give rise to unacceptable negative impacts, mining should not take place. In such cases, it is unlikely to be possible or appropriate to rely on the latter steps in the mitigation*."

The second step in the hierarchy "*consider[s] alternatives in the project location, siting, scale, layout, technology and phasing that would* ***minimise impacts*** *on biodiversity and ecosystem services*."

The third step refers to "***rehabilitation*** *of areas where impacts are unavoidable and measures are provided to return impacted areas to near-natural state or an agreed land use after mine closure. However, rehabilitation may fall short of replicating the diversity and complexity of a natural system*."

The fourth and final step is to offset impacts. This refers to "*measures over and above rehabilitation to compensate for the residual negative effects on biodiversity after every effort has been made to minimise and then rehabilitate impacts.* ***Biodiversity offsets*** *can provide a mechanism to compensate for significant residual impacts on biodiversity*."

Concerns about degradation of wetlands are widespread in South Africa. A recent review of depressional wetlands (pans) in South Africa (De Klerk et al., 2016) states that "*since the 1960s South African wetlands have been recognised as important aquatic ecosystems … commonly impacted by unsustainable social and economic pressures, for example agriculture, industries, mining, overgrazing, water abstraction and the discharge of disposal of sewage waste*" (De Klerk et al., 2016: 1 citing DWAF, 2004). As a result, "*in South Africa between 35% and 50% of wetlands have already been lost or severely degraded*" (De Klerk et al., 2016: 1 citing Dini, 2004).

Wetlands have received much research attention. Important publications include the following: DWS 2014 "Guideline: Assessment of activities/developments affecting wetlands" (DWS, 2014); The Cape Nature factsheet "A landowner's guide to managing wetlands"; the Mining and Biodiversity Guidelines (DEA et al., 2013); "Guidelines for Integrating the Protection, Conservation and Management of Wetlands into Catchment Management Planning (Dickens et al., 2003) and "Wetlands and people (Kotze, 1996).

The WRC WET series from 2007 "*offer[s] a sound scientific basis for planning, implementing and evaluating wetland rehabilitation, providing guidelines to: develop an overall planning framework (WET-RehabPlan); assess the condition of catchments and individual wetlands (WET-Health); assess the functions and values of individual wetlands (WET-EcoServices); evaluate the need for rehabilitation (WET-Prioritise and WET-Legal); identify why wetlands degrade and what rehabilitation interventions are appropriate (WET-Origins and WET-Methods); guide the selection and implementation of rehabilitation methods (WET-Methods); monitor the success of rehabilitation projects (WET-Rehab-Evaluate and WET-EffectiveManage)*" (Dada et al., 2007).

The '*Wetlands in Working Landscapes'* and related research generally focuses on two themes: providing support to better decision-making around coal mining in the Mpumalanga coalfield through the development of mapping tools and refinement of spatial data on wetlands (Mbona et al., 2015), and a High-Risk Wetland Atlas for mining planners including regulators. The South Africa Mine Water Atlas is a resource that maps "*the un-mitigated threat of mining to water resources across South Africa*", by consolidating and making available existing but fragmented data "pertaining mostly to "*mineralogy, water quality, flow, present ecological state and hydrogeological information", in the hope that this "…will help water resource managers from all sectors to understand where the vulnerabilities are, and lead to more co-ordinated decision-making*" (WRC, 2016: 6).

The second theme is to make available to mining companies the option of wetland offsets as part of the water use authorisation process (in the case of the destruction of wetlands) so that there would be no net loss of wetland functions and values (Macfarlane et al., 2016a), thus providing offsets as a final mitigation or compensation measure. This policy direction, supported by an introductory guide to wetland rehabilitation (Macfarlane et al., 2016b), uses the example of the rehabilitation of the Zaalklap wetland, near Emalahleni, (in: Oberholster et al., 2016).

Adopting a multi-disciplinary approach, this study provides a comparative assessment at five different points before and after rehabilitation involving improvements in water quality (sulphate, total dissolved solids, pH, alkalinity, chlorophyll and arsenic), the status of the bacterial consortium and freshwater algal communities, assessment of mine water impacts on selected vegetation, and teratogenic potency and embryotoxicity of contaminated surface water from Grootspruit. It concludes with a study in resource economics which finds that "*…by rehabilitating the Zaalklapspruit at a cost of R1.7 million, we have been able to produce R130–R560 million on the natural asset balance sheet of South Africa"* (Oberholster et al., 2016). The main reasons for this evaluation were the provisioning and cultural services provided by the wetland, its regulating services, and its service of water purification and waste assimilation dealing with contaminated mining water emanating from the ash dumps of Highveld Steel, the Anker Coal Elandsfontein colliery and other upstream mining operations.

Despite these guidelines, more refined knowledge on the vulnerability of water resources to coal mining impacts, coal and water pollution issues have increasingly attracted critical attention of civil society and the media. Such discussions move beyond the provision of data and negotiations in the mining companies' comfort zone, to questioning the mining of coal altogether in the light of climate change concerns, air pollution (as a result of coal use) as well as water- and land- pollution related to the mining process (see Hallowes and Munnik, 2016). In addition, there are concerns about the effects of coal mining on South Africa's food security (BFAP 2012) as well as mining activities that impact on protected areas and strategic water resource areas (the 8% of the combined surface area of South Africa, Lesotho and Swaziland provide 50% of the country's water (see WWF, 2011).

Such studies have received the co-operation of the CSIR. In 2016, the Centre for Environmental Rights published a report (entitled "Zero Hour") in which the Department of Mineral Resources, together with other government departments, were accused of poor governance in relation to mining, as it had allowed the violation of environmental rights in Mpumalanga. In such perspectives, there is an assumption of a carbon constraint on the expansion and continued operation of the coal industry (relating to coal-fired power stations and exports of coal) in the context of climate change.

The present literature review provides information on a new style of questioning concerning decision-making within the coal mining life cycle. In particular, it supports the alignment and integration of biodiversity and environmental water quality with coal mining activities.

Other literature dealing with C-SES, legal regulation of mining, and valuation of ecological infrastructure are introduced in Chapters 3, 4 and 5.

1.2 Aligning and integrating biodiversity and environmental water quality into the mining development life-cycle

While the research mentioned above represents an impressive body of work, it is limited in the sense that there is no consideration of the actual decision-making process: It is limited to providing important scientific expertise, in relation to the extent, biodiversity importance, and spatial ordering of wetlands, based on the assumption that better data provision will lead to better regulation. This research is essentially pragmatic in that it seeks consensus with coal miners within a horizon that assumes ongoing and even increasing coal mining. While such an approach has the benefit of immediate relief and implementation, it excludes important perspectives relating to the decision-making process (see Chapter 2).

Decision-making (and subsequent monitoring) is a complex social, political and economic process. While quality data is a prerequisite for good decision-making, it is not sufficient. The decision-making process is, at heart, one of balancing conflicting interests, including those of future generations and land users. The balance between coal mining and other present and potential land uses, has consistently been described as 'absent' by participants in this project. In response, the present project provides an opportunity to develop an adaptive, participatory and inclusive integrated water resource quality management framework, the aim of which is to facilitate streamlining of conservation mandates, minimise duplication of effort, and clearly specify roles and responsibilities of different authorities, complemented by a decision support system.

Such an approach needs to deal with conflicts and contestation around coal mining as symptoms of a more fundamental problem (outlined in Chapter 2), namely that coal mining emerges as a privileged land user during the process of decision-making concerning land uses. A fundamental issue is that badly-regulated coal mining developments place water-based eco-infrastructure at risk, which is not only important for current alternative land uses, but also for the potential future transition to a low carbon (or green) economy (CER 2016, Swilling et al., 2016). To create an inclusive, open, multi-stakeholder space to explore these issues, the project undertook a process of dialogue and capacity building within the Upper Komati Catchment Management Forum (see 1.3 for a discussion on the reasons for locating this dialogue in the UKCMF).

In the context of this research, the umbrella concept implies that decision-making concerning coal mining, environmental water quality and biodiversity takes place within a **complex social-ecological system**. River catchments are viewed as complex adaptive systems (Cilliers, 2000). Human activities, such as land-use change, create modifications to ecological structures and functions that affect ecosystem resilience (the capability of a system to absorb disturbance and sustain a similar state) (Folke, 2003; Biggs et al., 2015b). Interlinked and interdependent components make up complex adaptive social-ecological systems. The support and strengthening of such systems requires a shift in thinking (Folke, 2003; Ison, 2010), sometimes referred to as complex systems thinking, an approach that adopts resilience, adaptability and learning to embrace uncertainty and change, as opposed to trying to control change (Folke, 2003; Ison, 2010). The former approach involves taking a holistic view of the multiple linkages between social and ecological elements while allowing for adaptive management as a response to uncertainty (Folke, 2003; Costanza et al., 2016).

System elements include social and ecological components, the latter of which range from cells, individual species of fauna and flora, to soil, water and ecosystems (Biggs et al., 2012). Social components include landscape users and governance systems (Holland, 1994; Biggs et al., 2012). Each element within the ecological (biotic and abiotic) and social components has its own properties and functions (Odum and Barrett, 1971; Pianka, 2011; Biggs et al., 2015a). Properties and functions of the catchment are a reflection of individual components, within and between different levels of ecological and social hierarchy, interacting with each other (Noss, 1990; Pollard and du Toit, 2011; Biggs et al., 2015a). Interactions within and between components, drive cause and effect relationships, and a network of integrated and interdependent parts emerge as a system (Pollard and du Toit, 2011; Ison et al., 2007).

Berkes and Folke (1998) describe an "integrated system of ecosystems and human society", such as a catchment, a complex social-ecological system (C-SES). Such systems are characterised by the phenomenon of emergence, an example being the emergence of direct and indirect services from an ecosystem. These services are the result of the cumulative outcomes of interactions throughout the system, starting as selection processes and interactions at the basic levels of an ecological hierarchy (Pollard et al., 2013; Biggs et al., 2015a). The concept of C-SESs adopts a "humans-in-nature perspective", thus recognising social and ecological components as interdependent elements (as opposed to the traditional understanding of all components being separate entities of a system (Walker and Salt, 2012; Audouin et al., 2013; Biggs et al., 2015a).

Because of its broad ambition, this approach requires definitions of boundary, the central idea being that "*tensions arise at the interface between communities with different views of what constitutes reliable or useful knowledge*…" (Clark et al., 2016: 4615).

The distinguishing feature of this research is that it engages with current process of decision-making, based in participants' immediate and practical experience, supported through the development and sharing of reliable knowledge, as outlined below:

- In-depth legal analysis, from a number of points of view, including those of regulators, mining managers, mining consultants, activists and impacted communities.
- Contestation analysis from a perspective of political ecology.
- A detailed understanding of wetlands as key elements of ecological infrastructure.
- A hydro-pedological understanding of hydro-connectivity.
- Analysis of the translation of biodiversity and EWQ into the language of ecological infrastructure.
- The co-creation of knowledge resources at different levels of accessibility to support envisioned inclusive decision-making processes.

The project thus worked on both a multi-disciplinary and a transdisciplinary level, both of which require boundary work.

A central hypothesis is that *"… boundary work is more likely to be effective in promoting used and useful research to the extent that it exhibits at least three key attributes: (i) meaningful participation in agenda setting and knowledge production by stakeholders (ii) governance arrangements that assure accountability of the resulting boundary work to relevant stake-holders and (iii) the production of "boundary objects" (collaborative products such as reports, models, maps, or standards that "are adaptable to different viewpoints while remaining robust enough to maintain identity*" (Clark et al., 2016: 4615).

During this process a number of other concepts, approaches and discourses emerged as important boundary concepts.

The concept of **hydro-connectivity** emerged as an important boundary concept, meaningful to local participants. It bridged the divide between local and expert knowledge. For example, local farmers' knowledge of geological and groundwater features as well as an appreciation of soil fertility accorded well with hydropedology analysis (see Appendix C) and helped to bridge the divide between social and natural science. This process enhanced stakeholder understanding of the threat of mining to wetland ecological infrastructure.

Ecological infrastructure was another interesting concept. While participants in the dialogue process had an appreciation for the effort to "value nature", to include into a money-based decision-making processes, they baulked at the idea of translating nature into monetary terms, fearing that it would be an under-estimate and risk encouraging the "sale" of nature. Many proponents of ecological infrastructure arguments do not see monetarisation of nature as a necessary part of this process. A resource economics analysis of coal and agriculture land uses within an area of Carolina was used to explore this approach.

The SANBI definition of ecological infrastructure refers to "*naturally functioning ecosystems that deliver valuable services to people, such as water and climate regulation, soil formation and disaster risk reduction. It is the nature-based equivalent of built or hard infrastructure, and can be just as important for providing services and underpinning socio-economic development. Ecological infrastructure does this by providing cost effective, long-term solutions to service delivery that can supplement, and sometimes even substitute, built infrastructure solutions. Ecological infrastructure includes healthy mountain catchments, rivers, wetlands, coastal dunes, and nodes and corridors of natural habitat, which together form a network of interconnected structural elements in the landscape*." (SANBI)

The definition used by Collins (2005) refers to "*land that is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances, supports or would support vegetation typically adapted to life in saturated soil.*"

Strategic adaptive management (SAM) is an established approach to stakeholder knowledge, decision-making and monitoring. Adaptive management is intellectually well understood and developed, owing to experiences in both conservation and the Kruger National Park (see Biggs & Rogers, 2003) as well as in the water sector, particularly catchment management (see Pollard et al., 2008; Pollard & du Toit, 2011). SAM has also been applied at institutional levels in conservation planning in the Kruger National Park, and in the IUCMA area (Rogers & Luton, 2011) to move towards a desired future. This approach enables a prioritisation of strategic projects and allowed for the co-creation of the Inkomati Catchment Management Strategy with other stakeholders. This infrastructure definition allows for the absorption of large amounts of information, some of it uncertain, into a planning process that facilitates decision-making and implementation. Its flexibility enables it to avoid capture by specific interests and its commitment to social learning and inclusive decision-making leads to the creation of "communities of practice" (Wenger et al., 2011) at different levels and in different locations. The Upper Komati Forum, in which Carolina Acid Mine Drainage issues were taken up, is one such emerging community of practice.

A multi- and transdisciplinary research project team*.*

The issues raised above clearly needed a multi- and transdisciplinary approach. We argue that this is typical of all complex social-ecological systems (CSES) and that, in most cases, problems such as the impact of coal mining on biodiversity and wetlands will require such an approach to properly address issues. This research thus displays some detail on specialised research to demonstrate the range and complexity of the issues involved.

The dialogue process can be regarded as the core of this type of research. It required an approach that took into account past and current developments in South Africa's catchment management system (Munnik et al., 2015, Palmer et al., 2015) as well as skills relating to conducting dialogue within a safe space, while making use of social learning and community of practice (trust building) principles (Engeström 2001; Wenger et al., 2011)

The legal process underpins the creation of rights and obligations in coal mining and protection of water and biodiversity. It is a complex system (for example, 50 legal instruments were identified (see Appendix A). The legal setting is also in transition, because of new legislation (changing Mineral and Petroleum Resources Development Act (MPRDA)) since 1994, as well as the very recent consolidation into a single system. Chapter 3 provides a detailed discussion of relevant law and how it relates other concepts used in the research, particularly with respect to ecological infrastructure.

The legal process manifests as an administrative system with a number of detailed forms to be income completed, inspections by regulators, and knowledge to be shared. Careful research enabled the team to understand the administrative burden of applying for rights to prospect, mine coal, and close mines, reflecting a perspective of mine managers that they are "overpoliced". Such perspectives from mine managers, regulators and local community members were researched, following the Cultural Historical Analysis Theory (CHAT), then mirrored back to participants who later served as the basis for developing an alternative process.

The case study of the AMD event in which the Boesmanspruit wetland (which empties into the Boesmanspruit dam), spoiled Carolina's drinking water supply dam. This provided the empirical base and clarified the social and political threat of Acid Mine Drainage on the Mpumalanga Highveld.

Wetlands were at the centre of the research. The current ecosystem health of seven wetlands was assessed and related to current land uses through CHAT research. A range of methods to measure water quality is presented in Chapter 4. The use of hydropedology enabled the project to connect to local knowledge and to understand weaknesses in current wetland delineation and the immense difficulties associated with rehabilitating landscapes in the Carolina area after coal mining, particularly when it punctures the sandstone/plinthic, layer responsible for a perched water table. Hydropedology confirmed the connectivity of rivers, wetlands, aquifers, springs and fountains in the landscape.

This discovery and confirmation of local knowledge led to question about the efficacy of rehabilitation. The case study pointed to a number of examples – including the still unrehabilitated wetland and river reach of the original Leliefontein/Holbankspruit/Anker Kolen case – where rehabilitation has failed. Other, similar failures were highlighted in Hallowes and Munnik, 2016, and CER, 2016 (also WWF, 2011).

Political ecology was needed for this research (Greenberg & Park, 1994) because the mining and burning of coal is a highly contested activity in the context of increasing climate change and resistance from fence-line communities to pollution and interruption of livelihoods that coal mining brings such contestations should be taken into consideration during new decision-making processes relating to coal mining.

The question of value and valuations received considerable attention. A case study, based on resource economics, provided an example of deployment of concepts and pointed to the depletion of natural capital through coal mining in the area (see Chapter 6).

Our research team included aquatic ecologists, a political ecologist, a legal researcher, a hydropedologist, and a resource economist. Participants in the UKCMF brought with them extensive knowledge resources including knowledge of local landscapes, local ecology, the coal mining process, and a sense of how the landscape is connected. Participants used knowledge, and engagement with this research to help formulate a new decision-making process.

1.3 Choice of Carolina as research site

This section considers the "Carolina" case study, which centres on an acid mine drainage event in 2012.

1.3.1 Choice of Carolina as research site

The research team developed and tested the project's theoretical framework in Carolina for future, broader applications, because of numerous advantages associated with this site, when compared to the Upper Olifants Catchment.

Carolina is included in the Inkomati-Usuthu Water Management Area. As a result, it is supervised, regulated and well-studied (in terms of information gathering and consultation for the ICMA CMS, 2014). The IUCMA has established an Upper Komati Catchment Management Forum in which Carolina and surrounding mines are included (see below). This presents a future configuration for other areas that are currently without CMAs (but are regulated by proto-CMAs in DWS or regional DWS offices). As a study site, it thus provides a “glimpse into the future”, when more advanced and better resources regulation structures may become available.

Carolina experienced a dramatic Acid Mine Drainage pollution event in January 2012. Extensive historical material relating to this event is available, including administrative-legal records, such as the first inspection report, IUCMA records, a biophysical analysis (McCarthy & Humphries, 2013) and social analyses on impacts on the town (Tempelhoff et al., 2012). Multiple actions were taken in response to this incident: the IUCMA installed a number of monitoring points; the legal directives were issued to five coal mines in the area; and a consultant firm undertook a detailed study (Golder, 2014). We are thus in a position to investigate a “before and after pictures”, as well as regulatory responses, following the event. Such documents facilitate investigation into underlying mechanisms and dynamics the involvement of institutions as well as providing a case study relating to the legal instruments used to respond to the event as well as final outcomes.

In addition to the information contained in the IUCMA CMS (2014), wetland mapping projects (WRC Atlas project, for example: see previous section) as well as literature on the National Freshwater Ecosystem Priority Areas (NFEPA) areas and the Mpumalanga Biodiversity Conservation Plan.

Case study analyses, often used when events are current, may not always distinguish current events from past events. Such studies can, however, be used to compare or develop theory for broader applications (Yin, 2009). After piloting the framework in the Upper Komati, the intention is to test whether some of its recommendations can be applied to the Upper Olifants catchment.

While the Carolina case study is centred on a specific AMD event, its outcomes can be extended to pose questions concerning the conceptual relationship between ecological infrastructure and regulation instruments, as outlined below.

1. Is an appreciation of eco-infrastructure reflected in the regulatory tools?
2. Which instruments were used, before and after the AMD event?
3. Are there provisions for mine closure and rehabilitation?
4. What was the damage to ecological infrastructure, and is the damage ongoing?
5. Which institutions are involved?

Carolina, with a population of *circa* 23 000, is situated in the eastern Highveld between Middelburg and Ermelo. Its assured water supply, from fountains in the area, was a reason for its original settlement (in 1883) as a service point for farmers (Tempelhoff et al., 2012). Rapid coal mining activity in the last decade has led to a more diverse economy (McCarthy & Humphries, 2013). It is now part of the Albert Luthuli local municipality within the Gert Sibande district. Carolina, lies within the X11B quinary catchment, a sub catchment of the upper Komati (Mpumalanga) that influences the Boesmanspruit and associated tributaries (ICMA, 2014) (Golder Associates, 2014).

The ICMA (2014) identified six operational mines that occur within the Carolina quinary catchment: Tselentis Colliery (three separate mines), Mimosa (two separate Mines), and Droogvallei. One unauthorised mine and one closed mine (Witkranz) are also located within the area. There is also an application to mine — a prospecting application (Onbekend mine (Figure 1).

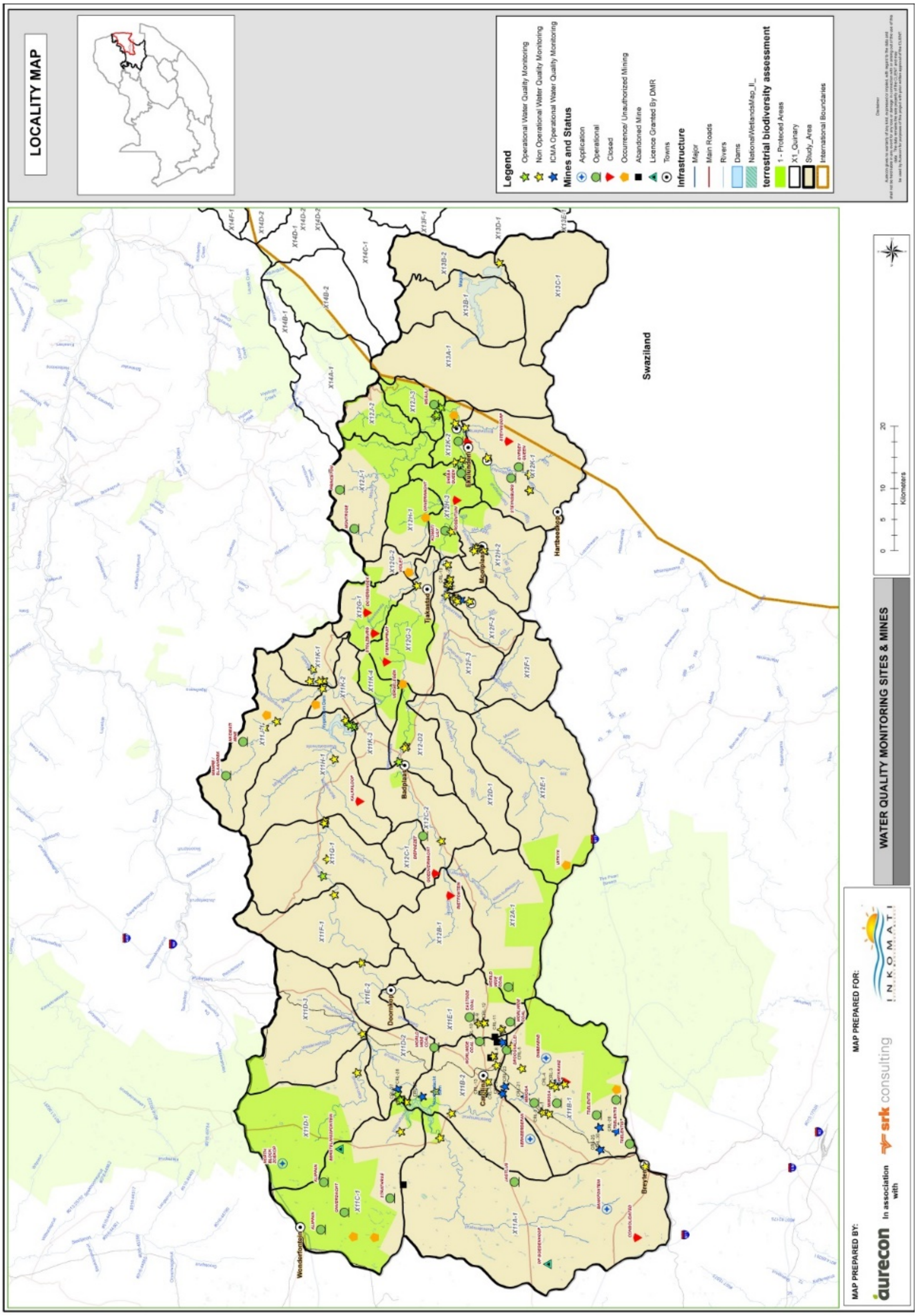

Figure 1: The town of Carolina, associated coal mines, and monitoring points within the Upper Komati catchment (figure from Golder Associates, 2014)

Golder Associates (2014) have identified five operational mining companies in the catchment, as well as numerous defunct colliers and coal sidings:

- Msobo's Tselentis Colliery located 30 km south of Carolina and 30 km north of Ermelo. Its mining rights area covers a portion of catchment X11B. Msobo has approximately 5 years' life-of-mine remaining.
- Msobo's Verkeerdepan Colliery's mining rights area is located in the vicinity of Jagtlust Colliery of Northern Coal. At the time of research, the mining right and EMP had been approved, and waiting approval of the water use licence. Prospecting has therefore only taken place at Verkeerdepan, with an expected life-of-mine of 12 years.
- Msobo also operates a coal siding (Witrand Siding 1), adjacent to the coal siding used by Northern Coal (Witrand Siding 2).
- Northern Coal's Jagtlust Colliery is located 10 km south of Carolina and 40 km north of Ermelo. Current mining is taking place at Jagtlust Colliery, north-west of the R36.
- Mimosa Colliery, Northern's second colliery, ceased mining activity in 2008 and has since been rehabilitated. A beneficiation plant still operates here, which supports operations at Jagtlust Colliery. The plant is situated roughly 5 km south-east of Jagtlust Colliery, along the R36. The mine also operates a siding (Witrand Siding 2), 1 km north-west of Mimosa Colliery.
- Siphethe Coal, located 10 km south of Carolina: operated both Witrand and Coastal Fuels Collieries.
- Witrand Colliery (now closed), located close to the R36, north of the Northern Coal processing plant premises on the farm Witrand 52 IT.
- Coastal Fuels Colliery, situated east of the Northern Coal processing plant, near the Goedeverwagting road on the farm Droogvallei 41 IT, portion 2.
- Witrand Colliery was mined as an open pit mine from 2000 to 2006. Mining at Coastal Fuels Colliery ceased before 2012, and some rehabilitation occurred. Both of these mines are presently abandoned.
- Eastside Coal Company's main operation does not lie within the X11B boundaries, but some historic bulk sampling activity took place within this catchment (Black Gold Colliery) west of the Northern Coal processing plant, 10 km south-west of Carolina. This mining area has been rehabilitated.
- Pembani Colliery, located approximately 5 km east of Carolina. Although it lies within the X11B catchment, it drains to below the Boesmanspruit Dam, flowing west and north to Nooitgedacht Dam.
- Some defunct mines, located within the X11B catchment, are listed below.
    - The Old Witrand Colliery on Msobo's Verkeerdepan Colliery property and abandoned prior to the granting of Mining Rights to Msobo Coal. Its ownership is unclear. This area has been rehabilitated, but there is a decant point on site.
    - BHP Billiton's Union Colliery, located 5–10 km west of Msobo. Although surface infrastructure is located outside the X11B catchment, historical underground workings as well as historically rehabilitated coal discard dumps fall partially within the catchment, with underground water flowing in the direction of Msobo Coal.
    - BHP Billiton's Black Diamond Colliery, located 5–10 km north-west of Msobo. Limited public data is available for this colliery but there is evidence of rehabilitated and abandoned coal discard dumps within the catchment, as outlined below.
        - An abandoned rail siding north of the Black Diamond rehabilitated and unrehabilitated discard dumps.
        - In addition to their defunct collieries Siphethe Coal also operated a rail siding immediately east of Carolina. It is now abandoned, and its runoff flows from the Boesmanspruit Dam (to the north).
        - Droogvallei coal siding, located 2k m south-east of Carolina: currently operated by Pembani, it is a joint venture between Pembani Coal and Eastside Coal Company, aka

Droogvallei Rail Siding Company which drains into a tributary of the Boesmanspruit Dam.

There are no other known active mining or industrial activities within the X11B catchment that could potentially influence the water quality of the Boesmanspruit Dam.

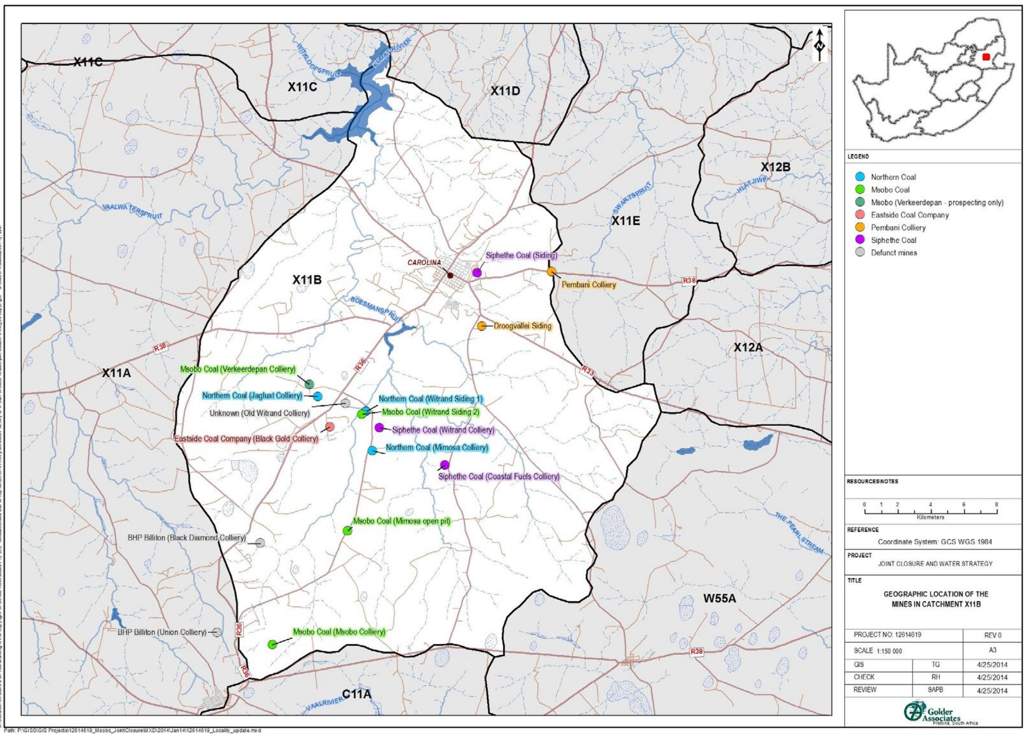

Figure 2: Quaternary Catchment X11B: current and defunct mining activity (Golder Associates, 2014)

Accounts of the 2012 AMD event in Carolina

"*On the morning of 11 January 2012 residents [in] Carolina … woke to find that their municipal tap water was undrinkable. Most … were unaware that their water had been contaminated by mine water. They were however aware that the water tasted bad and tended to burn the skin when they washed themselves*." (Tempelhoff et al., 2012: 7). There were also reports of porridge turning blue when cooked in this water.

In January, 2012, the Boesmanspruit Dam (Carolina's potable water supply) underwent a rapid deterioration in water quality, where, following a large storm, the pH dropped to 3.7, with resultant increases in iron, aluminium, manganese and sulphate concentrations, rendering the water toxic and unsuitable for use. Coal mining was believed to be the source of the contamination (ICMA, 2014). The lack of potable water supply lasted for 7 months, with emergency notices posted throughout the town. Boreholes and installed plastic water tanks were the only sources of safe water for residents (McCarthy & Humphries, 2013).

The first officials on the scene were from the Mpumalanga Tourism and Parks Agency (MTPA). The MTPA report clearly identifies the following sources through visual inspection of surface flow patterns.

The sources of AMD were found to be a result of previous activities that had taken place on the farm Verkeerdevlei, as outlined below.

- Northern Coal (Mimosa Colliery) coal washing plant, via a furrow leading from the haul road to Boesmanspruit. The report stated that "[it] washes in coal dust. No storm water control structures. Not adequate dust control measures. This soil shows high levels of sulphate (SO4)".
- The wall of the pollution control dam, associated washing plant, was breached, allowing for spillage of contaminated water into a hillslope seep wetland.
- A coal-hauling site and railway siding, "Northern Coal Witrandspruit private siding".
- White deposits of salts in the wetlands.
- Dead and dying wetland plants.
- Coal dust and pieces of coal, washed into the wetland over a long period of time (evidence obtained from hand auger tests).
- Low pH levels downstream of the coal washing plant.

This above description clearly indicates that pollution of the municipal water was a peak event in an ongoing pollution situation. Later investigations by McCarthy & Humphries (2013) showed that the pollution was the result of a complex chain of events. The extensive coal mining that had taken place in the catchment, including some severely polluted closed and decanting mines. The study suggests that the wetland, located below the mines and above the Boesmanspruit Dam, had over a period of one year when no inter-basin transfer had occurred (which, under normal circumstances, may have flushed the polluted water from the wetland) accumulated a substantial amount of pollution that was finally washed out in January 2012, a washout that would have included the over-flow from the coal mining holding dams during the same storm event. These events resulted in a decline in dam's pH to 3.7, consequently a mobilisation of heavy metals, as they become bioavailable under low pH conditions.

The measuring sites by McCarthy and Humphries are shown in Figure 3. Templehof et al. (2012) explain the transfer scheme, where water is transferred from the Jericho Dam on the Usutu scheme, which is run via the Witrandspruit to the Nooitgedacht Dam. This is done in order to have a reliable supply of water to Eskom's power stations which are found in the region. This transfer of water did not take place in 2011 due to a broken pump (Mail and Guardian, 2013).

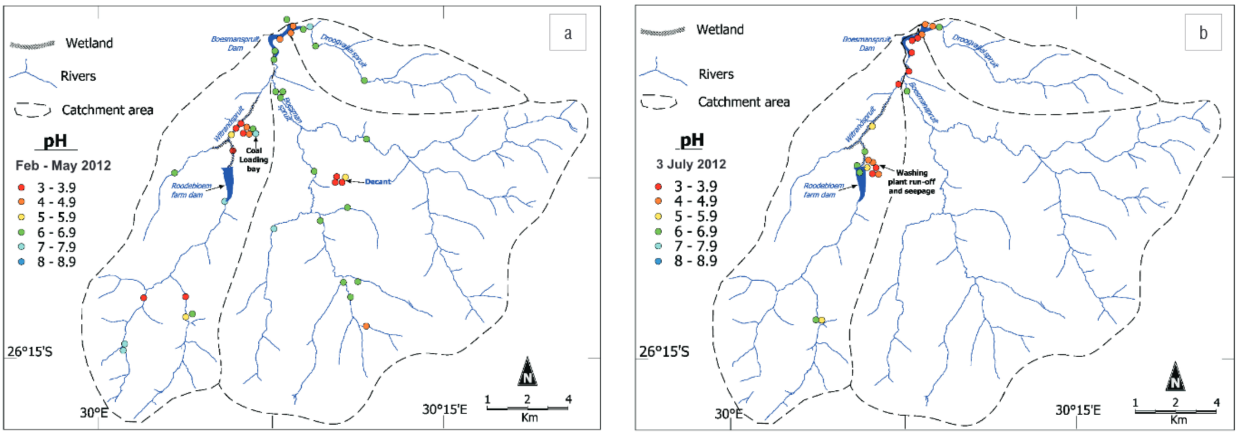

Figure 3: Changes in acidity in the Boesmanspruit catchment (McCarthy & Humphries, 2013)

The acidification of the Boesmanspruit Dam has been attributed to a combination of events (Tempelhoff et al., 2012):

- the continuous accumulation of AMD in the sub-catchment, mainly the wetland, which had the potential for a significant accumulation of pollutants;
- the 2011 cessation of the water transfer scheme, which would normally have diluted the water in the catchment and wetland and increased the buffering capacity of the sub-catchment;
- the overflow of pollution control dams at certain mines and stockyards;

- the overflow of AMD seepage control dams, exacerbated by an intense localised storm which occurred in the upper reaches of the catchment on the 10th of January 2012.

In March, 2012, the Department of Mineral Resources (DMR) issued five companies with a directive to develop a joint water and closure strategy, with clear specification requirements, as outlined (in italics) below.

The strategy must focus on negative environmental impacts as a result of your mining operations/or your neighbouring mines which can affect your planned closure objectives and the implementation of your environmental management options as described in the existing approved Environmental Management Programmes pertaining to your operation. The aforesaid strategy must incorporate the risks associated with mining (i.e. depending on the type of commodity), the following:

- *Current groundwater levels;*
- *Surface and groundwater quantities;*
- *Spontaneous combustion; and*
- *Surface subsidence."*

Msobo Coal commissioned Golder Associates to assist in the remedial actions (Golder Associates, 2014):

- Identify the risks posed by the mining operations in catchment X11B
- Assist in the creation of an interim joint closure and water management strategy.
- Identify the gaps in knowledge with regards to mitigating risks associated with future closure planning in the catchment.

The project included the following mines: Msobo Coal, Northern Coal, Pembani Coal, and Eastside Coal. Siphethe Coal did not participate.

The Department of Water Affairs (DWA) and ICMA currently have seven active monitoring points in the Carolina Quinary Catchment X11B. The parameters being monitored are dependent on activities in the area. Measured activities are limited to those relating to mining activity, including open cast mining, underground mining, coal and waste storage, holding dams and destruction/removal of the environment in Carolina, pH, Electrical Conductivity, iron, aluminium, manganese and sulphate. Monitoring points (blue stars) associated with these actions are illustrated in Figures 4.

Water quality trends are of concern in the Upper Komati, although present monitoring data suggests that the available water is available is still fit for all current water users.

The study area has naturally acidic soil (lacking alkalinity). There is thus a low natural ability in surface waters to counter the effects of AMD, confirmed by in-stream water quality in areas unaffected by mining. The presence of AMD has been confirmed in other study areas, as evidenced by high total dissolved solids, high sulphate concentrations and fluctuating pH levels (Golder Associates, 2014).

It can be argued that acid mine drainage overwhelmed the ability of the wetland to act as a natural filter, and that this process had been masked by regular flushing of the wetland due to the Eskom water transfer.

The interruption lasted seven months, leading to high costs and inconvenience for Carolina: buying water, queuing for water, and driving long distances to wash clothes in other towns. Local residents noticed the bad taste of the water, and that it tended to burn the skin when they washed themselves. Social responses to the AMD event provided some insights impact dimensions and how these could be valued.

Within days, municipal officials and key community leaders held a crisis meeting (on 26 January 2012) and by the end of the month there were reports of people becoming ill after drinking the municipal water.

On 10 February 2012, more than a thousand Carolina residents held a peaceful march, to demand clean water. This was not new: as far back as 2003 residents had marched to demand clean water. Based on Blue Drop evaluations of 2010, 2011 and 2012, the municipality was one of the worst performers in Mpumalanga (Tempelhoff et al., 2012). Local activist Dr Koos Pretorius argued that the municipality could not be expected to treat acid mine drainage in its raw water. People queued for water brought in from other municipalities (at an estimated cost of R1.3 million from January to early May). During this period, care takers from the two mosques in Carolina allowed everybody free access to their water reserves (Tempelhoff et al., 2012).

In February 2012, the DWEA Rapid Response Unit (RRU) started working with the municipality. On 10 March 2012, Water and Environmental Affairs Minister Edna Molewa visited the town and announced support of R3 million to immediately fix the problem. The minister personally issues pre-directives to the five mines. In May 2012, a senior member of the Mpumalanga provincial government announced that the Green Scorpions would investigate the situation.

A second protest followed in May 2012. Municipal buildings were set alight, and Pakistani shops were looted and burnt. Six police officers and three protesters were injured. In July 2012, the Federation for Sustainable Environments, the Silobela Concerned Residents Association and the Lawyers for Human Rights took the local Chief Albert Luthuli municipality to court. A week later the judge ordered the Gert Sibande district municipality to provide water for residents within 72 hours, which prompted an appeal from both these authorities (local municipality and district municipality) against the order on 26 July 2012.

The AMD event showed that not only the wetland was overwhelmed by the AMD pollution, as were the local and the district municipalities, events that led to court cases, negative publicity, and a violent march that resulted in injury to people and damage to property. National departments had to intervene and citizens had to find alternative water supplies for seven months and had to engage in various forms of activism to gain attention. The breaching of an ecological threshold thus had serious effects on the social and political capital of the area.

1.3.2 Carolina: biodiversity, water transfers and acid mine drainage

The section that follows is a very preliminary description of Carolina's biodiversity patterns. It is given here to provide a general orientation.

According to the ICMA (2014), the terrestrial biodiversity assessment has put the area of Carolina as 'important and necessary' to the south west, 'irreplaceable' to the north, and either 'highly significant' or 'no natural habitat' remaining for the rest (Figure4). Carolina falls within a vulnerable eco-status, according to the SANBI Ecosystem Status (Figure 5).

The MPTA (2012) report states that "*This area is …in a vulnerable vegetation type known as Eastern Highveld grassland (Gov. Notice 1002, Dec 2011), numerous NFEPA wetlands occur in the area… According to the MBCP, 2007 (Mpumalanga Biodiversity Conservation Plan) the terrestrial biodiversity in the catchment of the Boesmanspruit is highly significant and the aquatic biodiversity is also highly significant and needs to be protected.*"

Species richness of wetlands in the area includes red data fauna and flora. The importance of the wetland areas for the Komati catchment is also emphasised and the observation, as a result of extensive agricultural activities, these wetlands probably sustain the last biodiversity centre of these areas, representing corridors that link other remnant areas along which movement of genetic material can still take place.

Carolina also forms part of the important grassland biome (SANBI, 2013).

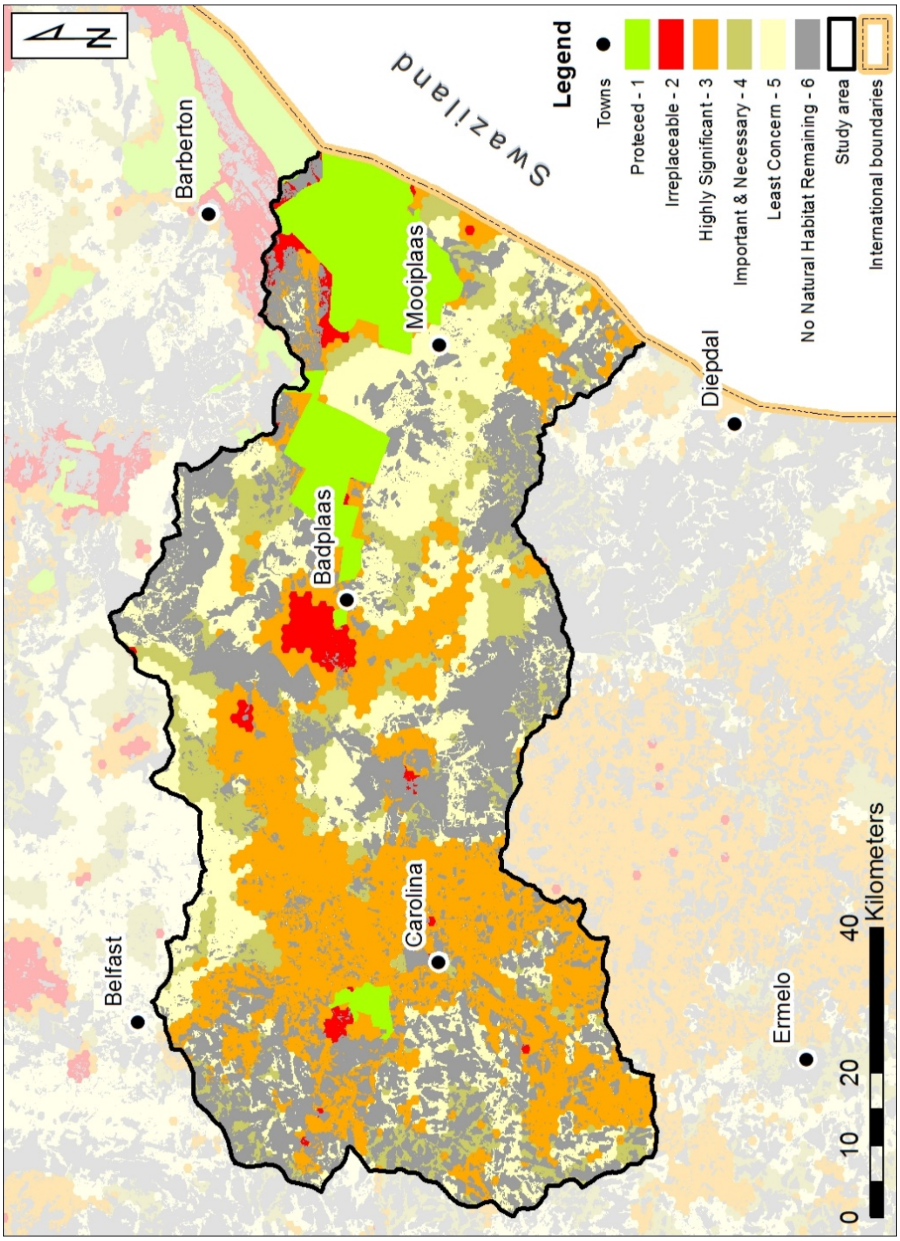

Figure 4: Terrestrial Biodiversity Assessment (ICMA, 2014)

An interesting aspect of Carolina's looming AMD crisis is how it was masked by the Eskom water transfer scheme (the Komati Water Scheme, transferring 132 million cubic meters of water per year from Nooitgedacht and Vygeboom dams to Arnot, Hendrina, Komati and Duvha, power stations of Eskom). The diluting water came from the Usuthu catchment. Carolina – and its AMD spill – is therefore part of a larger structure, moving water upstream and into the Vaal catchment, for power generation to several power stations. This water transfer is described as "strategic", meaning that it takes precedence over other water uses (Fine & Rustomjee, 1996).

The system can thus be regarded as an example of an ecosystem services footprint that extends into the Upper Komati system, and operates at a far larger scale. The AMD incident pointed to the ability of this bigger system to (1) mask the ongoing contamination of the local wetland and (2) remove the evidence through a single flushing of the system. Such an overwhelming outside system thus poses challenges to local understanding of, and decision-making about, ecological infrastructure and services.

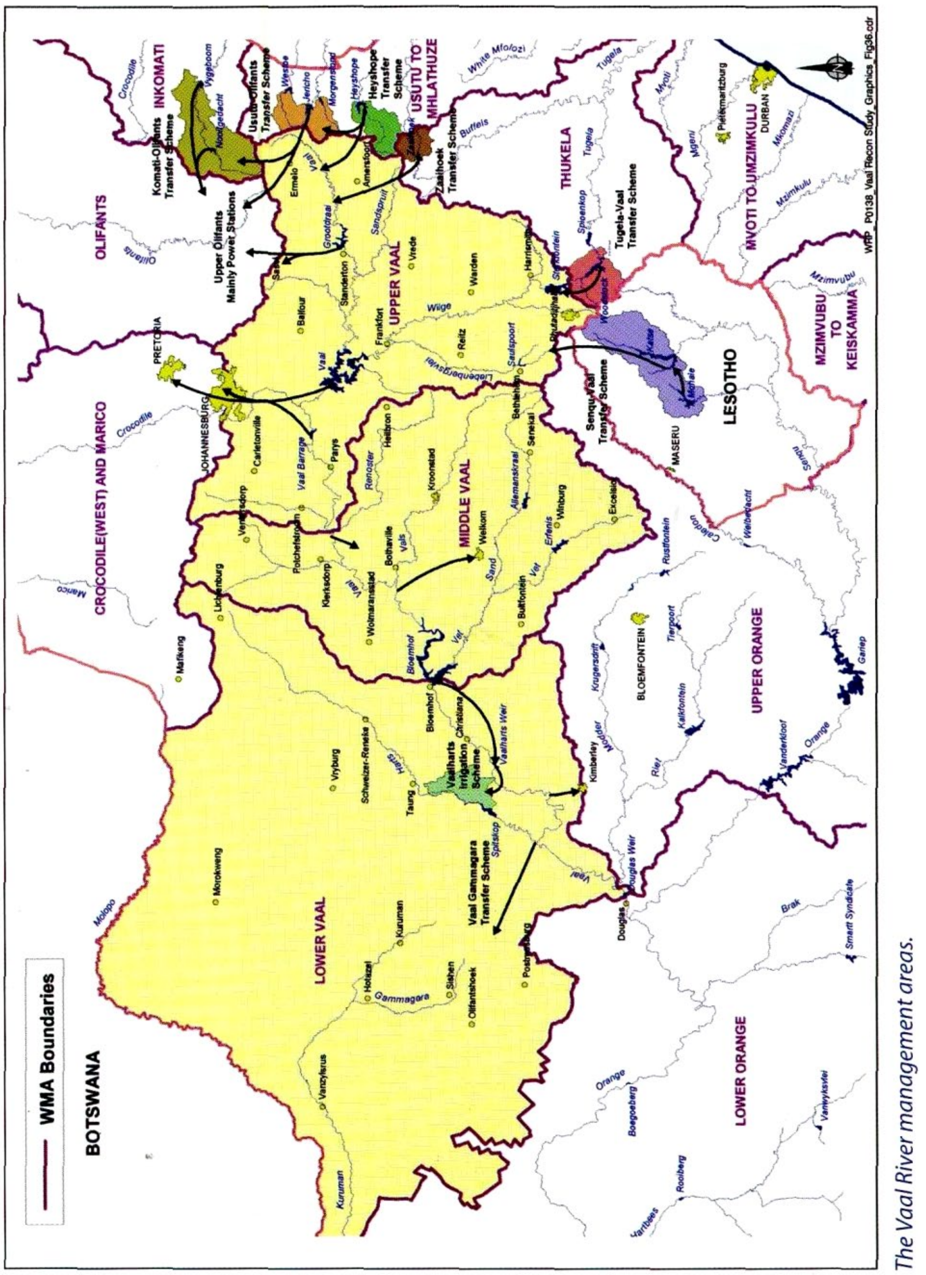

Figure 5: Carolina water resources form part of an elaborate water support system to coal-fired power generation

Upper Komati Catchment Forum (UKCF) and the Acid Mine Drainage Task Team

The UKCF was established in 2008 as part of the then ICMA establishment. The forum was not very active when the AMD event occurred but after some time the ICMA drew the discussion into the Upper Komati Forum, where it belonged (Tony Sibiya, IUCMA, personal communication, Oct 2014). In 2014, an AMD task team was established with a wide range of stakeholders, to "*assist the IUCMA [to manage] water resources … for the benefit of all users …*".

Its draft terms of reference listed the following objectives (document distributed at the meeting of, 22 Oct 2014):

- Establishment of a database and GIS map of mines in the Upper Komati detailing information such as location, owners, water uses and expected life of mines.;
- Identify problem areas (within the catchment) that are associated with mining related impacts;
- Ensure the implementation of measures for short, medium, and long-term projects aimed at remediating, preventing and treating mine- related decants;
- Facilitate, enable and strengthen co-operative governance between national government, provincial government, local government and parastatal;
- Establish and determine the roles and responsibilities of various stakeholders including mining houses and government institution
- Engage, or make recommendations for, the implementation of remedial actions on priority case studies such as abandoned, or derelict mines, with associated impacts on water resources;
- Encourage co-operation and buy-in by mining houses and the DMR to implement mitigation measures to protect water resources.

In the light of its comprehensive membership, including regulators, [representatives from] government department and the mines, and all interested and affected parties the UKCMF and AMD task team were seen as ideal settings for the social learning process. For details of the dialogue process, see Chapter 6.

1.4 Ecological infrastructure, resource economics and the challenge of internalising biodiversity costs into the mining life cycle

1.4.1 Introduction to concepts

The central challenge of the research project – internalising the value of externalities into decision-making by coal mines, as a means of protecting water resources and other ecological infrastructure – requires serious consideration of the question of valuing nature:

- How do we put a value on wetlands, rivers and other water resources?
- How do we do this in a way that is able to assess decision-making about land use choices that have not only economic, but also ecological implications?
- How do we deal with thes issues in a way that is inclusive, efficient, and sustainable so that coming generations inherit the natural capital of which we are currently the custodians?
- How do we ensure that these important considerations become a central part of economic and regulatory decision-making?

To answer these questions, it is necessary to set out an approach that draws on the core concepts of adaptive management, ecosystem services and the ecological infrastructure that produces them, within an understanding of social-ecological systems. The ultimate aim of this exercise will be to set up a process of valuing, making decisions and monitoring, in order to set up an ongoing, inclusive adaptive management system.

The chapter concludes that the integration of knowledge systems relating to different aspects of wetlands, biodiversity, ecosystem services and eco-infrastructure is difficult. Nevertheless, they can be integrated (in other ways) by those who live and work in these environments, because such people have to deal with these questions via dialogue embedded in their own life experiences (Visvanathan, 2009). This idea is further explored in Chapter 6.

The emerging recognition of ecosystem services and ecological infrastructure provides useful ways in which to evaluate land-use decisions (particularly mining) and weighting them against alternative development paths. In this chapter, we explore how these concepts can assist us in evaluating mining and mining-related licensing processes, and their related water use scenarios, in relation to biodiversity and conservation goals associated with water resource protection.

After introducing the concepts, we note that it is certainly possible to ascribe value to ecosystem services and the ecological infrastructure from which they arise. A number of approaches and techniques have been developed to deal with the “failure of the market” to assign monetary values to ecosystem services. But can such a valuation adequately express the value of the ecological infrastructure for future generations, as well as deal with incomplete understanding of how these services are provided as well as the interrelationships among them? Moreover, how can these valuations form part of decision-making that affects ecological infrastructure? What types of decision-making would be adequate to the task?

Our starting point is to consider the place of the market – and its abilities to value ecological infrastructure – in a broader perspective. The formal market is absolutely dependent on interactions with, and (in practice) is inseparable from, four other “economies”. These economies do not follow the same formal, monetised logic A formulation of such an approach is outlined below (after Barry, 2007).

1. **The official market economy:** all transactions and relationships involve money, including wages, consumption, production, investment and savings. This section of the economy is often seen as the only economy and its indicators, particularly Gross Domestic Product of GDP, are commonly used as the only basis for state planning and private enterprises.

2. **The underground economy:** cash transactions that are hidden to avoid taxes or prosecution for illegal activities such as drug trafficking or pornography. Non-compliance with environmental and social regulations are arguably part of an underground — or at least — a grey economy that escapes detection, documentation and valuation. Like the rest of the criminal economy, it can have serious effects on the other economies.

3. **Government expenditure:** money spent by government on social security, defence, education and infrastructure such as roads, bridges, airports, sewers and public transport. This includes the social wage, which provides a safety net for people excluded by the formal economy. Government expenditure also fills in where the formal economy fails, for example taking over the care of abandoned mines to prevent further damage to the environment and shared public assets.

4. **Social economy:** all non-market economic activities. This includes subsistence farming, housework, parenting, volunteer labour, home healthcare and DIY as well as barter or skill exchanges. In Northern economies, the informal economy is estimated to be one-and-a-half times the size of the visible market economy. In the South, large parts of the economy follow a subsistence pattern, consisting of transactions (such as the provision of food, traditional health and mental health care and transport) that are not recorded in the market and, therefore, do not officially or form part of “economic” planning.

5. **Nature:** the natural resource base represents the largest and most basic support for the monetary economy. All economic activity depends on the survival of healthy, natural ecosystems. Nature contains all the other economies and cannot be reduced to any one of them.

The decision-making processes that characterise these different realms in which humans live with each other and with nature, vary greatly. They cannot all be subjected to monetary evaluation. Fundamentally, the only way in which they really connect is through the experiences of the living worlds of individuals, groups and communities in which they come together. This concept will play an important role when we turn to decision-making relating to these competing values. Fundamental to this way of thinking is that all human economies are supported by, and included in, an economy of nature.

Therefore, it is impossible to reduce natural functions to economic calculation only (see below for discussion of the fallacy of "infinite intersubstitutability" which illustrates this point).

But first we need to explore how the concepts of biodiversity protection, eco-system services and ecological infrastructure are interrelated along a conceptual-historical continuum. Also, how natural capital or ecological infrastructure functions as an inclusive, umbrella concept.

In this research, we take wetlands evaluation as a starting point because wetlands provide an excellent example of the provision of many eco-system services, as well as demonstrating how their interconnectivity in the landscape can be understood as an instance of ecological infrastructure.

Wetlands were not always regarded as worth preserving. As recently as 1986, Edward Maltby (1986:9) wrote "*Wetlands are wastelands; that, at least, is the traditional view." Of course, he then proceeded to argue that "… far from being wastelands, they are among the most fertile and productive ecosystems in the world*".

Wetlands are both water and soil ecosystems and are extremely productive. As van Vuuren (2014) noted: "*South Africa's wetlands are arguably its most valuable ecological infrastructure. Not only do these special ecosystems support water resources by purifying water and regulating flows, they also act as sponges that store water and release it slowly, filtering pollutants and reducing the impacts of droughts and floods… sustaining a rich diversity of faunal and floral species, wetlands also support the economic activities of many rural communities, including the provision of food and fuel*."

Yet, wetlands are the most threatened ecosystem in South Africa, particularly in the Mpumalanga Highveld, where miners find the low-lying wetlands the easiest access to shallow coal seams. Such systems are also extremely vulnerable to pollution from acid mine drainage (Van Vuuren, 2014). This very research project – K5/2355 – is funded by a fine (Golfview court case) paid by a mine that had damaged a wetland.

In South Africa, extensive research into wetlands has taken place over the past decade and a half. For the past 16 years, national wetland indabas have taken place annually. The Mpumalanga Wetlands Forum is 15 years old. As Umesh Bahadur (Director: SANBI: *Working for Wetlands* programme) noted: "*Over past 8 years I have really seen wetlands research community grow in knowledge and confidence"* (personal communication, October 2014). The Mpumalanga eco-infrastructure programme includes a partnership with Coaltech, which undertakes research for coal mines, aimed at minimising the impacts of coal mining on wetlands.

The WET series, a WRC-published set of integrated tools for wetland monitoring and management, was published between 2007 and 2009. The series offers "*a sound scientific base for planning, implementing and evaluating wetland rehabilitation: providing guidelines to develop an overall planning framework; assessing the condition of catchments and individual wetlands; assessing the functions and value of individual wetlands; evaluating the need for rehabilitation; identifying why wetlands degrade and what rehabilitation interventions are appropriate; guiding the selection and implementation of rehabilitation methods; and monitoring the success of rehabilitation projects*". The initiative includes guidelines for prioritising wetlands at national, regional and local scales (TT337/09).

The question is: In what framework will this happen? Traditionally, the protection of biodiversity has been the central framework because it located the resilience of ecosystems in their diversity, which made them self-organising.

1.5 Biodiversity, wetlands, ecological infrastructure and the question of valuation

Much of the development of ecosystem services and ecological infrastructure thinking has come from the efforts of conservation biologists who actively support conservation efforts in the field (Norton, 2003).

Biodiversity can be defined as "*variability among living organisms from all sources, including terrestrial, marine and the ecological complexes of which they are part*" (TEEB, 2010).

Nunes et al., (2003) provided a slightly different definition:

"*Biodiversity encompasses four levels: Genes (Genes, nucleotides, chromosomes, individuals); Species (kingdom, phyla, families, genera, subspecies, species, populations), Ecosystem (bioregions, landscapes, habitats) and Functional (Keystone process species, ecosystem resilience, and ecological services)*" (Nunes et al., 2003: 9; see also Noss, 1990).

South Africa undertakes world-class conservation biology and science research (Reyers et al., 2008) in keeping with its status as one of the world's most biodiverse countries (DEA et al., 2013). Worldwide, and in South Africa, conservation biology evolved as "*mission oriented, crisis discipline over 20 years ago out of a sense of deep despair felt by a group of visionary scientists deeply concerned about the destructive impact of human beings on the natural world*" (Redford & Sanjayan, 2003, in Reyers et al., 2008). Its mission was "*to address the problems of protection and persistence of species, as well as communities and ecosystems*". The discipline was deeply normative, in the same sense as medical science, with an obligation to act without all information necessarily being available.

By the time of the Millennium Assessment (2005: 136), this war was largely being lost, with large declines in important biodiversity components, loss of ecosystems and habitats (in the range of 20 to 50%), high extinction rates, and losses in overall (internal) species diversity. (Reyers et al., 2008: 136). This failure forced conservation biologists to bridge two gaps: interdisciplinarity and implementation.

South Africa has an extensive system of conservation areas and has built a large stock of conservation knowledge. At the same time, conservation history, which operated in tandem with colonial and apartheid land alienation, has cast a shadow over the future. According to Cock (2007) and Anderson and Grove (1989) many of black politicians, representing view of the majority of black South Africans, are suspicious of conservation. In Reyers' account, the conservation discipline went through considerable research activity in the 1980s and 1990s and through a donor phase after democracy in 1994. This phase broadened interdisciplinary work, and resulted in extensive conservation plans. But the implementation of these plans remains a challenge that concerns four aspects (Reyers et al., 2008: 163, 164):

- Broadening of focus, from biophysical assessments to inclusion of the social, economic and political environments.
- Developing strategy and management within this broader setting;
- Effective land use planning, inclusive of biodiversity concerns.
- Incorporating national values — those in the South African constitution, and those in the public imagination — into conservation planning processes, while taking into account the following effects of extreme poverty into account:
    - Rejection of land-hungry conservation plans (including corridors supporting ecological processes);
    - Rejecting precautionary approaches around uncertainty in ecological thresholds;
    - Supporting localised and fragmented planning at the municipal scale without an overarching national framework;
    - Focusing exclusively on the human well-being aspect of conservation (e.g. ecosystem services, tourism income).

The above challenges in the political and planning environment carry over into all aspects of sustainability planning. Because of the urgency to deal with economic inequality, they may work together to predispose current planning to short term economic calculations that ignore, or severely discount, natural capital. This issue is discussed in more detail below (Section 1.5.1).

1.5.1 Ecosystem services

In an attempt to respond to difficulties associated with gaining support for biodiversity protection, ecosystem arguments focus on the value, and therefore also the valuation, of services provided by healthy ecosystems. A fourfold classification of streams of ecosystem services was established by the landmark Millennium Ecosystem Assessment Framework (MEA, 2005).

- **Provisioning services** are the harvestable goods or products obtained from ecosystems such as food, timber, fibre, medicine, and fresh water.
- **Cultural services** are the non-material benefits such as heritage landscapes and seascapes, recreation, ecotourism, spiritual values and aesthetic enjoyment.
- **Regulating services** are the benefits obtained from an ecosystem's control of natural processes, such as climate, disease, erosion, water flows, and pollination, as well as protection from natural hazards.
- **Supporting services** are the natural processes such as nutrient recycling, soil formation and primary production that maintain the other services (DEA et al., 2013).

Ecosystem services are provided by healthy ecosystems, is recognisable as a restatement of arguments put forward for protecting biodiversity, such as that used by SANBI: Ecosystems are *"…assemblages of living organisms, the interactions between them, and between them and their physical environment. Each eco-system is characterised by its composition (the living and non-living parts of which it is made), its structure (how the parts are arranged in time and space) and the ecological processes (functions such as nutrient cycling, water flows and dispersal) that maintain the composition and structure and keep it functioning as a unit*" (SANBI 2013:1).

Healthy, natural ecosystems are understood to be able to handle pressures from their environment, moving from one state to another in response to changes, but remaining resilient. Certain disturbances, often anthropogenic in nature, can however move the ecosystem to a state in which change cascades through the system and impoverishes it (Norton, 2003). An appropriate definition of a healthy ecosystem describes it as having 'ecosystem integrity'. An ecosystem has an integrity if it retains (a) the total diversity of the system, i.e. the sum total of the species and associations that have held sway historically, and (b) 'autonomous processes' (systematic organisation) that maintain diversity, including the multiple layers of complexity through it (Norton, 2003).

Ecosystem health and integrity and its ability to provide ecosystem services, therefore depends on the self-organising ability of the ecosystem, which in turn depends on its complexity and diversity. Policy arguments for protecting ecosystem services are fundamentally similar to those for protecting biodiversity, but contain an important additional component: they value biodiversity for its support to the provision of services to humans. This focuses attention on the human-biodiversity interface.

The avowed anthropocentrism (Norton, 2003) of an ecosystem services approach enables it to enter into socio-political decision-making much more effectively than a traditional conservation approach. It also means that ecosystems have to be recognised as "fused" natural and social, or social-ecological systems. In practice, this means that social and environmental decisions are inseparable.

1.5.2 Ecological infrastructure

The argument for protecting "ecological infrastructure" takes this process a step further. This because it can rely on:

- a robust science built up through decades of conservation, biodiversity and ecosystems services research;
- its relevance for sustainability arguments, and
- its potential to influence mainstream decision-making via economic valuation.

The concept holds the potential to make explicit the process of turning natural capital (Freeman, 2003) into economic capital. In the Natural Capital Protocol,

> "*valuation refers to the process of estimating the relative importance, worth, or usefulness of natural capital to people, in a particular context. In financial accounting terms, valuation is understood to mean monetisation, but in environmental economics and this Protocol, valuation means more than just monetisation. It includes qualitative, quantitative, and monetary approaches, or a combination of these*"
>
> (Natural Capital Coalition, 2016: 3).

Mineral resources, by law, belong to all South Africans in common and are held custody by the state, which allows and regulates the exploitation of minerals. Ecological infrastructure valuation enables a visible transition from socially owned wealth to private wealth, as well as a form of accounting for negative and positive values. For example, pollution, depletion of resources financial profits and social investments. Water resources belong to all South Africans, with the government as their custodian, and it can be argued that ecological infrastructure can follow the same logic of common ownership.

An organisation involved in the developing and practical application ecological infrastructure concepts, SANBI, offers the following definition.

> "*Ecological infrastructure refers to naturally functioning ecosystems that deliver valuable services to people, such as water and climate regulation, soil formation and disaster risk reduction. It is the nature-based equivalent of hard infrastructure, and can be just as important for providing services and underpinning socio-economic development. Ecological infrastructure does this by providing cost-effective, long-term solutions to service delivery that can supplement, and sometimes even substitute, built infrastructure solutions*."

This definition can be regarded as a further development of Myrick Freeman's description of 'natural capital' as a means to measure environmental resources: "*Natural resources, such as forests and commercially exploitable fisheries, and environmental attributes, such as air quality, are valuable assets in that they yield flows of services to people*." (Freeman, 2003: 3).

1.5.3 Challenges of valuation

The valuation of ecosystem services and ecological infrastructure in monetary terms enables the translation of a range of values and options into a single "currency", in the hope that this will enable and encourage decision makers to take them into account.

How are such valuations carried out? Economic valuation is instrumental, focusing on the welfare of humans. Nunes et al. (2003) explain that "*the theoretical basis for economic valuation is monetary (income) variation as compensation, or equivalent for direct and indirect impacts of certain biodiversity change on the welfare of humans*". But they warn that "*although values of environmental services may be used to justify biodiversity protection measures, it must be stressed that value constitutes a small portion of the total biodiversity value*" (Nunes, 2003: 16). In other words, the ever-present risk is to understate the value of ecological infrastructure.

Biodiversity can be evaluated (in monetary terms) as revealed or stated preferences. The first makes use of monetary values already attached to biodiversity features. For example, the cost of bioprospecting rights associated with a contract between a multinational company and a government or local community. Alternatively, biodiversity evaluation could, for example, refer to expenditures people are prepared to make to visit a national park (Nunes et al., 2003) or to avoid unpleasant ecological effects. For example, the costs, to polluting industries, associated with activism against a proposed development (in the case of negative externalities, such as health costs resulting from pollution) (Scorgie, 2004).

There are objections to both of the above methods. The amounts may not properly reflect value (for example, the bio prospecting contract may be of far less value than the future potential such as earnings associated with local knowledge and the use of indigenous herbs). Such valuations may be determined by power relationships between the negotiating parties rather than true value. There is also no causal relationship between the value of a wilderness, and the cost of travelling to it. As Scorgie (2004) observed, not all health costs are usually counted. For example, the cost of air pollution may not include the slow to surface costs of cancers. Some evaluation methods take the consumer relationship as a given (for example, Polasky, 2012). In a highly unequal country like South Africa, effective demand (i.e., having sufficient income to actually buy) is unevenly spread and generally reveals the preferences of an elite.

Stated preferences are solicited on the basis of what people would be prepared to pay. For example: paying to preserve a certain species, or habitat, or to have “green electricity”. Stated preferences are also subject to critique, in particular the assumption that the interviewees have a true understanding of what is at stake in ecosystems. Such assumptions are largely unwarranted and relate to the neoclassical assumption of full information for all who participate in markets (Norton, 2003).

Another method of evaluation – and assigning monetary values – on ecological infrastructure proceeds from more inherent characteristics, namely the components and functions in eco-systems, as the following two examples show. Pimentel et al. (1997, quoted in Wall, 2004) used the example of estimating economic benefits from the services of soil organisms worldwide, a contribution that has long been underestimated. The estimation is strongly controlled by the components of ecosystems.

Table 1: Estimated economic benefits of biodiversity with special attention to the services that soil organism activities provide worldwide (modified from Pimentel et al., quoted in Wall, 2004)

Activity	**Soil biodiversity involved**	**World economic benefit in US $10,000,000,000/year**
Waste recycling	Saprophytic and litter-feeding invertebrates (detrivores), fungi, bacteria, actinobacteria and other micro-organisms	760
Soil formation	Diverse soil organisms, e.g. earthworms, termites, fungi, *Eaubactera,* etc.	25
Nitrogen transformations	Biological nitrogen fixation by diasotroph bacteria, conversion of NH4 to NO3 by nitrifying bacteria, conversion of NO3 to N2 by denitrifying bacteria	90
Bioremediation of chemicals	Maintaining biodiversity in soils and water is imperative to continued and improved effectiveness of bioremediation and biotreatment	121
Biotechnology	Nearly half of the current economic benefit of biotechnology agricultural-related biotechnology involves nitrogen-fixing bacteria, and the pharmaceutical industry.	6
Biocontrol of pests	Microhabitat provision for natural enemies of pests, soil organisms (e.g. mycorrhizae) contributions to host plant resistance, and plant pathogen control	160
Pollination	Many pollinators may have edaphic phase in their life cycle	200
Wild food	For example, mushrooms, earthworms, small arthropods.	180
TOTAL		1542

SANBI’s Grassland Ecosystem Guidelines (2013) values the flow of ecosystem services from South African grasslands at “some R9.7 billion per annum” (2013: 10). These include:

- Water production, water purification and flood attenuation
- Quality forage for animals
- Nutrient cycling, carbon sequestration and storage
- Pollination services
- Thatching or weaving
- Medicinal and food plants
- Cultural, heritage and recreational amenities, often with tourism value
- Deep, nutrient-rich soils.

1.5.4 Ecosystem services and ecological infrastructure in decision-making

Of particular relevance to the Carolina case study are two recent sets of guidelines, the Grassland Ecosystem Guidelines (SANBI, 2013), and the Mining and Biodiversity Guideline (DEA et al., 2013). Both work with concepts of biodiversity, ecosystem services and ecological infrastructure, quoting the Millennium Ecosystem Assessment.

SANBI's grassland guidelines (SANBI, 2013) formulates a "landscape approach", which:

- Recognises that all ecosystems are to some extent impacted or modified by humans
- People and their livelihood activities are an integral part of landscapes
- Not all land-uses are compatible with biodiversity conservation, although some are
- There are thresholds beyond which the ability of the landscape to sustain life and productivity is seriously diminished
- Management actions must be carried out at the environmental scale suited to the issue being addressed.

These guidelines, and the processes that led to their formulation, imply that these concepts are becoming familiar in the sector, and being integrated into planning and decision-making.

In 2013 "Mining and Biodiversity Guidelines", published by the Department of Environmental Affairs, Department of Mineral Resources, Chamber of Mines, South African Mining and Biodiversity Forum and South African National Biodiversity Institute produced a consensus document, outlined below.

> "*Mining continues to be one of the most significant sectors of our economy, providing jobs, growing our GDP and building relations with international trading partners… On par with this mineral wealth are exceptional endowments of biodiversity and ecosystems. This rich biodiversity and ecological infrastructure underpin and support our social and economic development in numerous direct and indirect ways. It is currently impacted upon by mining and other land uses in ways that are not sustainable. Sustaining the goods and services that flow from our ecosystems, and the benefits that these provide over the long term, will require limits in mining and other activities in certain areas…*"

The document also offers principles to address biodiversity in a mining context.

1. Apply the law……This included clauses applying to the law, biodiversity, stakeholder engagement, best practice EIAs to identify and evaluate impacts on biodiversity, mitigation measures and the development of robust Environmental Management Programmes (EMPs) and a recommendation to enforce effective implementation of the EMP, including adaptive management.

Point 1 seems to indicate that the law is not yet being properly applied. The agreement thus appears to be aspirational, rather than *de facto* in all cases.

In a study specifically investigating practical implications of Mining and Biodiversity Guidelines, and how "*a good understanding of ecosystem services values and their appropriate use(s) in various decision-*

making processes…can meaningfully help mining companies to improve their socio-economic and environmental performance and legacies" (Houdet & Chikozho, 2014: 7), the authors observe that there are still many obstacles to a functional integration of ecosystem services and ecological infrastructure considerations into decision-making in mining in South Africa. While ecosystem services concepts have entered into impact assessments, these are mostly confined to individual studies, often on the initiative of consultants rather than clients.

1.5.5 Decision-making consequences of valuation

SANBI argues that, as in the case of built infrastructure, ecological infrastructure needs to be maintained and continuously attract investment. This argument, and has contributed to the emergence of the Strategic Infrastructure Project (SIP) on ecological infrastructure (SIP 19), an indication of progress made towards achieving the entrance of natural capital considerations into mainstream decision-making. It does, however, raise the question of whether this definition runs the risk of giving a voice to biodiversity and ecosystem concerns at the price of reducing them to what is simply economically visible? It is the ambition of resource economics, a neoclassical approach – and its rival, ecological economics, which departs from ecosystems understanding – to present the value of natural capital in economic terms, in order to address challenges in policy and decision-making: "*Public policies and the actions of individuals and firms can lead to changes in the flows of these services, thereby creating benefits and costs"*. Because of externalities and the common-property and public good characteristics of at least some of these services, "*market forces can be relied on neither to guide them to their most highly valued uses nor to reveal prices that reflect their true social values*." (Freeman, 2003: 2).

In addition to the above ideas relating to valuation, consideration has also been given to the ideas of a number of economic philosophers, such as Norton (2003), Houdet and Chikozho (2014), who argued that the closest approximation to underlying value of ecological infrastructure is restoration or rehabilitation of wetlands, approach sees wetlands as natural capital that has a replacement cost.

Norton (2003) responds to the difficulties of the PII problem by developing a typology of risk severities, following the principle of "comparative reversibility" which flows from the extinction of species (or irreversible degradation of ecosystems) and other experience in biodiversity, which directly contradict the applicability of a principle of substitutability. Note that the strong principle of substitutability underlies the field of economic evaluation of nature, while a weak principle underlies the practice of off-sets (currently under discussion in wetlands and other biodiversity policy decisions in South Africa). Norton isolates a space in which irreversibility risks are so high that the basic economics logic of substitutability cannot operate.

These distinctions point to the inherent differences between financial capital and natural capital. Natural capital, in the form of ecological infrastructure, consists of ecosystems characterised by:

- Thresholds;
- Functional diversity (including some redundancy that allows resilience at different states) that are dynamic and fluctuate between states depending on the broader context or larger scale influences;
  and
- Keystone functions and keystone species.

Financial capital and natural capital are thus structured in specific ways, with the latter breaching certain structural, functional or process-related eco-barriers (for example, habitat, biodiversity corridors, species complexity, quantity and quality of water). This results in their impoverishment and increasing the risk of collapse, thus diminishing and even removing, these ecosystem services from the landscape.

Norton (2003) concludes that "*sustainable activities do not destabilise the large-scale dynamic biotic and abiotic systems on which future generations depend*". It is, however, important to appreciate that ecosystems differ and therefore need different management regimes. In recognition of the variability of contexts, Norton (2003: 178) suggests five axioms for ecological management:

- **Dynamism:** Nature is more profoundly a set of processes than a collection of objects: all is in flux.
- **Relatedness:** All processes are related to all other processes.
- **Hierarchy:** Processes are not related equally but infold in systems within systems, which differ in terms of the temporal and spatial scales on which they are organised.
- **Creativity:** The autonomous processes of nature are creative and represent the basis for all biologically-based productivity. The vehicle of that creativity is energy flowing through systems which in turn finds stable contexts in larger systems, thus providing sufficient stability to allow self-organisation within them, through repetition and duplication.
- **Differential fragility:** Ecological systems, which form the context of all human activities, vary in the extent to which they can absorb and assimilate human-caused disruptions in their autonomous processes.

1.5.6 Towards a theoretical and practical model

In the next two sections, we explore the option of an adaptive management and social learning process, as a form of multi-criteria, participative decision-making that includes, but goes beyond, economic valuation.

Norton (2003) argues for a process of co-creation of values, which is local, brings in both criteria of ecological economics (on the basis of a valuation of ecosystem services) and natural capital, while also acknowledging the following limitations:

- Economic rationality and consumer–preference (with the available methodologies to give them content) are generally only adequate to decisions affecting a single lifetime (at most) and are most effective in the short term. Most decisions affecting natural capital are not on that scale.
- Certain decisions are characterised by risk, irreversibility, large scale uncertainty; and issues that concern values (such as sense of place, cultural continuity).
- Decisions need to be made that keep options open for future generations, i.e. not diminishing their options (including natural capital) that may well be embedded in, and entwined with, cultural capital.

The above decisions are beyond monetised evaluation and should therefore be made with reference to the correct decision-making spaces and methodologies.

South Africa is fortunate and in that many building blocks or elements of such an approach are already available, particularly in the Carolina and Upper Komati catchment areas. Adaptive management is well understood and developed, owing to experiences in both conservation and the Kruger National Park (see Biggs & Rogers, 2003; Pollard et al. 2008; Pollard & Du Toit, 2011).

SAM has also been applied at institutional levels --- in the Kruger National Park, and in IUCMA area (Rogers & Luton, 2011) and was used in the IUCMA (then ICMA) from 2008 onwards where the approach enabled staff prioritise strategic projects, and co-create (with stakeholders) an Inkomati Catchment Management Strategy. Flexibility of the system enables avoidance of capture by specific interests. Its commitment to social learning and inclusive decision-making leads to the creation of "communities of practice" (Wenger et al., 2011). The Upper Komati Forum, in which the Carolina Acid Mine Drainage issues were taken up, is one such emerging community of practice.

1.5.7 A participatory framework for understanding water-related ecosystem services

The Association for Water and Rural Development (AWARD) has developed and tested a participatory framework, water-related ecosystem services (WatRES) with support from researchers (Pollard et al.,

2013) in the Sabie-Sand, sub catchment which, like the Upper Komati, is located in the Inkomati-Usuthu Catchment Management Area.

The WatRES framework is an excellent example of a co-creation process, through inclusive groupings of stakeholders, of valuing ecosystem services. The challenge is to extend this framework from participatory valuation to inclusive decision-making, ongoing monitoring, and adaptive management.

The WatRES framework "*places processes that support stakeholder engagement at centre stage*" (DEA et al., 2013: 55). It requires a process that:

- Is participatory;
- Builds on what people know;
- Involves iterative steps that allow revisit concepts based on changes in participants' understanding through, for example, engagement with others;
- Is linked to 'real-life' practices or management actions and creates situations where people are able to explore and learn in a constructive manner;
- Provides a collective understanding of WatRES for a specific area rather than simply an amalgamation of individual perception, while seeing consensus, notes and accepts different opinions and understandings in an open and transparent manner.

People's epistemologies (ways of knowing) allow them to participate in such a process. Facilitators – and participants – therefore need to work in an open way with different agendas and knowledges and facilitate healthy diversity in which these complement each other. This approach is essential for:

- Allowing people to see different perspectives from their own,
- Anticipating future areas of potential contention and in doing so,
- Allowing participants to plan for this in an appropriate manner and
- Recognising areas of critical research, often characterised by contention and critique." (DEA et al., 2013: 56).

A core issue is the terms in which valuation of ecosystem services and natural capital take place. These cannot be the calculations of outsiders, who may miss important aspects. It must start from people's lived realities, experiences and knowledges. It is, however, acknowledged that scientific understandings of processes – for example, links between wetlands, groundwater, water pathways in the soil, springs and fountains etc. – may enrich and strengthen appreciation of ecosystem services. During its testing phase, the WatRES process made use of expert and general stakeholder focus group methods.

Other key principles are that:

- exploring water-related ecosystems services needs to be embedded within a wider context of IWRM for sustainability\
- the framework must take a systemic and dynamic view of social-ecological systems.
- the identification of ecosystem services can be crucial in linking social and ecological aspects.
- the process must be iterative-based with respect to social learning and the development of trust or social capital – which allows for a situation leading to a community of practice, enabling collective action.

1.6 Discussion of objectives and how they were achieved

This section gives explains how objectives were met.

First objective

To conduct an analysis of available resource and catchment-based tools aimed at sustainable development of water resources and management.

Attendance and interaction at CMF meetings, legal analysis of streamlined decision-making system, and a working group evaluation of processes. Also, a reliance on an existing diagram designed by Prof Palmer (Rhodes University Institute for Water Research). See Chapter 2 (Appendix A) for further detail of this analysis.

Second objective

To investigate and evaluate the decision-making processes followed in issuing mining authorisation which involved the following actions:

- Legal analysis (Humby of requirements a mine manager perspective, when applying for a license (Thompson);
- Interviews with mine managers, consultants, regulators (Thompson),
- Discussions in participatory action research process with catchment working group including mirroring back research findings (UKCMF). (see Chapters 2, 3 and 6).

Third objective

To determine the relationship between licensing processes and ecological infrastructure from a landscape and connectivity perspective

This was undertaken during the legal analysis, specifically interrogating legal provisions for coal mining in terms of ecological infrastructure. A social connectivity exercise was done with the CMF working group. The connectivity perspective was also addressed in Dr Van der Waals' hydropedology analysis (Chapter 4).

Fourth objective

Propose an integrative decision-making process and institutional arrangement to support licensing for sustainable use of natural capital

This integrated was developed through a series of dialogues and other knowledge co-creating exercises with the UKCMF working group from February 2014 to September 2016. Knowledge inputs were based on desktop research, specialist research and feedback. The 10 steps proposed are the foundation for the integrative decision-making process rooted in the catchment forum, thereby contributing to the effectiveness of the forum (Chapter 6)

Developing guidelines to understand the socio-economic value of selected wetlands

Develop guidelines, based on existing law and best practice for different user groups on wetlands, were compiled and presented to the UKCMF, with the suggestion that these be developed further, in the light of the different rules that apply to different activities. The draft guidelines were also supported by two assessments of the wetlands and a land use economics study (Chapters 4 and 5).

1. Develop and test a multi-sectoral integrative monitoring framework linked to a decision support system catering for bio-physical, economic and societal needs

   A co-created multi-sectoral integrative monitoring framework linked to a decision support system was developed during the dialogue process from February 2014 to September 2016 to cater for bio-physical, economic and societal needs. It was tested, together with the designers of the knowledge support system, in a simulation exercise with the UKCMF workshop. The framework is presented in chapter 6.

2. Develop appropriate capacity for officials involved in licensing, business, and affected communities

The above guidelines encouraged the growth of a community of practice, in which social trust was built as well as a shared understanding of the material reality of coal mining and its impacts on water resources was developed. In addition, a dialogue/explanation exercise also facilitated further understanding of the licensing process and its complications.

During the above processing, a serious but unavoidable limitation arose with respect to the absence of representatives from the DMR despite repeated invitations. Participants in the working group confirmed that this was usual. The group therefore focused the willing participants that were present, including mine managers, mining consultants, government officials (DWS, incl. AMD task team, IUCMA, DAFF, local government and provincial officials) as well as citizen groups from different socio-economic backgrounds. The growth of a community of practice was encouraged.

1.7 Overview of contents of report

The chapters that follow illustrate the multidisciplinary nature of this research project.

Chapter 2 explores the current coal mining decision-making process, starting with an account of the myriad of questions a prospective coal mining enterprise needs to fill in. It then presents the results of structured interviews in the Carolina area with mining managers, regulators and other land users. The system was also evaluated through a series of multi-stakeholder dialogues which found that decision-making was not inclusive enough, or transparent enough, and that it did not take into account and protect wetlands and water resources, and that this may limit future economic and land use options in the area; that there is a lack of transparency, and therefore suspicion about decisions, and that information in the coal decision-making process is difficult to access and understand. There is suspicion about "political interference" in decision-making processes and that the benefits and costs of coal mines are not clearly explained to the public during consultation processes. The chapter concludes with a political ecology perspective: an overview of contestations around the mining and use of coal, including climate change, the politics of knowledge around coal mining, the exclusion of other interested government departments in coal decision-making, the new catchment management system as an ongoing, potential regional decision-making space, the role of civil society and activists in contestations, the externalised costs of coal mining and burning to communities, and a conclusion that the current coal mining decision-making process is too narrow to contain the contestations around coal.

Chapter 3 presents an in-depth legal analysis of the coal mining life cycle. The focus in this chapter falls on the nature and scope of multiple licensing processes undertaken during the course of a mining life-cycle, evaluated against key principles of the new environmental governance; i.e. governance that acknowledges the complexity and adaptability of linked social-ecological ecosystems by establishing a framework for decision-making that is more open-ended, science-based, and reliant upon the development of a committed epistemic community. In the process, the analysis critiques the manner in which South African law frames institutions, processes, conception of the natural world, information requirements and forms of participation relevant to mining and the protection of wetlands, biodiversity and ecological infrastructure. Section 2 develops this analysis further by analysing how the law frames resistance and contestation in the arena of mining and the protection of wetlands, biodiversity and ecological infrastructure.

Chapter 4 addresses Aim 1 of the project: *To conduct an analysis of available resource and catchment-based tools aimed at sustainable development of water resources and management.* Wetlands were selected as the key ecological infrastructure elements to assess. The widely used WET-Health and WET Eco-services methodologies were applied, evaluated, found to be limited, and extended. The value of multiples lines of evidence was demonstrated clearly. In this case, the resilience of wetlands and the efficiency of the ecosystem services they offer, especially in mediating water quality, were clear. Hydro-pedology revealed wetland vulnerability to impacts that puncture the rock layers that provide hydrological connectivity. Chapter 4 study shows: (i) coal mining is a long-term, irreparable, threat to wetlands in Highveld grassland ecosystems; (ii) agriculture has some impacts but wetlands are resilient in the face of these; and (iii) hydrological connectivity is the key function necessary for the persistence of wetlands in these ecosystems. The water resource management recommendation is: to use hydro-pedology mapping to identify those wetlands in the Highveld grassland ecosystem that are still hydrologically connected and implement a moratorium on any part of the coal mining life cycle (Chapters 2 and 3) within in the perimeter of the still-connected wetland systems.

Chapter 5 sets out an approach that draws on the core concepts of adaptive management, ecosystem services and the ecological infrastructure that produces them, within an understanding of social-ecological systems, to propose a process of valuing, making decisions, monitoring and ongoing, inclusive adaptive management. It develops a theoretical framework that can balance water resource and biodiversity protection with water use for mining as a foundation for the dialogue reported on in the next chapter.

Chapter 6 introduces and discusses the development of a “Draft Integrated Monitoring Plan able to align biodiversity and mining development, accompanied by an appropriate DSS in the Upper Komati CMF working group.

Chapter 7 looks at the policy implications of this research

Chapter 8 provides conclusions and recommendations for further research.

This report has six appendices:

Appendix A: Regulation Through the Mining Life Cycle

This appendix consists of an annotated list of 50 instruments relevant to regulating the relationship between mining (including coal mining) and the environment, with comments on their usefulness, and relationship to ecological infrastructure thinking

Appendix B: A Mining Manager's Perspective on the Legal Life Cycle Of Coal Mining

This appendix was developed to understand which information was important to enable a mining to follow many different pieces of legislation, required to legally prospect, mine/produce and close a mining site.

Appendix C: Hydropedology: Wetland Assessment, Conservation, Management and Rehabilitation in Mining Environments on the Mpumalanga Highveld

This report provides a systematic breakdown of the different components required for adequate wetland assessment, focussing specifically on hydrologically based assessment processes. This entails the description and elucidation of hydrological functioning of landscapes, to propose realistic landscape and wetland management and rehabilitation procedures.

Appendix D: How to..EEngage with Coal Mines through a CMF

This popular guide was produced as part of the knowledge system (Decision Support System) for an integrated, participatory process of valuing, making decisions, monitoring and ongoing, inclusive adaptive management that has as its objective to balance the exploitation of coal resources with the sustainability of wetlands and other water-related ecological infrastructure. It is meant for citizens who want to protect water and biodiversity.

Appendix E: Record of UKCMF Dialogues

This appendix provides records of the UKCMF meetings through which the inclusive decision-making and monitoring process was developed.

Appendix F: Ecological Infrastructure, Mining Licensing and Contestation

This appendix further develops the analysis by asking how the law frames resistance and contestation in the arena of mining and the protection of wetlands, biodiversity and ecological infrastructure.

2 THE CURRENT COAL MINING DECISION-MAKING PROCESS AND ECOLOGICAL INFRASTRUCTURE

2.1 Introduction

The current mining decision-making process encompasses three logical steps: prospecting, mining and closure, legal requirements that are complex and contested. The requirements encompass 50 legal instruments, annotated in Appendix A. To provide a broader view of these requirements, the chapter explores stakeholder perspectives in the Upper Komati in relation to coal mining, through a CHAT research method. It then broadens the frame by looking at contestation between mining and other land uses.

An evaluation of the current mining life cycle process was produced by the UKCMF multi-stakeholder working group, providing an idea of how the rules and requirements are applied in real life. The chapter arrives at a conclusion that considerations of biodiversity, hydro connectivity and ecological infrastructure are presently not well integrated into the current coal mining decision-making process.

2.2 Summary of legal requirements in the coal mining life cycle

A mining manager needs to follow many different pieces of legislation to legally prospect, mine/produce and close a mining site. These include The National Water Act, 1998; The National Environmental Management Act, 1998; The Mineral and Petroleum Resources Development Act, 2002; Mine Health and Safety Act, 1996; National Heritage Resources Act, 1999. These are available to all mining companies who wish to apply or renew their various licenses. There are three phases to a mining lifecycle- Reconnaissance and Prospecting; Mining/Production and Decommissioning and closure. Each needs its own distinct licenses from various government authorities. The process is very detailed and cumbersome, and is given in detail in Appendix B. Chapter 3 presents an in-depth legal analysis, and Appendix A presents 50 legal instruments that are, or can be, applicable to the coal mining life cycle.

2.3 Stakeholder perspectives in Upper Komati in relation to coal mining

But does mining in Carolina work according to the detailed rules? This section reports on a set of interviews, conducted in November 2014, to investigate whether the mining industry is complying, or not, to current legislation. For this purpose, a mining manager/owner, two officers and specialists from the Mpumalanga Tourism and Parks Authority (MTPA), and three compliance and enforcement officers from a regulatory body of government were interviewed.

Following the methodology of Cultural Historical Activity Theory (CHAT), background questions were asked, to understand the role player's responsibility, years of experience, decision-making abilities, and changes that have occurred in the industry.

The tools that the role players used were assessed, as well as which rules (formal and informal) they need to follow. The extent to which mining agents follow these rules was questioned, to get an idea of compliance by different role players. The division of labour was also assessed. The effect(s) of mining operations effect on wetlands, biodiversity, and water quality were also assessed Legacy issues, their management and possible solutions were also questioned, as this is a major problem in South Africa. Any changes in the mining company's compliance and attitude towards complying after the Carolina Crisis were also assessed.

A major limitation in this study related to a general lack of willingness, from most mining companies' representatives, to be interviewed.

2.3.1 Background

South Africa is a megadiverse country, which is home to a vast amount of species in relation to other countries (DEA et al., 2013). The environment in general needs to be adequately protected in order to maintain our ecosystems that sustain all this life. Mining can result in considerable impacts on biodiversity and ecosystem services, which could include direct, indirect, cumulative and induced impacts, which may be short or long term, they could be permanent or irreversible, and they pose serious risks to other economic activities, ecological infrastructure and livelihoods (DEA et al., 2013).

Although the mining industry plays a vital role in the growth and development of the South African economy (DEA et al., 2013), there is often a loss in land use potential for other socio-economic benefits, such as a loss of ability to hunt, fish and gather; a loss of freedom of movement; locals being forced to resettle or relocate; and a fundamental disrespect for traditions (Hilson, 2001). Coal mining tends to have a noticeable negative impact on the environment, with its severity dependent on whether or not the mine is operational, the methods used, and the local geological variables (Bell et. al., 2001).

AMD, dangerous sinkholes and collapsing entry points are just some of the consequences of inadequate rehabilitation of the environment from mining, which is a major problem in South Africa (WWF, 2012). Government will struggle to address this problem adequately, due to its large scale, with over 6000 abandoned mines found in South Africa (WWF, 2012).

During the interviews of many agents involved with the mining licence procedure, including government regulators, decision makers, land use advisors and mining managers in the Carolina catchment have raised various issues with the current procedures when it comes to the licensing of mining operations. In the sections that follow, these issues are presented from the perspective of each of the groups of agents. Although no quotation marks are used, the words and expressions are taken from the interviews without comment from the researchers.

2.3.2 From the mining operations perspective

Mining managers believe there is a lack of monitoring of other industries, while they are singled out for over policing. Other industries, such as agriculture, that are much more damaging to the water resources, are not as heavily policed.

Managers see a great amount of duplication in legislation. NEMA and the MPRDA are seen to be extremely similar. This duplication causes a financial strain on the companies, who need to hire specialised consultants to meet all these requirements, often doing similar work for different pieces of legislation.

Separate authorisations are an issue. Government requires mining companies to apply for various different authorisations through different departments. This causes a delay in operations, as they are processed at different speeds.

The DMR holds financial provision for rehabilitation, but never uses it. The mining companies hand over these provisions, and they generally accept that they will not get that money back, for use of rehabilitation post operation, or even to refund their costs of rehabilitation. Section 41(2) of the MPRDA states that if a holder of a prospecting right, mining right or mining permit fails to rehabilitate or manage, or is unable to undertake such rehabilitation or to manage, any negative impact on the environment, the Minister may, upon written notice to such holder, use all or part of the financial provision to rehabilitate or manage the negative environmental impact in question (DMR, 2005). This money should be used accordingly.

In Mpumalanga, the IUCMA is seen as a complete duplicate of the Department of Water and Sanitation, causing issues with authorisations. The mining managers believe they have to treat the two institutions as separate entities, although they should be dealing with one. This increases cost and time, and there is a lack of clear communication between the departments. Also, who should be contacted for what by the mining companies needs to be addressed, as they often don't know who the relevant person is in certain instances.

The Mining and Biodiversity Guideline (DEA et al., 2013) is known in the mining community, but not followed as it is seen just another duplication of legislation, and they believe they have to adhere to enough already. This shows the mining companies attitude towards biodiversity and the environment, as they only wish to adhere to the bare minimum. Houdet and Chikozho (2014) report that mining companies have historically complied with the absolute bare minimum requirements. They identify a gap of an approximate 30% margin of non-adherence by environmental assessment practitioners to the Mining and Biodiversity Guideline principles (Houdet & Chikozho, 2014).

Often smaller mining companies find it easier to circumnavigate legislation rather than adhere to them. For example, a mine can bulk sample, where they do not need a mining right, so if they have a slightly smaller operation, they can fall within the bulk sampling restrictions, and avoid needing a license. This happens often with very small mining companies.

Bigger mining companies with deep pockets tend to have a more negative attitude with regards to legislation, where they can threaten cutting thousands of jobs if they are told they are not adhering to certain legislation.

The lack of capacity at government level causes problems with authorisations, where highly qualified consultants make reports that aren't always understood entirely by the authorities.

There is an issue with selling mining operations near the end of their productive life, seen often by larger mining companies, where the operation only has as much value left in their production as the rehabilitation costs, so they sell the mine for a fairly cheap price to a smaller mining company, that cannot afford to rehabilitate the operation, leaving environmental problems, and often the smaller companies bankrupt. It should be more difficult for directors and companies to jump out of an operation to avoid rehabilitation costs.

2.3.3 From the Mpumalanga Tourism and Parks Authority perspective

The land advisor unit's assessments of whether or not mining should take place in a specific area or not, and what possible mitigations they should have, were only considered as recommendations by the DMR (the DMR can still grant mining licenses regardless).

The legislation did not take into account the accumulative impacts of mining operations, which is seen as a large problem, with a large potential to damage the resource.

Mining companies did not appear to have much concern for wetland conservation, nor with biodiversity and water quality. Wetlands were generally seen as a hindrance, rather than something that they should be protecting.

There is a concern that no legislation prevents mining operations taking place in rehabilitated areas.

2.3.4 From the regulator's perspective

Implementation of legislation and guideline is an issue of concern. particularly in cases where certain legal provisions are not properly applied or explored. For example, the National Water Act allows for DWS/IUCMA to obtain upfront financial backing by the mining operations before they grant the water licenses (where such the money should be kept for rehabilitation of the water resource once the mine is closed but the DWS does not exercise this right, and the IUCMA does not yet have the power to do so.

There have been instances where mining managers were just ill-informed about the operations and made bad decisions due to a lack of knowledge.

Closure certificates are no longer issued, and mines are put on a care plus maintenance regime. This is because the authorities involved do not want to take the responsibility for the mining operations once they close. This needs to be looked at from a legislative point of view. Mining houses need to consider their obligations relating to long-term closure plans.

The DWS is reluctant to implement Section 12 of the National Water Act, which allows for prohibit activities in order to protect the resource. This is rarely seen. For example, mining and prospecting is continuing in the Nooitgedacht Dam catchment, even though the IUCMA advises against such activity. The DWS abdicates responsibility, by claiming that it is a National Environmental Management Act (NEMA) problem The IUCMA has no power in this regard, and can only advise until all the powers and responsibilities are transferred from the DWS to the IUCMA.

The lack of cooperation between departments has hindered other departments from doing their work. This was observed during the Carolina AMD crisis, where the relevant monitoring data of the Boesmanspruit Catchment prior to the Carolina Crisis were held at DWS. During investigations into pollution incidents in Carolina, the DWS would not make this data available to the IUCMA, forcing the IUCMA to request mining companies for access to their historic monitoring data. This lack of cooperation is also seen between DMR and other departments.

There are very few cases where a mining company or individual has gone to court due to not having a valid water related license. The result is that mining companies are not as concerned with about water licenses as the MPRDA procedures, which may elicit server punishment (including imprisonment) for non-compliance.

2.3.5 The South African Collieries Environmental Practitioners Association's Perspective

There are various interpretations of the law by regional offices and officers of the DMR.

DWS officials are reputed to lack of accessibility, and getting feedback for submitted applications is extremely difficult. This problem relates to a high staff turnover.

Environmental impacts of mining operations are regulated by three pieces of legislation: the NWA, NEMA, and MPRDA. These do not integrate very well with regards to EIA and EMP processes, resulting in increased costs of mining operations with respect to compliance. Efficiency would improve if these processes were aligned into one piece of legislation.

2.3.6 Positive observations on the mining licence procedures

Although the current mining licence procedure has many negatives, a few positive trends emerged from this set of interviews.

Nearly all government authorities interviewed believed that water users, including mining companies, are improving their practices with regards to water management. They believe the managers are realising that there will be long-term negative impacts if water is not properly managed.

All of the interviewees believed that the relevant legislation and guidelines, with regards to mining legislation, are more than adequate to protect the resource and the environment. Mining managers believed that the tools are well written and easily understood, such as the Government Notice 704, issued on 4 June 1999, entitled “Regulations on use of water for mining and related activities aimed at the protection of water resources” (commonly known as GN704), which is easily followed.

Most interviewees believed that the Carolina Crisis led to a positive outcome with respect to improved communication between all parties involved, considerable sharing of information, a greater awareness of problems relating to AMD and the negative impacts of mining, as well as improved monitoring and governance by departments. Mining companies have been more diligent since this event and were eager to correct any issues or problems experienced during their operations. Incidents of ‘finger-pointing’ by mining companies have declined, and many personnel are now working together to rectify problems in their catchments and in downstream mining operations.

An AMD task team has recently been set up by the IUCMA, in which mining companies and other agencies are key stakeholders. Their aim is to address the AMD problem and look at possible ways to rectify legacy issues, such as decants from abandoned mines.

According to the mining managers interviewed, there is very little (or no) perceived corruption occurring.

2.4 UKCMF coal mining working group evaluation of current mining life cycle process

In the two meetings (21 October, and 24 November 2015, documented in Appendix E), some concerns were raised about general decision-making processes, which were addressed via the proposed decision-making system.

1. *“That decision-making is not inclusive enough at present, not of government departments other than DMR, and not of affected people;*
2. *That decision-making is not transparent, that it is unnecessarily complicated and demanding (e.g. in terms of paper work, including very thick reports);*
3. *Information is difficult to access and difficult to understand;*
4. *That decision-making does not take into account and protect wetlands and water resources, and that this may limit future economic and land use options in the area;*
5. *That mining impacts are unfairly singled out, while agriculture and local government are not so strongly regulated;*
6. *That the current decision-making process does not protect people from water quality threats;*
7. *That there is no follow up on decisions, no compliance monitoring;*
8. *That various facets are not integrated, e.g. social, environmental aspects;*
9. *That DWS inputs are ignored, DWS is not able to refuse water licences;*
10. *There is a lack of communication between DMR and other departments;*
11. *There is a widespread suspicion of political inference in granting mining permissions (where they should not be granted);*
12. *That benefits and costs of coal mines are not clearly explained to the public during consultation processes.”*

This evaluation formed part of the dialogue process in the UKCMF and is further pursued in Chapter 6, in an attempt to address these issues. These challenges, combined with broader challenges in the political ecology of coal, lead to a wide range of contestations around coal mining.

2.5 Contestation between mining and other land uses. A political ecology.

Contestation is a crucial part of balancing decisions to proceed with coal mining and/or to protect biodiversity, including ecological infrastructure, and water resources and to preserve the widest possible range of future options for the use of ecological infrastructure. In South Africa, there is increasing contestation about and against coal mining, based primarily on concerns about climate change, air and local pollution from coal mining, and use. This section aims to demonstrate that much of this contestation takes place within the prescribed processes in the coal life cycle decision-making process. The influence and potential of other arenas for contestation and decision-making about coal is also considered. These include the public sphere (the media), environmental activism, policies relating to energy, health, biodiversity, water resources management and food security, and the emerging catchment management system, which offers extensive possibilities for public participation. Contestation also takes place in emerging social movements (see Tilly and Wood, 2009) concerned with environmental justice, social justice and mining impacts.

This project aims to develop new approaches to deal with this complicated issue. It takes into account changing contexts in the new South Africa created by the post-apartheid political transition, as well as the global sustainability transition, which has led to a new set of activities in politics, business and the public sphere: namely environmental management within a framework of sustainability thinking (Spaargaren et al., 2000). Transitions inevitably lead to contestations between the old and the new, as new contexts (or new opportunity structures) open up, especially for citizens to influence decision-making processes. This is the case in South Africa. particularly as our political economy moves from domination by a “Minerals Energy Complex” (MEC), to greater democracy and a concern with sustainability.

2.5.1 Contestation around coal - issues, agendas, actors, arenas and their relationship to eco-infrastructure

Contestation and argument is a crucial part of decision-making. Contestation can lead to the clarification of agendas, values and options; also, negotiation and agreement. The outcomes of contestation form the basis of systems that emerge in terms of property rights, freedoms, restrictions and institutional arrangements.

Contestation has been defined as “*the action or process of disputing or arguing*”, (Cambridge English Dictionary). This section explores contestations relating to ecological infrastructure and/or social ecological systems that contain them, including environmental impacts that arise from the use of coal. It deals with wetlands, water resources, biodiversity, conservation, climate change, air pollution, health impacts, the legacy of abandoned mines and decision-making processes. Its aim is to give a sense of the contestations around coal, and how these relate to ecological infrastructure. But first, this chapter, provides the political-historical background without which these contestations would not be understandable.

2.5.2 South Africa: born from contestation

The next section argues that contestation about coal mining was established over the past 140 years, since the minerals revolution in the last quarter of the 19th century. Two powerful, current transitions are fast changing this terrain: the post-apartheid, democratic and rights-based transition since 1990, and the worldwide transition to sustainability and environmental management, since the 1960s.

2.5.3 Transition, democracy, and environmental rights

Numerous developments in South Africa have created space for contestation around coal mining. Most fundamental are two constitutional rights: (environmental rights (Section 2)) and the right to live and work in an environment that does not threaten people's health and wellbeing, the latter being expressed in and buttressed by numerous legislative provisions (particularly, but not limited to, the NEMA acts. The environmental right, combined with rights to access information, organise and debate in the public sphere, and question administrative decisions, has created new arenas for contestation, (see below for details). A recent appeal court decision has confirmed the right of civil society to monitor the behaviour of business, including mining and heavy industry (AMSA decision in Appeal Court, November 2014). These rights have attracted the attention of rights groups and communities neighbouring industrial and mining sites resulting in a growing movement that contests whether, how, and where, coal is mined. This questioning of local negative impacts of mining will be explored below. Other, emerging forms of public participation are driven by concerns relating to biodiversity and climate change. The notion of ecological infrastructure – understood as the natural capital that provides ecosystem services – is a relatively new idea in this contestation that is set to play a central role in debates on the "green economy", which relies on the use and protection of ecological infrastructure (see Chapter 6).

As framing conditions change, history gives way to new energy planning processes, with public participation and the emergence of an independent national energy regulator, NERSA. Nevertheless, much of the complacency (relating to environmental problems) of earlier times remain. For example, up until December 1991mining and its waste (comprising more than 80% of solid waste in South Africa: CSIR, 1991) was not regulated according to rules applying to other waste streams. The mining industry still enjoys other legal privileges: for example, a land owner's consent is not required to enter and use land in order to exploit mineral resources. In the light of recent transitions, it can be expected that some of the historical privileges and assumptions given to mining will be eroded.

The mining industry has responded to these changes. Internationally, guidelines for mining, including the environment and relationships with communities neighbouring mines have been developed. The Global Mining Initiative has been the most prominent, including its participation at the World Summit on Sustainable Development (WSSD) in 2002. The Global Mining Initiative was initiated by nine of the world's biggest mining companies to deal with the pressures of criticism against social and sustainability issues in mining (see Buxton, 2012).

In South Africa, the mining industry participated in the creation of the Mining and Biodiversity Guidelines. The industry is also active in research initiatives of both Coalteach (with industry funds) and the Water Research Commission (public funds). Sustainability research and debate is an arena in which mines participate actively.

2.5.4 Issues and arenas for contestation

For the purposes of this chapter, an illustrative (but not exhaustive) set of issues with clear contestation aspects have been chosen. These are listed below.

- Abandoned mines: the burden of history.
- Water resources and acid mine drainage.
- Biodiversity, conservation and tourism.
- Climate change and energy policy.
- Agriculture and food security.
- Local pollution and health issues.

To unpack specific forms of contestation and arrange these in categories, this section explores the following questions a number of questions.

What is the origin and basis of the contestation, and how does this contestation relate to ecological infrastructure?

What is the nature of the pressure and the demands?

To answer this question, one needs to consider the following:

- Issue formulation is a dynamic process.
- Issues develop and transform over time, from original grievances to alternative visions, (Dobson, 1995).
- Coal mining and its use is a worldwide practice that has been subject to a long history of contestation "*at least since the 18th century*" (Alexius et al., 2014) [but] has also been seen as essential to economic growth and a trove of riches that cannot be left alone.

It is important to consider whether the issues raised in contestation about coal constitute a defence of ecological infrastructure, or a debate about alternative uses, or decisions (or policy directions) that make a difference to ecosystem services. Are the contesting actors using eco-infrastructure terms, or terms that could be translated into this language? These questions emphasise the need to understand ecological infrastructure as embedded in social ecological systems – in other words, in terms of the difference it makes to people or groups that use, or are dependent on, the ecological infrastructure.

Fundamental questions concerning the above points of view relate to arguments about the use of ecological infrastructure for different purposes, and whether they take the view that mining is primary and unavoidable and therefore important to deal with its impacts (avoidance, mitigation, offsetting) on the ecological infrastructure. This choice of point of view establishes a frame for decision-making which contains unspoken and unresolved debates. Lukes (2005) argues that the most powerful decisions are often made when framing the question, which then excludes the debating of questions and/or options.

The valuation of ecological infrastructure — to whom it provides services and how these are valued — crucially affects decision-making. Such questions often relate to land use, conservation, biodiversity and water planning documents. Knowledge (scientific, economic and social) is crucial here as a basis for contestation and decision-making. Ecological infrastructure is approached via the eco-system services they provide, following the Millennium Ecosystem Assessment Framework (MEA 2005), which describes the following ecosystem services:

- **Provisioning services:** harvestable goods or products obtained from ecosystems such as food, timber, fibre, medicine, and fresh water.
- **Cultural services:** non-material benefits such as heritage landscapes and seascapes, recreation, ecotourism, spiritual values and aesthetic enjoyment.
- **Regulating services:** ecosystem's control of natural processes, such as climate, disease, erosion, water flows, and pollination, as well as protection from natural hazards.
- **Supporting services:** the natural processes, such as nutrient recycling, soil formation and primary production that maintain the other services (DEA et al., 2013).

Who are the social groups or actors taking it up such services, and what arenas are used for these contestations? To whom do these issues matter – for example, local communities affected by local coal pollution, or blasting – and what influence do they have in national debates or local decision-making? For example, in August 2015, a "national meeting of communities affected by coal mining" on the Mpumalanga Highveld, in Limpopo, Gauteng and KwaZulu Natal met with four members of a parliamentary portfolio committee to discuss their agenda for contesting health and other issues arising due to their proximity to coal mining. This case demonstrated how a group that may seem marginal, can achieve access to prominent decision makers.

Where does the contestation take place?

Is it in the public sphere, or he media? Global, national or local? Discursive or material, power? Do contestants use the courts? Do contestants participate in specific decision-making processes, and does such participation produce satisfactory outcomes that motivate them to continue their participation? What is the space for contestation? How much freedom is there to debate, and what resources are available? (For example, under colonialism and apartheid, there was little space for debate about mining).

Some exceptions did, however, occur: for example, when (in the 1970s) the Wildlife Society (now WESSA) argued against the development of coking coal mines in in the Kruger Park. This opposition was successful in preventing coal mining (see Clarke, 1991).

In general, where "invited spaces" (such as EIA processes) do not adequately accommodate social pressure and debate, these pressures flow into "invented spaces", which may be more one-sided than dialogic, for example protest marches with memoranda (Miraftaab, 2004). Various social groups have differential access to decision-making arenas. For example, there are strategic water users and energy users' groups: 'big water and energy' users have privileged (and often cheap) access to resources, as well as direct access to decision makers.

How does this affect the mining decision-making process?

Does this contestation affect the mining decision-making process? If so, how? This question relates back to the descriptions and analysis outlined in Part 1 and pose questions on whether current options for contestation around coal are adequate.

Six arenas of contestation, as identified earlier, are surveyed below.

2.5.5 Abandoned mines – a legacy of the Minerals Energy Complex (MEC)

Mining's most enduring environmental legacy consists of more than 4000 (another figure is "*more than 6000*") ownerless and abandoned mines. These are not only coal mines at least 166 are located in the Witbank area (Rapson, 2004). A dramatic illustration of the consequences can be seen in [a] Witbank/Emalahleni mine that came into production before 1900 (Rapson, 2004). This mine has been burning underground for decades (Singer, 2011). Contaminated (acid mine drainage) water has found its way from underground into the Wilgespruit, which flows into the Olifants River.

Abandoned coal mines carry risks of spontaneous combustion in waste heaps, which include the release of unrecorded greenhouse gases, sinkholes, salinisation and sterilisation of soil, windblown pollution, spread of alien vegetation, and aesthetic disturbance (Rapson, 2004). They clearly pose an ongoing threat to the ecological infrastructure of the area.

Such mines should also be understood in terms of social-ecological systems. Abandoned mines create an immediately dangerous situation for communities who settled in the surrounding areas (Filitz, 2011). Arbor near Delmas, for example, was attractive for settlers because of access to houses, trees planted by the mines, and discard coal, as well as its semi-rural location (interview, Chief Skhosana, 2015) Informal settlements around the Coronation mine, outside Witbank, are exposed to sinkholes as well as sinkhole events, that pose a serious risk to residents. In an analysis of the life cycle of mining, Adler et al. (2007) argued that rehabilitation is essentially unaffordable, but not taken into account adequately during financial analysis and planning. This situation thus represents a transfer of wealth (rehabilitation subsidy) from the public purse to mine owners. This question will be pursued after the hydropedology discussion in Chapters 4 and 6, details of which are also outlined in Appendix C).

The central actors on this terrain are the state, including the Department of Mineral Resources, as well as parastatals including the Council for Geosciences as well as the Water Research Commission (which is part of the state), who are supported by public funds.

The issue has been taken up by organisations of affected communities, including the pioneering Green Revolutionary Council, led by ex-Witbank councillor Mathews Hlabane, who has organised up to 20 "toxic tours" focusing on Transvaal and Delagoa Bay, the intermittently functional Brugspruit DWS Water Treatment Works. The tours agenda also includes a number of dams of red AMD water (Munnik, 2009). A new organisation, HEJN (which started in 2015) recently guided members of a parliamentary portfolio committee through the area. The issue is on the agenda of a number of national environmental organisations (for example, GroundWork, Earthlife Africa, Centre for Environmental Rights, Environmental Monitoring Group) and international environmental organisations including Greenpeace, Friends of the Earth, and ActionAid.

Evidence of abandoned mines and their problems is visual and compelling and translates into dramatic media coverage and experiential tours. A number of farmer's groups, including the Escarpment Environmental Protection Group (EEPOG) under the leadership of farmer and activist Koos Pretorius of the Federation for Sustainable Environments (FSE), have joined forces with other activists, including the Wonderfontein Community Association, and academics (see McCarthy & Pretorius, 2009).

But what has been the influence on decision-making? While HEJN has demanded that no new coal mining licences be issued before abandoned mines are rehabilitated, there has been no response. The FSE, whose activism is directed against new mining applications on farming land, does interact directly with the mining licensing process. Activism does not seem to influence decision-making. Instead, it builds up a mobilisation against coal mining in general which will find expression in other arenas.

2.5.6 Water contestations: wetlands, water resources and acid mine drainage

South Africa is a water scarce country (the 29th driest in the world, our annual rainfall amounting to only half the world average) and our water resources are practically fully allocated. Any contamination of water is a direct threat to economic development.

Conscious policy choices in favour of mining, that have brought pressure on South Africa's water resources, date back to the decision made for the dewatering of the West Rand dolomitic aquifers in favour of gold and uranium mining, as expressed in the 1960 Jordaan report (Adler et al., 2007). The decision led to the ruin of small vegetable farmers, and over the longer term, incidents of acid mine drainage from gold. Acid mine drainage from coal is an equally serious problem, the more so since the Mpumalanga Highveld coalfield as a whole, is situated in an area that affects the headwaters of the Vaal, Olifants, Usuthu and Komati rivers (Hallowes & Munnik, 2016).

A recent description of ecological infrastructure and ecosystem services in the Mpumalanga Highveld states that this mostly grassland area contains "*numerous threatened and conservation-worthy species and ecosystems*" (Nkamba et al., 2015). This includes the Eastern Highveld Grasslands (a vulnerable ecosystem), the Wakkerstroom/ Luneburg grasslands (endangered) and the Chrissiesmeer Lakes Area (endangered). The Mpumalanga grasslands and wetland ecosystems are species rich, including endemic plants and birds (it is a birdwatchers' paradise). "*The area also has one of the highest concentrations of Freshwater Ecosystem Priority Areas (FEPAS) in the country*" (2015: 4). The Mpumalanga Highveld contains headwaters of the Vaal, Olifants, Komati and Usuthu rivers, which "collectively contribute 26% of South Africa's mean annual runoff and 28% of its available water yield." The Lake Chrissie system is an ancient remnant catchment, with a fascinating geological history (McCarthy et al., 2007). It lies lower than the surrounding catchments and therefore any pollutants cannot escape from it. The area has a rich birdlife as well as historical and archaeological sites, of interest for tourism (McCarthy et al., 2007).

These four river headwater systems are "*characterised by areas rich in wetlands that provide a range of ecosystem services, including regulating services (such as stream flow regulation, water purification and flood attenuation) that contribute to the sustainable functioning of the river basins, as well as* *provisioning (including grazing and water supply*" and cultural services". The Mpumalanga Highveld is known as a cultural heartland for both historical and current tourist reasons. It is also estimated to contain 51% of national recoverable coal reserves. and hosts 12 power stations – the largest power stations in the world, providing the vast majority of South African coal fired electricity – in a small area, a situation that concentrates risks of air pollution, s acidification of land, and local pollution (for example, ash). As our sibling project states: "*The trade-offs required in this region, in relation to the water-biodiversity-food-energy nexus, are thus currently more visible and contested than anywhere else in the country*" (2015: 6).

In 2009, McCarthy and Pretorius reported that both the Witbank and Middelburg municipal water supply dams were showing "*a steady increase in Total Dissolved Solids (TDS) and sulphate concentrations over the past 30 years… a tenfold increase in TDS (since mining began) and that … the sulphate in the Middelburg Dam now exceeds the maximum recommended concentration of water for human consumption, and is still rising*" (McCarthy and Pretorius, 2009: 61). A more dramatic example of the threat of acid mine drainage to social-ecological systems is the 7-month interruption of municipal water supply in the Carolina municipal dam in 2012 (Tempelhoff et al., 2012; McCarthy & Humphries, 2013).

Social groups, or actors, taking up the issue, and their influence

The Department of Water and Sanitation, as well as the emerging Catchment Management Agencies system, carry the official responsibility to protect the nation's water resources. The Department of Environmental Affairs (DEA) carries primary responsibility for biodiversity, but wetlands cut across mandates within and between spheres of government. At national level, DEA, DWS and DAFF all have a direct involvement. Affected local farmers have formed a number of "protection groups", affiliated with the FSE, which is in turn integrated with a vibrant environmental justice movement.

A large number of actors contribute to knowledge creation on this aspect, with the intention of feeding into decision-making. These include the parastatal CSIR (with its NFEPA atlas), Civil society organisations (including WWF and Greenpeace) have taken this issue up in terms of knowledge creation. This has in mapping these areas (CSIR, SANBI for wetlands) and producing guidelines for their protection. Wetlands protectors are well organised into a national alliance of academics, practitioners and concerned citizens (see the literature review in Chapter 1).

What is their influence?

The National Water Resources Strategy, catchment management forums and catchment strategies, are used but have more potential. South Africa has a strong water quality science base, including CSIR and WRC. Some research results supported by the mining industry (e.g. Coaltech) rare not fully accessible to the public. Water issues arise in individual Environmental Impact Assessments (EIAs) when related to local issues or specific aquatic environments.

Court cases are widely used in contestations. The Golfview Mining case (that originated this research project) provided an interesting example of contestation. The case was driven by the FSE, and the end result was an agreement to make money available for research that would provide a robust evidence base for the protection of wetlands during mining decision-making. This suggests that civil society is stepping into the vacuum left by inadequate DMR regulation.

2.5.7 Biodiversity, conservation, heritage and tourism

Currently a number of coal mine applications throughout South Africa are being opposed on conservation grounds. Examples include the Fuleni Mine (close the iMfolozi Game Reserve in northern KZN) and a new mining development close to the Mabola Protected Environment in Mpumalanga. Such developments have resulted in the rise of community organisations aligning themselves under environmental activist groups, such as "Mining Affected Communities in Action" (MACUA).

The above examples show that consideration of ecological infrastructure and ecosystem services are already central in contestation actions between coal mining and biodiversity/conservation interests. Eco-infrastructure includes water, wetlands, soils and the biodiversity of grasslands and ecological infrastructure as a component of social responsibility.

Decisions by the DMR to allow mining in environmentally vulnerable areas point to a disconcerting pattern of ignoring biodiversity concerns and the plans of biodiversity organisations, including those with an official government mandate such as the Mpumalanga Parks and Tourism Agency (MTPA). Response against this decision have been organised under a coalition consisting of environmental groups including Birdlife South Africa, AWARD (Association for Water and Rural development), Earthlife Africa, FSE, groundWork, the Mining and Environmental Justice Alliance of South Africa (MEJCON), the Benchmarks Foundation and the Endangered Wildlife Trust.

Trends in environmental activism suggest more sophisticated protest actions, with arguments being proposed on the basis that biodiversity is not ‘a good’ in itself, but also as providing a foundation for tourism, agriculture and subsistence farming (WWF, 2011).

Biodiversity actors are intensely involved in creating scientific knowledge as a basis for arguments, mounting economic arguments, participating in EIAs of coal mines threatening biodiversity areas, mounting media as well as legal challenges, and mobilising communities across class and racial lines. As noted earlier, mining interests have participated in the creation of guidelines for mining and grasslands, as well as mining and biodiversity.

2.5.8 Climate change and energy policy

Climate change, which arises overwhelmingly, although not exclusively from, the burning of coal, is a high level ecological infrastructure concern because it impacts on planetary regulatory services.

There is little scientific disagreement about anthropogenic climate change, although a small number of dissidents are in the business of spreading doubt about it (Oreskes & Conway, 2010). Carbon capture and storage is a controversial and unproven technology, yet it is used in planning for coal use, e.g. in Coal Road Map. It is argued, that if all the planned power stations in India and China are built and operated, (to which SA coal exports are oriented) this would set a certain trajectory to six degrees Celsius global warming.

Climate change, which has rapidly arisen in the national consciousness, forms the basis of a trajectory that foresees a peaking of GHG emissions between 2020 and 2025. However, *“…despite domestic policy on climate change mitigation, South African upstream coal infrastructure expansions are going ahead, with the result that the country will likely exceed its self-allocated carbon budget in future. Both economic and political interests in the coal sector are driving this, as well as short- and medium-term energy security concerns.*” (2014: 23). The authors warn of a “lock-in to a high emissions trajectory”.

Climate change politics take place primarily in terms of energy policy in debates and planning about the relative proportions of coal and renewable energy in future planning. A large range of actors are involved in this, including DEA, certain trade unions (NUM and NUMSA) NGOs, universities and faith based environmental organisations. Climate change concerns have broad public exposure in the media, but also consist of direct support to renewable energy options, and opposition to coal. For example, WWF’s (2010) argument that Renewable Energy can provide 50% of South Africa’s electricity by 2030.

Does this contestation affect the mining decision-making process? Climate change is a very large-scale, aggregate rule-making process with the effect of limiting and dividing up “carbon space” internationally. Ultimately its outcomes will have direct implications for both coal mining and coal use, including the infrastructure that coal expansion is premised on, (Burton & Winkler, 2014). From a regulatory and sustainability point of view, the possibility does exist that each proposed new coal mine could be assessed in terms of its contribution to climate change over its life span.

Wetlands can play an important role in ameliorating climate change effects in the hydrological cycle, acting as sponges absorbing water in a flood event and releasing water during drought periods.

2.5.9 Agriculture and food security

There is direct competition for land between agriculture and coal mining in Mpumalanga. Even the best restoration efforts are unlikely to succeed in recreating ploughable land. Restored mining land is more likely to be suitable for grazing uses only.

Maize farmers present a food security vs. coal argument saying that "*South Africa has only 1.5% high potential arable soils and 46.4% of this total area is in Mpumalanga.*" There are thus fears that mining expansion will lead to a higher maize price (BFAP 2012: 5). The report also listed the (negative) impacts of coal mining on natural resources and sustainability:

Soil degradation: the BFAP report claimed that *"Mpumalanga has potentially lost approximately 26% (225 217 hectare) of its high arable soils to current mining activities, including AMD (Acid Mine Drainage) and the acidification of soil.*" (BFAP, 2012: 6).

Water quality effects: "*Coal mine drainage can be detrimental to the aesthetic appearance of streams and rivers and destroy the living organisms that inhabit them. This in turn reduces their self-purification power and makes streams unfit for domestic, industrial or agricultural use, requiring surface waters to be extensively treated (at very high costs) before they are suitable for such uses.*" (BFAP, 2012: 6). Eight km downstream from Loskop mine, near Wakkerstroom, coal pieces washing down the river, and water cannot be used to cook food. (Hallowes & Munnik, 2016).

Health risks associated with mining: "*Studies on the health effects in coal mining communities 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)*" (BFAP, 2012: 6).

These arguments from the maize growing industry indicate that mining is contested. They argue that mining is doing harm not only to humans and ecosystems, but that this harms the very sustainability of nature on which production and healthy living – a constitutional right – depends. In a 2015 interview, activist farmer Koos Pretorius from the Bethal area in Mpumalanga, and participant in the UKCMF working group, argued that Mpumalanga's maize production plays a strategic food security role in protecting the country from the need for expensive maize imports in dry years. Pretorius argues that in about 30 years' time, the demand for coal extraction will fall drastically because it will no longer be able to compete with renewable energy options. The implication of these arguments is that regional plans describing, where coal mining could do less damage, should be drawn up. Catchment management strategies could provide the ideal vehicle for this.

The actors in this contestation are mostly white farmers. They are well organised have extensive knowledge of land use history and the means to hire their own legal representation. While it may be relatively easy isolate to isolate them as historical beneficiaries from apartheid, their arguments about food security are sound and could attract support from that perspective.

2.5.10 Air pollution and public health

The Mpumalanga Highveld has long been seen as an area of bad air quality. Environmental journalist James Clarke, writing in 1991, compared Mpumalanga to Eastern Germany in its extent of air pollution, and referred to studies showing stunted growth in boy children as a result. Numerous studies, from the

1990s onwards supported Clarkes' contentions. In 2015, the NGO groundWork released a study which argued that "*over the last five years, and estimated 70 to 165 people's lives could have been saved through implementing the WHO air quality standards*" (McDaid, 2014). Such studies prompted the formation of the Highveld Environmental Justice Network (HEJN) which was a partner in a successful legal contestation against ESKOM and SASOL's applications to be exempted from the application of air quality standards that had flowed from processes in the priority air quality area of the Highveld. It is not known what the financial burden of coal-related air pollution externalities are for the Department of Health, but it must be substantial. Provision of clean air is a regulatory ecosystem service, via dilution and dispersal of pollutants, but in areas such as the Mpumalanga Highveld this service is now overstrained.

Activism on air pollution is driving at establishing these costs, making them known to voters in Mpumalanga, and using them to influence the decision-making process on coal. The slogan of this campaign, seen on colourful t-shirts worn by activists, is "Coal Kills, Kill Coal".

The arena for this contestation is in the public sphere, media, infused by expert knowledge generated in South Africa and globally, and interaction with politicians on national, provincial and local levels. As alliances between communities, policy, activist and legal NGOs grow, the list of consolidated demands and positions has grown. These activists are also in close contact with other South African and global anti-coal struggles, including those waged by Friends of the Earth, Greenpeace, and the WWF. Opposition to mining from neighbouring communities has been growing, and a number of networks of communities affected by and/or opposing mining have been formed, including (most notably) the Mining Affected Communities United in Action (MACUA) and the Mining and Environmental Justice Community Network (MEJCON).

In August 2015, a meeting took place between coal impacted communities nationally and the Parliamentary Portfolio Committee on Environment, which has now visited the Mpumalanga Highveld Area three times. The following recommendations indicate that the Portfolio Committee has, to some extent, been moved by this emerging activism. After an October 2014 visit, the environmental portfolio committee decided that:

- The environmental affairs portfolio committee must maintain open lines of interaction with communities to be in tune with the implementation of policy and law
- Communities should urgently be provided with electricity.
- Companies must take responsibility for the health impacts of pollution. They must be adequately punished and must provide compensation for their impacts.
- Parliament should make sure that all government spheres, including local government, have the necessary capacity to monitor and enforce air quality laws.
- Government should monitor the impact of air and water pollution on communities.
- Government must urgently undertake studies to determine the externalities of air pollution in priority areas to assess economic, social and environmental costs.

A draft report after the visit in July 2015 recommended that:

- Government needs to dedicate ring fenced funding for air quality management at district municipality level to ensure the existence of fully functional air quality management units capable of monitoring and enforcing license conditions to hold polluters accountable.
- Government and industry should consider setting up a fund for victims of pollution.
- All municipalities need to have Air Quality Management Plans.
- Real-time emissions monitoring to ensure compliance and accountability.
- The Portfolio committee should meet with mayors, provincial legislatures and treasury to find solutions so that local authorities in meeting their air quality management obligations.

In the meantime, the communities themselves resolved to:

- ensure that communities understand the risks and impacts of coal.
- raise awareness and mobilise on the issues of coal.
- use legal means to enforce our constitutional and legal rights.
- network and work in solidarity with other impacted communities.
- create a new vision of a clear energy future, and lobby to achieve it.
- ensure that we are part of decision-making and that we influence policy.

2.6 Conclusions: options to address contestation

Mining managers complain about duplications in the system, and feel that they are overpoliced. Other interest groups, like regulators, do not have enough power to protect water resources, as the catchment management system is still emerging and transfers of powers are slow.

Participants in the UKCMF found that decision-making was not inclusive enough, or transparent enough, and did not take pay sufficient attention to the protection of wetlands and water resources. This may limit future economic and land use options in the area They also noted a lack of transparency, suspicion about decisions made, and insufficient information about the coal decision-making process, “political interference” in the decision-making processes, and that the benefits and costs of coal mines were not clearly explained during the consultation processes.

The survey of current coal contestations points to the following conclusions:

- Climate change politics are changing attitudes towards coal and the resources.
- Much effort goes into improving the knowledge basis for decision-making but the socio-political-economic dimensions receive less attention. A number of government departments are variously involved in protecting the eco-infrastructure BUT they seem to be trumped and frustrated by the DMR, who [reportedly] ignore inputs from other groups. A case in point was the granting of the Atha-Africa licence to mine in the Mabola protected area of Wakkerstroom, where the protection of a protected area is being breached, with the agreement of the DEA.
- Regional solutions and strategies – as for example required by the ministerial directive in Carolina in 2012 -- seem to be a more reasonable approach than one-off contestations about mining licences. Catchment management strategies have the potential to provide overviews and regional land use strategies, particularly as regards water resources seen as ecological infrastructure.
- In these circumstances, civil society – organised citizens – have come together in a variety of organisations, networks and coalitions to play the role of regulator where regulators have left a vacuum.
- Activists, from directly affected communities mobilise themselves into community organisations, which are taken up in solidarity by broader environmental justice movement as well as national and international NGOs.
- Costs to communities are largely calculated in terms of health problems. These considerations can be expected to increase in importance in national debates around the mining and use of coal.
- The current mining licensing process is too narrowly conceived to provide opportunities for contestations on the grounds laid out above. The project therefore recommends that these decisions should be nestled within a catchment management strategy

3 LEGAL ANALYSIS OF THE MINING LIFE CYCLE

The focus in this chapter falls on the nature, and scope of, multiple licensing processes undertaken during the course of a mining life-cycle, evaluated against key principles of the new environmental governance; Section 2 develops this analysis further by analysing how the law frames resistance and contestation in the arena of mining and the protection of wetlands, biodiversity and ecological infrastructure.

For detailed information on legislation, see the following Appendices.

- Appendix A: Regulation throughout the coal mining life cycle, which covers relevant legislation applicable throughout the mining cycle, particularly in relation to the following aspects:
    - Water resources and Determination of the Water Reserve
    - Issues relating to the Protection of the Ecosystem (NEMBA)
    - Rehabilitation and Environmental management plans
    - Closure certificates
    - Statutory duty of care (with respect to the Environment)
    - Lawful Water Use
    - Environmental Monitoring
    - Criminal Offences
- Appendix B (perspectives on the legal life cycle of coal mining in relation to resource protection, from a mining manager's point of view).

3.1 Introduction

The concepts of ecosystem services and ecological infrastructure provide useful new lenses to evaluate the benefits of a variety of water uses, including water for mining and water for the conservation of aquatic ecosystems. The discourse of ecosystem services and ecological infrastructure essentially restates the arguments for protecting biodiversity, but for the sake of the services and value provided to humans. Ever-present risks are that the value of ecosystem services and ecological infrastructure will be understated, and that the myth of the infinite intersubstitutability of financial and natural capital will be perpetuated. As the ecosystem and resilience-based approaches to natural resource management have demonstrated, in some instances there are irreversibility risks so high that the logic of substitutability cannot operate.

This report turns to legal frameworks for valuing wetlands, biodiversity, ecosystem services, and ecological infrastructure within the specific context of the mining life-cycle. This gives rise to questions on whether legal frameworks can be applied to regulation of the mining life-cycle, (particularly the *licensing process for mining)*, would be appropriate for safeguarding the integrity of ecosystems and ecological infrastructure? To what extent should the law safeguard participation and to what extent should the law itself be adaptive?

In responding to these questions, this chapter (1) outlines the importance of law as a framework for decision-making; (2) describes how ecosystem and resilience-based perspectives and adaptive management approaches have shifted understandings of environmental and natural resources law; (3) defines the mining life-cycle and the South African laws that frame this cycle; and (4) explains recent shifts in the South African legal framework governing the mining life-cycle, the movement away from a fragmented model of regulation to a single environmental system, and how the single environmental system frames the issues in the previous paragraph.

3.1.1 Law as a framework for decision-making

Law is never the only factor framing decision-making. Economic, political, social, and cultural factors probably play a greater role in shaping the chain of actions and reactions that result in ecosystems being destroyed or protected.

But law is important for a variety of reasons. It foregrounds some conceptual resources at the expense of others, thereby contributing to shaping worldviews. Deep-seated cultural assumptions about nature and its workings are invariably coded into legal texts. Law also allocates legal powers, rights and duties amongst key agents, both in and outside of government. The 'legal' nature of such decisions ultimately rests upon the willingness of the State to utilise its legitimised violence (fines, confiscation, and imprisonment) to uphold such powers, rights and duties. Compliance with the law provides a veil of moral probity to a particular activity. The risk however, is that compliance with the 'letter of the law' may not lead to the socially-desirable outcomes articulated by the law (the 'spirit of the law').

3.1.2 Shifts in the nature of environmental and natural resources law

Insights in conservation biology that have led to understanding ecosystems as complex and adaptive, with thresholds, tipping points, functional redundancy, and so on, and the development of adaptive management and collaborative adaptive management as particular approaches in natural resource management, have preoccupied legal scholars for a number of years, and there is a burgeoning literature on this topic (Humby, 2014b), which recognises that law is itself a complex adaptive system that operates at different scales.

For many years, environmental laws have rested upon two key false assumptions: That humans should be considered separate from ecosystems, and that ecosystems tend toward steady-state equilibrium that would remain perpetually in balance (Humby, 2014b: 108). Nature conservation laws were characterised by 'fencing-off' strategies, propagating the fiction that fenced-off areas could remain in a 'state of nature', free from human influence (Tarlock, 2003: 1183). Pollution control laws, characterised by fixed standards for emissions and resource quality criteria, usually ignored the cumulative impacts of pollution or the impact of pollution on the adaptive quality of ecosystems (Adler, 2010: 139).

The law itself has thus been 'maladaptive', a feature Arnold and Gunderson (2013: 10428) recently delineated into four categories:

- The systemic goals of environmental and natural resources law are too narrowly focused on advancing the stability of political and economic goals.
- The law is based on monocentric (too centralised), unimodal (placing too much emphasis on uniform models), and fragmented structures of government in which there are frequent scale mismatches.
- The law favours inflexible methods that employ rules and legal abstractions promoting resistance to change. Key amongst these are the so-called 'rule of law' values of certainty, accountability and liability for harm.
- The law is based on a rational, linear, legal-centralist approach that assumes away uncertainty.

Underscoring these maladaptive features, Humby notes that a number of scholars have criticised the linear, front-end nature of environmental legal structures and processes which assume that resource managers are sufficiently knowledgeable about the intricacies of social-ecological systems, and that 'impacts' on a variety of environmental media can be predicted (and consequently prevented or mitigated) before they occur. This presumed linearity of cause and effect, mirrored and further constituted by the law, "*conflicts with the much more complex ways in which law intersects with both society and nature*" (ibid).

Over the last two decades many legal scholars have accordingly tried to redefine what an ecosystem-resilience-based approach to law would look like.

3.2 Legal frameworks for valuing wetlands, biodiversity, ecosystem services and ecological infrastructure in the mining life-cycle.

3.2.1 The mining life-cycle and framing South African laws

Although no two mines are exactly alike, there is a recognised mining 'life-cycle' that may commence with reconnaissance operations (geological, geophysical and photo-geological surveys) and then proceed to prospecting, which disturb the surface of the earth due to excavations, pits, trenches and drillings that initially commence over a larger area, and become more focused over time. The cumulative impact of these activities may well cause significant environmental impacts (Hermanus, Watson & Humby, 2014: 11).

If a promising mineral deposit is located, the prospector evaluates the reserve and the financial feasibility of extracting it. If feasible, a process of mine planning, which should include planning for mine closure, commences. This is a 'critical' phase for addressing environmental impacts during the life of the mine and upon closure (ibid).

The phase of greatest environmental impact mine construction and operation which may involve surface strip mining, open pit mining, dredge mining, dump reclamation; shallow underground mining; and deep underground mining (Hermanus, Watson & Humby, 2014: 12–17). The operational phase of a mine may disrupt or destroy wetlands, biodiversity, ecosystem services and ecological infrastructure in the mining area.

Once a mine has reached the end of its 'life', there should be decommissioning (engineering works to decommission and dismantle infrastructure, transferring assets and environmental obligations, demobilisation of the labour force) and closure (completing rehabilitation, instituting post-closure monitoring and maintenance).

3.2.2 South African laws framing the mining life-cycle

The introduction to this chapter outlined why law is important as a framework for decision-making and to understand how the law operates to frame decision-making. Essentially, the law functions by allocating rights, powers, and duties (and sometimes exemptions), creating institutions and defining processes.

Law functions to create certain licensing, authorisation or permitting processes

These processes prohibit certain activities from being conducted until the state has given the activity its stamp of approval. Licensing processes (in this narrow sense) seek to secure the state and/or public interest in carrying out a particular activity. In the narrow sense, licensing and permitting processes are significant because they are the most obvious point in the legal frame at which a decision is taken to allow or disallow an activity from taking place.

The decision to licence, authorise or permit, creates a right in property which may then not be expropriated without just compensation, and which may itself become a marketable commodity. Licensing processes do not necessarily comprise a single decision: there may be a series of decisions that ultimately culminate in the granting of a licence, authorisation or permit.

Law creates a frame for the conduct of licence holders and their regulators

Law not only functions to create a frame for the approval of a particular activity, but also defines the ambit of public and private powers, rights, duties and exemptions within the licensing relationship. Thus, the law typically vests powers in the regulator to define the conditions pertaining to a particular activity, to make subsequent approvals (applications to amend an environmental programme, or to transfer the rights granted by a licence), to monitor the activity by requesting and reviewing information submitted by the licence-holder, and to enforce compliance through administrative action (issuing directives or orders; suspending or withdrawing a licence) or initiating a criminal prosecution.

Licence-holders are vested with both rights and duties. The right to conduct a particular activity is accompanied by various explicit and implied rights. The duties of licence-holders are typically defined in the conditions of the licence itself, but may also be articulated in broad, framing ways by the legislation. For example, a duty to rehabilitate the environment affected by the prospecting or mining operation, or to apply for a closure certificate. This functionality of law also establishes a decision-making frame. Each of the decisions taken in the subsequent outworking of the licensing relationship may be reviewed by a court.

Law creates regulatory powers outside of the licensing relationship

Licensing, in the broad sense, encompasses the definition of regulatory powers that can be applied irrespective of whether a licensing relationship exists with the regulatory authority or not. Thus, the law includes broad standards that apply over and above the conditions laid down in specific licences (for example, specification of standards for the use of water in mining operations) and regulatory powers that may be exercised against 'everyone' or 'anyone' and not specifically against the licence holder (for example, the requirement that everyone who damages a water resource should take reasonable measures to prevent such damage from occurring). These powers compensate for the chief weakness of powers exercisable against and duties attaching to the licence-holder, which is that the licence-holder is a particular natural or juristic (i.e. a company) person. Unscrupulous mining companies can abuse this feature of the law by ensuring that the juristic person holding the licence is not the juristic person holding the major assets of the company.

In South Africa, the licensing process for mining (in the broad sense) comprises multiple and at times, overlapping procedures governed by different pieces of legislation[1] and mandating a variety of authorities with regulatory oversight.

At the centre of the web of laws constituting the safety net for the integrity of wetlands, biodiversity, ecosystem services and ecological infrastructure is the National Environmental Management Act, 1998 (NEMA), grounded in the concept of 'sustainable development'. It also articulates an extensive list of principles for environmental management in South Africa (both the constitutional environmental right and NEMA are discussed further below). The most salient national laws further implementing s 24 of the Constitution and the NEMA include the following:

- National Water Act, 1996 (NWA).
- Mineral and Petroleum Resources Development Act, 2002 (MPRDA).[2]

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1. For purposes of this report, legislation refers to Acts of Parliament. Secondary legislation or regulations refers to rules made by the executive to implements various Parliamentary Acts, and judgments of the courts refer to the decisions of the High Courts, Supreme Court of Appeal and Constitutional Court in individual cases that create 'precedent' for subsequent cases.

2. In the case of *Maccsand (Pty) Ltd v City of Cape Town & others* 2012 SA (4) 181(CC) the Constitutional Court found that the MPRDA was one of the laws passed to promote s 24 of the Constitution (at para 5).

- National Environmental Management: Waste Act, 2008 (NEMWA).
- National Environmental Management: Air Quality Act, 2004 (NEMAQA).
- National Environmental Management: Biodiversity Act, 2004 (NEMBA).
- National Environmental Management: Protected Areas Act, 2003 (NEMPAA).
- National Environmental Management: Integrated Coastal Management Act, 2008 (NEMICMA).
- National Heritage Resources Act, 1999 (NHRA).

In addition to these pieces of national legislation, following the Constitutional Court's decision in the Maccsand case and other cases defining the ambit of municipal authorities' powers over land use planning,[3] it is now also generally accepted that mining companies must also comply with laws dealing with land use planning.

At the time, the crisis in Carolina unfolded, the following licensing, permitting and authorisation procedures applied to mining (Table 2):

Table 2: Licensing process for mining prior to 8 December 2014

Licence/Authorisation	Governing Legislation	Authority	Appeal Authority[4]
Environmental management plan for a prospecting right or mining permit	MPRDA	Minister of Mineral Resources/official acting with delegated authority	Minister of Mineral Resources or Director-General of the DMR
Environmental management programme for a mining right	MPRDA	Minister of Mineral Resources/official acting with delegated authority	Minister of Minerals or Director-General of the DMR
Environmental authorisation	NEMA	MEC for environment/official acting with delegated authority (in most cases) Minister for environment/official acting with delegated authority (in limited cases)	Minister or the MEC of the environment respectively against decisions taken by officials acting with delegated authority
Water use licence	NWA	Minister of Water Affairs or a catchment management agency (if the power to licence has been assigned to the agency)	Water Tribunal
Waste use management licence[5]	NEMWA	MEC for environment/official acting with delegated authority (in most cases)	Minister or the MEC of the environment respectively against decisions taken by

3. See note 4 above.

4. The 'authority' is the government agency mandated to grant a license or authorisation in the first instance. The appeal authority is the government agency within the executive branch of government that may reconsider an application on the merits, thus granting a so-called 'internal' right of appeal (as opposed to an appeal made to the courts of law).

5. The Waste Act initially excluded residue deposits and residue stockpiles (i.e. the large bulk of mining waste) regulated under the ambit of the MPRDA from its provisions. The need to apply for a waste

		Minister for environment/official acting with delegated authority (in limited cases)	officials acting with delegated authority
Atmospheric emissions licence	NEMAQA	Metropolitan or district municipalities	Not yet specified[6]
Permit for the catching, capturing or killing of any threatened or protected species	NEMBA	Minister of environment or an organ of state delegated with authority to issue permits	Minister of environment
Additional considerations for environmental authorisations for coastal activities	NEMICMA	Competent authority for the issuing of an environmental authorisation	Minister or the MEC of the environment respectively against decisions taken by officials acting with delegated authority
Permit for the destruction, damage, alteration or removal of a national or provincial heritage resource	NHRA	Committee of the National Heritage Resources Council or provincial councils	South African Heritage Resources Agency (SAHRA) Council or provincial heritage resources councils (first appeal); thereafter an independent tribunal
Land use authorisations (mostly re-zoning)	Various pieces of provincial land use planning legislation	Metropolitan, district and local municipalities	Town planning boards, the MEC for planning and development in some instances

Each of these laws established rights, powers, duties and exemptions for the subsequent outworking of the licensing relationship, as well as powers exercisable outside of this relationship. Chief amongst the latter were s 28 of the NEMA and s 19 of the NWA that established statutory duties of care in relationship to the environment more broadly, and to water resources more particularly. The statutory duty of care enabled regulatory authorities to order a person having a relationship to land, or to a water resource, to take 'reasonable measures' to prevent harm from occurring, continuing or recurring, and empowered the authority to take steps to recover costs thereof from a wide range of parties.

Since at least 2008, the South African government had been engaged in consolidating the fragmented model for regulation of mining and environment into a 'single environmental system' effected on 8 December 2014. The single environmental system chiefly affects the initial licensing processes under the MPRDA, NEMA, NWA and NEMWA. One of the chief criticisms of the fragmented model centred on the overlapping requirements to submit and obtain approval for an environmental management plan/programme under the MPRDA, as well as environmental authorisation for various listed activities under the NEMA. The first attempts to consolidate and streamline centred on these two authorisations, with water and waste authorisation processes being added at a later stage. Through a host of interagency agreements, legislative amendments, and judicial decisions, a new model was finally

management license thus applied to waste other than waste contained in residue stockpiles and deposits generated on a mining area.

6. The NEMAQA allows the Minister for environment to make regulations on appeals from the decisions of metropolitan and district municipalities, but to date no regulations of this nature have been formulated.

agreed upon by the end of 2013 (see Humby, 2015 for an overview of these developments). The essence of the new ‘single environmental system’ is outlined below.

- Regulation of environmental aspects of mining under the statutory authority of NEMA, and corresponding environmental provisions in the MPRDA, have been repealed. To obtain a prospecting or mining right it will only be necessary to obtain an environmental authorisation under the NEMA, not an approved environmental plan/programme under the MPRDA.
- The scope of the environmental authorities’ power to determine rules regulating the mining industry has been increased and now includes the power to make regulations on residue stockpiles and deposits, consultation with interested and affected parties, mine closure requirements, and financial provision for rehabilitation.
- The minister of environmental affairs can prohibit or restrict the granting of an environmental authorisation and/or the granting of a waste use management license for listed activities (i.e. inclusive of prospecting and mining) in a specified geographical area if this is necessary “*to ensure the protection of the environment, the conservation of resources, or sustainable development*”. This power can only operate prospectively and cannot strip existing licence-holders of their rights. It could therefore be used to prohibit or restrict mining in pristine, unmined areas all together, or it to prevent the authorisation of mining in a particular area, thus reducing the pressure of cumulative impacts.
- The minister of mineral resources has been vested with authority to issue the environmental authorisations under the NEMA for listed activities directly related to prospecting for a mineral and/or extraction and primary processing of a mineral resource.
- An appeal against his or her decision now lies with the minister of environment. The opportunity to lodge an appeal, however, has been hedged in with very strict rules.
- Mining waste in the form of residue stockpiles and deposits has now been brought under the ambit of the NEMWA, and the minister of mineral resources serves as the licensing authority under this Act.
- Water use licenses will still be issued by the minister of water affairs and, where authorised, a catchment management agency. The minister of water affairs is now duty-bound to align the process for the issuing of a water use license with the timeframes for issuing the environmental authorisation and prospecting/mining right. The applicant mining company’s right to appeal against a delegated official’s refusal of a water use license now lies with the minister of water affairs, and no longer with the Water Tribunal.
- Provision has been made for the appointment of a specialised corps of Environmental Mineral Resources Inspectors.
- The adaptability of the law has been reduced, since the latest amendments restrict the manner in which the law can be changed, so as to move away from the single environmental system (Section 50A NEMA or s 163A NEMWA).
- The granting of environmental authorisation for mining, prospecting, or mining right itself, and the granting of the water use license is intended to be aligned and coordinated with the entire process, taking no longer than 300 days, inclusive of decision-making by the regulatory authorities.

Table 3: Changes for "new single environmental licensing process" for mining post 8 December 2014

Licence/Authorisation	Governing Legislation	Authority	Appeal Authority[7]
~~Environmental management plan for a prospecting right or mining permit~~	~~MPRDA~~	~~Minister of Mineral Resources/official acting with delegated authority~~	~~Minister of Minerals or Director-General of the DMR~~
~~Environmental management programme for a mining right~~	~~MPRDA~~	~~Minister of Mineral Resources/official acting with delegated authority~~	~~Minister of Minerals or Director-General of the DMR~~
Environmental authorisation	NEMA	~~MEC for environment/official acting with delegated authority (in most cases)~~ ~~Minister for environment/official acting with delegated authority (in limited cases)~~ *Minister of Mineral Resources/official acting with delegated authority*	~~Minister or the MEC of the environment respectively against decisions taken by officials acting with delegated authority~~ *Minister of Environment*
Water use licence	NWA	Minister of Water Affairs or a catchment management agency (if the power to licence has been assigned to the agency)	Water Tribunal (for interested and affected parties) *Minister of Water Affairs (for applicant)*
Waste use management licence[8]	NEMWA	~~MEC for environment/official acting with delegated authority (in most cases)~~ ~~Minister for environment/official acting with delegated authority (in limited cases)~~ *Minister of mineral resources/official acting with delegated authority*	~~Minister or the MEC of the environment respectively against decisions taken by officials acting with delegated authority~~ *Minister of Environment*

7. The 'authority' is the government agency mandated to grant a license or authorisation in the first instance. The appeal authority is the government agency within the executive branch of government that may reconsider an application on the merits, thus granting a so-called 'internal' right of appeal (as opposed to an appeal made to the courts of law).

8. The Waste Act initially excluded residue deposits and residue stockpiles (i.e. the large bulk of mining waste) regulated under the ambit of the MPRDA from its provisions. The need to apply for a waste management license thus applied to waste other than waste contained in residue stockpiles and deposits generated on a mining area.

Atmospheric emissions licence	NEMAQA	Metropolitan or district municipalities	Not yet specified[9]
Permit for the catching, capturing or killing of any threatened or protected species	NEMBA	Minister of Environment or an organ of state delegated with authority to issue permits	Minister of Environment
Additional considerations for environmental authorisations for coastal activities	NEMICMA	Competent authority for the issuing of an environmental authorisation	Minister or the MEC of the environment respectively against decisions taken by officials acting with delegated authority
Permit for the destruction, damage, alteration or removal of a national or provincial heritage resource	NHRA	Committee of the National Heritage Resources Council or provincial councils	SAHRA Council or provincial heritage resources councils (first appeal); thereafter an independent tribunal
Land use authorisations (mostly re-zoning)	Various pieces of provincial land use planning legislation	Metropolitan, district and local municipalities	Town planning boards, the MEC for planning and development in some instances

In conclusion, this section has explained the various ways in which law may frame decision-making in protecting wetlands, biodiversity, ecosystem services and ecological infrastructure from mining. There is no one single statutory frame or process, and even within one statute the law functions in different ways to frame decision-making. The complexity of the mining process has also arisen from shifting the locus of rules on mining and the environment from the MPRDA to the NEMA.

3.2.3 Current laws framing the impact of mining on wetlands, biodiversity, ecosystem services, and ecological infrastructure

Having identified the laws that currently frame decision-making relating to mining and the environment, we turn to questions articulated at the opening of this chapter:

- What type of legal frameworks for the regulation of the mining life-cycle would be appropriate for safeguarding the integrity of ecosystems and ecological infrastructure, both for present and future generations?
- What processes should the law instigate?
- What institutions should it establish and with what rights and powers vis-à-vis the regulated community and amongst institutions themselves?
- What conceptions of nature should the law ideally convey to regulators and the regulated community involved in licensing processes?
- What types of information should legal decision-making rest upon?
- To what extent should the law safeguard participation, whether consultation or consent?
- To what extent should the law itself be adaptive?

The discussion in this part is focused on general trends. This section firstly examines the constitutional environmental right and the NEMA principles, before examining the framing effect of current laws on the decisions to prospect, mine, and mine closure respectively. In each case the analytical parameters

9. The NEMAQA allows the Minister for environment to make regulations on appeals from the decisions of metropolitan and district municipalities, but to date no regulations of this nature have been formulated.

of institutions, processes, conception of the natural world, processes, information, participation, and adaptability of the law are employed.

(See Appendix B concerning water use and EMPs related to mining).

3.2.4 Constitutional rights and environmental management principles

The constitutional right to a healthy environment

South African legal scholars have, for long, vaunted the right to environment in the South African Constitution, for example, as "*one of the most comprehensive environmental rights*" (Feris, 2008: 30). And yet, as the legal right to environment existing at the most abstract scale in South Africa (and hence the most difficult to change in the short term and the least adaptive) how solid a foundation does this right establish for the 'adaptive turn' in environmental and natural resources law discussed above? Does the environmental right, for example, perpetuate the myths of a separation between the human and natural worlds, and the idea of nature as being in a 'steady state'?

A standard manner of categorising human rights to the environment distinguishes biocentric (viewing the richness and diversity of life as having intrinsic value and maintaining that human beings have no right to reduce such resources, except to meet their basic needs) and anthropocentric approaches (focusing on the interconnectedness of nature and the role of humans therein) (ibid: 31–32). A further distinction is often drawn between an instrumental or strongly anthropocentric approach (regarding nature as a source of resources to be used, protected and conserved primarily for the benefit of humans) and a weakly anthropocentric position (recognising humanity's dominant role in nature and the manner in which humans find utility therein, but seeing also the value of the environment independent of its usefulness for humans) (ibid: 32).

Given these categorisations, the South African constitutional environmental right is probably of the strongly anthropocentric variety. Section 24(a) enshrines a right to an environment "*not harmful to health or well-being*", thus incorporating an anthropocentric measure to determine the extent of ecological degradation that will be regarded as constitutionally permissible. Section 24(b), as noted above, requires the state to take reasonable legislative and other measures to prevent pollution, promote conservation and so on, for the benefit of present and future generations, and not for the intrinsic value of the environment.

The most important Constitutional Court decision interpreting the right to environment to date, *Fuel Retailers Association of Southern Africa v Director-General Environmental Management, Department of Agriculture, Conservation and Environment, Mpumalanga Province 2007 (6) SA 4 (CC)*, confirms the interconnectedness of the fate of the human and natural worlds, particularly as far as 'development' is concerned, but similarly situates the rationale for environmental protection measures within the camp of strong anthropocentrism. In the case, the court famously remarked, for instance that:

> *[D]evelopment cannot subsist upon a deteriorating environmental base. Unlimited development is detrimental to the environment and the destruction of the environment is detrimental to development. Promotion of development requires the protection of the environment. Yet the environment cannot be protected if development does not pay attention to the costs of environmental destruction. The environment and development are thus inexorably linked (para 44).*
>
> *The court also affirmed a number of well-worn mantras of sustainable development, including a conception of sustainable development as development that meets the needs of the present generation, without compromising the ability of future generations to meet their own needs. Quoting from the 1987 Brundtland Report (produced by the World Commission on Environment and Development), the court further characterised sustainable development as a*

process of change aimed at enhancing both current and future potential to meet human needs and aspirations (para 47).

Given this strongly anthropocentric position, is there nevertheless room within the environmental right to accommodate a view of nature as complex, systems-based and adaptive? While there is arguably nothing in the constitutional text mitigating against perceiving nature in this way, there is equally nothing in the text that favours such a view. The conceptual paradigm framing the environmental right is 'sustainable development', a position affirmed by the NEMA and the Fuel Retailers decision.

Environmental management principles

Moving to the next level of legal organisation and adaptability[10], the NEMA articulates a set of environmental management principles that apply throughout the Republic and to the actions of all organs of state that may significantly affect the environment. These principles are not overriding however, and apply "*alongside all other appropriate and relevant considerations*" (section 2(1), NEMA). To what extent do these principles ground the 'adaptive turn' in environmental and natural resources law? Do they facilitate a view of nature as complex, systemic and adaptive, leading to information generation and increasing knowledge of social-ecological systems, inter-agency co-operation and collaborative adaptive management?

The first principle clearly affirms the strong anthropocentric bias of the environment right: "*Environmental management must place people and their needs at the forefront of its concern, and serve their physical, psychological, developmental, cultural and social interests equitably*" (section 2(2), NEMA). Nevertheless, development must also be socially, economically and environmentally sustainable (section 2(3), NEMA). Arguably, an environmental management approach that failed to respect the integrity of wetlands, biodiversity, ecosystem services and ecological infrastructure would not be environmentally sustainable.

Following on from these very broadly-stated principles, the NEMA goes on to articulate the 'considerations' sustainable development requires. Unlike the constitutional text, these principles are rather more conducive to an adaptive approach to environmental and natural resources law. A number of the NEMA principles, for instance, refer to ecosystems and biodiversity. Section 2(4)(a)(i) states that, in principle, the disturbance of ecosystems and loss of biological diversity should be avoided, or, where they cannot be altogether avoided, should be minimised and remedied. The development, use and exploitation of renewable resources and the ecosystems of which they are part should also not exceed the level beyond which their integrity is jeopardised (section 2(4)(a)(vi), NEMA). "*Environmental management must be integrated', section 2(4)(b) continues, 'acknowledging that all elements of the environment are linked and inter-related …*". Wetlands receive an honourable mention in section 2(4)(r), which reads "*[s]ensitive, vulnerable, highly dynamic or stressed ecosystems, such as coastal shores, estuaries, wetlands, and similar systems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure*".

In addition to these principles foregrounding a particular view of the natural world, there are principles dealing with the kind of knowledge upon which environmental management should be based. The principle that a risk-averse and cautious approach should be applied, taking into account 'the limits of current knowledge about the consequences of decisions and actions' (section 2(4)(a)(vii), NEMA) is normally taken to be a statement of the precautionary principle, but fits perfectly well with the procedural

10 Unlike the constitutional right to environment, the statutory text of NEMA would be easier to amend, requiring the passing of an amendment Bill in Parliament. However, as these principles are the foundation for a recently elaborated web of legislative texts, there would probably be very little political will to amend them.

logic underlying adaptive management. The principle that decisions should take into account the interests, needs and values of all interested and affected parties, including recognising all forms of knowledge (inclusive of traditional and ordinary knowledge) (section 2(4)(g), NEMA) is a mandate in favour of the use of a variety of knowledge sources in the decision-making process. There is nothing in the NEMA principles, however, that requires decision-makers to have regard to the 'best available science' or some similar standard. By contrast, section 2(4)(b) states that environmental management "*must take into account the effects of decisions on all aspects of the environment and all people in the environment by pursuing the selection of the best practicable environmental option*".

The NEMA principles are strongly supportive of participatory governance, which supports the concept of collaborative adaptive management. Section 2(4)(f) of the NEMA requires, for instance, that (i) the participation of all interested and affected parties in environmental governance must be promoted; (ii) all people must have the opportunity to develop the understanding, skills and capacity necessary for achieving equitable and effective participation, and (iii) participation by vulnerable and disadvantaged persons must be ensured. The 'vital' role of women and youth in environmental management and development must also be recognised and promoted (section 2(4)(q), NEMA). "*Community well-being and empowerment' must also be promoted 'through environmental education, the raising of environmental awareness, the sharing of knowledge and experience and other appropriate means*" (section 2(4)(h), NEMA).

Finally, a number of principles are pertinent to the manner of decision-making and inter-agency co-operation. Section 2(4)(k), for instance, requires that "*decisions must be taken in an open and transparent manner, and access to information must be provided in accordance with the law"*. There must be "*intergovernmental co-ordination and harmonisation of policies, legislation and actions relating to the environment*" (section 2(4)(l)), and "*actual or potential conflicts of interest between organs of state should be resolved through conflict resolution procedures*" (section 2(4)(m), NEMA).

While none of these principles are explicitly articulated as implementing an adaptive governance frame, there is nothing within them that mitigates against such a frame being applied. Even the principle that *"[t]he social, economic and environmental impacts of activities, including disadvantages and benefits, must be considered, assessed and evaluated, and decisions must be appropriate in the light of such consideration and assessment*", which arguably grounds a 'front-end' model of decision-making criticised by Ruhl (2005) does not necessarily require that decision-making should be 'once-off'.

In addition to the principles articulated in section 2, the NEMA contains a statement of the general objectives of integrated environmental management. Notable about this statement of objectives is that they were recently amended to move the focus of environmental management away from the front-ended, site-specific environmental assessment tool of environmental impact assessment, to accommodate a broader range of legal instruments. The application of 'appropriate environmental management tools' must be promoted (section 23(1), NEMA), and modes of environmental management 'best suited' to ensuring that a particular activity is pursued in accordance with the dictates of environmental management must be selected (section 23(2)(f)). Section 24(5) (bA) contains a listing of potential environmental management instruments, which include environmental management frameworks, strategic environmental assessments, environmental impact assessments, environmental management programmes, environmental risk assessments, environmental feasibility assessments, norms or standards, spatial development tools, and minimum information requirements. Such a list does not include 'adaptive management' as an option.

3.2.5 The decision to prospect

Legally, prospecting means "*intentionally searching for any mineral by means of any method (a) which disturbs the surface or subsurface of the earth, including any portion of the earth that is under the sea or under other water; (b) in or on any residue stockpile or residue deposit, in order to establish the existence of any mineral and to determine the extent and economic value thereof; or (c) in the sea or other water on land*" (section 1, MPRDA).

As noted in the description of the mining life-cycle above, prospecting is less invasive than mining, although the cumulative effects of prospecting in a particular locality can be significant. The holder of a prospecting right can also remove very large samples from the mineral reserve, ostensibly for evaluation purposes. Written permission of the minister of mineral resources is required in order to undertake bulk sampling (section 20(2), MPRDA).

In South Africa, as the law currently stands no person may prospect for a mineral resource without a prospecting right or an 'environmental authorisation' (section 5(A), MPRDA). At the time, the Carolina crisis unfolded no person was allowed to prospect without a prospecting right or an approved environmental management plan (section 5(4), MPRDA: now repealed).

Institutions

The institutions most clearly involved in granting prospecting rights in South Africa are the minister of mineral resources (according to the letter of the law), the director-general of the department of mineral resources (acting under delegated authority), the various sub-divisions of the national Department of Mineral Resources (DMR), the regional managers of the DMR's various regional offices, and officials in the regional offices. The applicant for a prospecting right's first point of contact with the State is with the regional manager of the regional office responsible for the region in which the reserves are located. Similarly, to the application for a mining right (described below), the application is evaluated by officials in the regional office before being passed on to the national office. At the time of the Carolina crisis, approval of the environmental management plan essentially took place at the regional level, whilst inputs on the technical and economic feasibility of the project were added by the national office's scrutiny (see Humby, 2013).

Until the recent implementation of the single environmental system on 8 December 2014, there was confusion and disagreement regarding a prospecting (and mining) right applicant's obligation to obtain other environmental authorisations. In practice, many prospecting and mining proponents did seek these authorisations, bringing a host of different institutions into the mix. The need to obtain an environmental authorisation for activities directly related to prospecting such as diverting a river or removing indigenous vegetation, required the applicant to appoint an independent environmental assessment practitioner to compile the technical reports necessary for the application (section 24(5)(e), NEMA read with the NEMA EIA regulations). The rule of independent environmental assessment has stimulated the development of an environmental assessment industry and provided a statutory basis for the involvement of private consultants as key institutional role-players in the decision to prospect (and mine).

Under the NEMA rules, the applicant was also brought into contact with the provincial department responsible for the environment. If an environmental authorisation was refused, the applicant could appeal to either the MEC of environment or the minister of environment, depending at which level the initial decision had been taken. Unlike the MPRDA, there is no inter-agency forum comparable to the RMDEC to consider objections to the grant of an environmental authorisation. The NEMA does however empower the Minister or the MEC to appoint an external specialist to review an application for an environmental authorisation where the technical knowledge available to review the application is not available within the competent authority, or where a high degree of objectivity is required and is not apparent from the documents submitted (section 24I, NEMA). It is now clear that obtaining an environmental authorisation is a 'condition prior' to the granting of a right (section 38A (2), MPRDA). Under the single environmental system, the range of mining institutions remains the same, although the locus of their authority changes.

Confusion also reigned over the necessity of obtaining a water use licence prior to the commencement of prospecting (or mining). This occurred because one of the entitlements attaching to a prospecting (or mining) right is the right to use water from any natural spring, lake, river or stream situated on or flowing through the land to which the right relates, or to sink a borehole or well for purposes of prospecting on such land, amongst others. These entitlements must be issued 'subject to' the NWA, however there was nothing in the MPRDA to suggest that prospecting could not commence prior to the water use licence being issued. Companies thus applied to the Department of Water and Sanitation (DWS) for their water use licences, but commenced with prospecting (and mining operations) before such licences were issued, primarily because if they did not do so they would have lost their prospecting right[11]. From 2011 onwards, the Minister of Water and Sanitation has been asked, and has responded to questions on the number of mines operating without water use licences.

The illegality of mining without a water use licence has therefore almost become institutionalised. Nevertheless, the minister and Department of Water Affairs are clearly role-players in decision-making relating to prospecting and, if and when, licensing powers are devolved to catchment management agencies they too will become involved.

The Water Tribunal, the unique appellate body established by the NWA, could have added a further layer of deliberation to the granting of a prospecting right. Prior to the collapse and suspension of this institution, a number of water use licences were challenged before the Tribunal. The Tribunal's approach was however marked by excessive formalism, and it decided many of these cases on the basis of the parties' standing to bring the case, a position that was successfully challenged in the high court case of Escarpment Environment Protection Group v Department of Water Affairs 2013 JDR (GNP) (see Chamberlain, 2014).

If the prospecting operations triggered the thresholds in the NEMWA or the NEMBA, or affected heritage resources the provincial departments responsible for environment and the South African national or provincial heritage resources agencies respectively, would have had an involvement. Prior to the Constitutional Court's decision in the Maccsand case, it was not clear whether local authorities (in the form of metropolitan, district or local municipalities) had a role to play. However, the Maccsand and other cases have affirmed that local authorities play a central role in municipal planning, and re-zoning of the land to accommodate mining is therefore required. Mining companies are also required to co-operate with local authorities, for instance, in the preparation of social and labour plans. This has strengthened the multi-scalar nature of the governance of prospecting. It is doubtful whether one could claim that governance of the decision to prospect is polycentric. In law, this decision is dominated by the view of the minister and department of mineral resources.

Processes

As framed by the MPRDA, prospecting involves the following legal processes:

- Application for a prospecting right.
- Application for an environmental authorisation.
- State review of the environmental authorisation, culminating in the decision to grant an environmental authorisation or not.

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11. Section 19(2)(b) of the MPRDA requires a rights holder to commence prospecting within 120 days of the right becoming effective, or such extended period as the minister may authorise.

- State review of the prospecting application, culminating in the decision to grant a prospecting right or not.
- Application for a water use licence and state review and approval thereof.
- Applications for a waste management licence, atmospheric emissions licence, permits relating to biodiversity and heritage resources (where necessary), and re-zoning of land, and state review and approval thereof.
- State monitoring of the prospecting operations, ensuring compliance and undertaking enforcement where necessary.
- Ongoing submission of reports on the prospecting operation to the DMR.
- Amendment of conditions relating to the environmental authorisation, if necessary.
- Renewal of the prospecting right or conversion through the application for a mining right.
- Closure of the prospecting site and application for a closure certificate.

As noted above, there are a myriad set of processes governing the licensing of prospecting (and mining) operations. Each process is governed by rules set out in the relevant legislation and accompanying regulations, which set out the steps to be taken by the applicant and the relevant organ of state, information requirements, criteria for decision-making, and timelines. As should already be apparent from the list above, these processes are concentrated at the 'front-end' of prospecting operations. A flurry of licensing processes occur which are characterised by the applicant gathering information and presenting this information to a range of disparate authorities for approval. The authorities consider the respective applications and define operational conditions that also bound the successful applicant's (now rights-holder) legal obligations relating to the project. Thereafter, the rights-holder conducts operations, submitting various reports (mostly to the DMR), while the state plays a policing role, monitoring the operations through routine and ad hoc inspections. This model, therefore, has all the hallmarks of a traditional, maladaptive approach to environmental and natural resources law. It is heavily reliant, for example, on the applicant's (or rather their consultant's) and state natural resource manager's capacities to accurately predict the future impact of various aspects of the prospecting operation, and the focus falls on legal compliance with narrowly defined minimum conditions. While the potential to amend the licence conditions pertaining to the environmental aspects, in the form of the amendment of the environmental management plan (at the time of the Carolina crisis) or the environmental management programme attached to the environmental authorisation (post 8 December 2014), allows for some measure of adaptability, it is not an inclusive or transparent process and not conducive to facilitating the creation of an epistemic community, united on the basis of deepening scientific knowledge of the operation in its particular social-ecological context.

In this regard, it is important to highlight the monitoring requirements applicable during the operational phase of prospecting (which extends for five years), and the manner in which rights, duties, powers and exemptions are framed by the law. The law imposes various active and reactive monitoring duties upon the prospecting rights-holder. The holder must monitor operations on a 'continuous basis' and conduct a performance assessment of the environmental management programme every two years (regulation 55, MPRDA regulations; section 24Q, NEMA). This information is submitted to the DMR, and not to a broader epistemic community. The minister of water affairs may also direct any person to implement a compliance monitoring network to monitor a programme of implementation aimed at preventing or rectifying pollution of water resources (regulation 12, GN 704). These duties position the rights-holder as the guardian of information and knowledge, which is then channelled to the relevant authorities in a disparate way, often over extended periods of time. There is no civil society participation in these processes, and therefore few possibilities for broader social processing of this information.

Conception of the natural world

Do the current laws framing prospecting promote a conception of the natural world as a series of interlocking, complex and adaptive social-ecological systems? Do they highlight the importance of ecosystems and ecological infrastructure? Environmental assessment process preceding the grant of a prospecting right require the applicant to investigate and assess the impact of prospecting operations on the environment, socio-economic conditions and cultural heritage. There is, however, nothing in the law that requires the applicant to elucidate the systemic connections between the various dimensions of the social and natural landscapes. While the NEMA principles do reference ecosystems and ecosystem services, these concepts are completely absent from more detailed rules governing rights, duties and exemptions. There is nothing in the law that requires the applicant or regulator to evaluate dimensions of the environment as forms of infrastructure, whose value to society is destroyed or eroded by prospecting (or mining operations). Although environmental assessment practitioners may adopt ecosystem services concepts, ecological infrastructure and social-ecological systems, this is not required by the law.

Information

Information necessary to submit to (and obtain) various authorisations discussed above is usually defined in regulations to the main statutes. Different categories of information must be submitted at different points in the decision-making cycle. Thus, at the outset, the applicant initiates his/her application by submitting information on various technical, financial, geological (including minerals to be extracted and land formations), the prospecting method to be implemented, planned expenditure, and so on (contained in the initial prospecting application and prospecting work programme). Once an application has been accepted, to obtain the approved environmental management plan or environmental authorisation, the applicant must submit information on the following:

- The environment likely to be affected by the proposed operations.
- Assessment of potential impacts of the proposed prospecting operation on the environment, socio-cultural conditions and cultural heritage.
- A summary assessment of the significance of potential impacts
- Proposed mitigation and management measures to minimise such impacts.
- Financial provision for rehabilitation.
- Planning, monitoring and performance assessment of the plan.
- Closure and environmental objectives.
- A record of the public participation.

While these information categories are standard for the entrenched environmental impact assessment procedure, they do not meet the information requirements of an adaptive management approach, which would lay greater stress on the following: complex, systemic adaptive nature of the system upon which prospecting (or mining) will be imposed; arrangements for monitoring; processing and dissemination of information, manner in which operational plans will regularly be reviewed. The law also fails to identify a scientific standard for the information to be submitted.

The question also arises whether the nature of information required from the applicant is sufficient for the regulator to exercise its discretion in approving the environmental authorisation and granting the prospecting right (in the light of statutorily defined criteria for decision-making). At the time of the Carolina crisis, the relevant criterion for obtaining prospecting right was that this would not result in "*unacceptable pollution, ecological degradation or damage to the environment*" (section 17(1)(c), MPRDA). (Neither the MPRDA nor any subsequent judicial decision has defined the meaning of 'unacceptable'). Concepts of ecosystem services and ecological infrastructure could be of great service in this regard, by linking the meaning of 'unacceptable' pollution for instance, to pollution that impacts on ecosystem structure and functioning beyond a certain threshold). Since 8 December 2014, the minister of mineral resources can only approve an environmental authorisation if it complies with the

NEMA principles) including those relating to pollution, ecological degradation or damage that will be caused; measures taken to protect the environment or to control, mitigate or abate pollution; the ability of the applicant to implement mitigation measures; and feasible and reasonable alternatives (section 24O, NEMA). Other than the (inferred) NEMA principles, there are no further criteria for the minister of mineral resources to decide upon an application for environmental authorisation.

The currency of adaptive management's solid scientific information highlights issues of access to information and transparency as paramount. There is no general rule in South Africa that prospecting or mining rights, environmental authorisations, environmental management programmes are in the public domain. To the contrary, access to such information is very difficult to come by, even when using the relevant provisions in the Protection of Information Act 2 of 2000 (see Centre for Environmental Rights, 2012, 2013a, 2013b, 2014). Ironically, for many years the regulations relating to environmental impact assessment have included a provision granting authorities a right of access to information held by private entities (see regulation 10 of the 2014 EIA regulations). This does not bode well for the adoption of an adaptive management approach, and access to information would need to be clearly and firmly addressed if such an approach were to ever be adopted.

Participation

Like many jurisdictions worldwide, South African law does not require that the owner, tenants or prospective owners of the land on which prospecting (and mining) is to take place, give their consent. At the time of the Carolina crisis, the applicant was obliged to consult with 'the land owner or lawful occupier or any other 'affected party' for a period of 30 days after the prospecting application had been accepted (section 16(4)(b), MPRDA). The law now requires applicants for an environmental authorisation to conduct prescribed public consultation as per the regulations passed to implement the NEMA. The current EIA regulations (published 4 December 2014, as GNR 982) require a basic assessment report (applicable in the case of prospecting) to have been subjected to a public participation process of at least 30 days (19(1)(a), EIA regulations). The EIA Regulation 44 provides further general guidance on public participation processes. These largely focus on the form of giving notice to interested and affected parties, and outline the duties on the part of the person conducting the public participation process to provide information that is relevant and to facilitate participation in such a manner that interested and affected parties are given the opportunity to comment (Regulation 44(6)). Despite these guidelines, public participation, before and after implementation of the single environmental system, largely resembles a 'cobbled together' process (Karkkainen, 2002) that involves some avenues for participation by more-or-less diverse parties.

The Constitutional Court's decision in the case of *Bengwenyama Minerals (Pty) Ltd & others v Genorah Resources (Pty) Ltd 2011 (4) SA 113 (CC)* is the most important precedent on participation in a mining context, when it affirmed a good faith standard for the consultation requirements in the MPRDA. The various notice and consultation requirements, the court said, were indicative of a "*serious concern for the rights and interests of landowners and lawful occupiers in the process of granting prospecting rights*".

The consultation requirements thus serve the purpose of seeing whether any accommodation between the prospecting right applicant and landowner is possible, while the second was to provide landowners or occupiers with the necessary information on the required actions in respect of the prospecting (for example, whether to object to the application or take it on appeal or review). It was therefore important to inform the landowner 'in sufficient detail' of what the prospecting operation would entail on the land so that the landowner could properly assess its future impact(s). While these guidelines may be sufficient to ensure a minimum level of environmental justice, it is doubtful that they are sufficient to support collaborative adaptive management. The present rules on public participation position affected parties as passive commentators whose inputs make little to no impact on the decision on whether or not to allow prospecting (CER, 2011).

Compliance and enforcement

'Mechanisms' of compliance and enforcement are an integral part of the traditional model of environmental governance. Having laid down conditions of operation in licensing processes, the law typically vests power in a state agency to monitor the applicant's compliance with these conditions and, where necessary, to enforce compliance using a variety of administrative and criminal measures. Literature on the adaptive turn in environmental governance has critiqued this policing aspect of governance on the basis that it is too centred on the allocation of blame and liability, thus restricting miners and regulators from experimenting with different approaches as part of a process of adaptive management. The counter-argument is that the law needs to uphold accountability.

At the time of the Carolina crisis, the MPRDA made provision for the appointment of 'authorised persons' with powers to enter prospecting or mining areas and direct any person in control or employed there to hand over information or answer questions, inspect books records, appliances, take samples, etc.; and to conduct routine inspections (sections 91–93, MPRDA). If an authorised person found that the rights holder was not in compliance with any provision of the MPRDA, or any term or condition of the environmental management plan (or programme), he or she could order the holder of the right to take 'rectifying steps' or order that operations be suspended or terminated (section 93, MPRDA). Such orders, however, had to be confirmed by the Director-General of the DMR (section 93(2), MPRDA). Acting under the mantle of the NEMA, the minister or MEC responsible for environment, and the minister of water affairs, could designate environmental management inspectors (EMIs) to monitor and enforce compliance with conditions attached to a variety of environmental authorisations (sections 31B–31C, NEMA). The EMIs could be appointed with varying mandates to enforce NEMA and specific environmental management Acts, or combinations thereof. In comparison with authorised persons under the MPRDA, they had a more extensive arsenal of regulatory tools at their disposal, including the power to issue compliance notices for regulatory infractions that did not need confirmation by a political head, but could be suspended by the minister or MEC responsible for environment (section 31L, NEMA). Since the implementation of the single environmental system, the statutory framework for the appointment of environmental mineral resources inspectors has been established. The general trend of legislative reform over the past decade, therefore, has been to strengthen the capacity of the state to police compliance with licence conditions, rather than investing in the development of more subtle forms of compliance inducement.

The development of a cadre of enforcement officials has been matched by significant increases in the administrative and criminal fines payable for contravening licence conditions. The highest fine payable under the MPRDA was R500 000 (or ten years' imprisonment) for failing to manage environmental impacts in accordance with the environmental management plan/programme (section 98(a)(iii) read with section 99(1)(c), MPRDA). The latest amendments to the MPRDA raise the bar substantially. Prospecting (or mining) without the requisite prospecting right or environmental authorisation will, once the amendments enter into effect, attract a fine equivalent to 10 per cent of the person's, or rights holder's annual turnover in the Republic and exports from the Republic during the previous financial years, or to four years' imprisonment. This reinforces the high stakes of the front-ended licensing process.

Under the NEMA, failure to obtain an environmental authorisation, failure to comply with a condition of the authorisation or contravention of a condition, commission of an act that causes significant pollution and environmental degradation, etc., attracts a fine of R10 million or 10 years' imprisonment or both (section 49A read with section 49B, NEMA). Unless the environmental authorisation is able to flexibly respond to changing exigencies of the social-ecological system in which mining takes place, these provisions lock licence holders and regulators into a rigid and potentially maladaptive frame.

In addition to the tools available to regulators as part of the licensing relationship, regulatory powers defined in section 28 of the NEMA and section 19 of the NWA enable them to request polluters of the environment more generally, or a water resource more particularly, to take 'reasonable measures' to prevent pollution or ecological degradation from occurring, continuing or recurring. These powers can be exercised against 'every person' who has a relationship to the land upon which pollution or ecological degradation is taking place, and may include owners, persons who had the right to use the land, or persons who were in control of an activity on the land.

In the case of the NEMA, these powers may explicitly be applied in respect of pollution or degradation that occurred prior to the date of NEMA's commencement, in 1998 (section 28(1A), NEMA). The reasonable measures an authority may request of a person causing pollution or ecological degradation to undertake include investigating, assessing and evaluating the impact of an activity on the environment; informing and educating employees about environmental risks of their work; ceasing, modifying or controlling any act, activity or process; containing or preventing the movement of pollutants; amongst others (section 28(3), NEMA). If the person fails to take measures within a stipulated time, the authorities can step in and undertake the work themselves, later recovering costs from an even broader range of parties. Section 19 of the NWA in particular has been put to good effect in addressing AMD in the Klerksdorp-Orkney-Stilfontein-Hartebeesfontein (KOSH) basin, despite being challenged by a number of mines (particularly Harmony Gold) in the courts. Although intentional and negligent failure to institute reasonable measures is criminally punishable under this provision, sections 28 and 19 create a frame for interaction rather more conducive to adaptive management than licensing conditions, possibly because there may be greater flexibility with respect to defining the reasonable measures that should be implemented.

Adaptability of the law

Environmental and natural resources law in South Africa has proven to be remarkably adaptive to increasing concerns surrounding sustainability and an extensive body of rules has been developed in a relatively short period of time. Such laws have also been subjected to continuing amendment, to sharpen and strengthen their application. The continued adaptability of laws relating to mining and environment, however, will in future be restricted by the statutory restrictions placed upon changing to the 'one environmental system' entrenched in the NEMA (described above). Legislation relating to NEMA and NWA is also covered in Appendix A.

3.2.6 The decision to mine

The model for the decision to mine is largely the same as the decision to prospect (Section 3.2.5). Unlike prospecting, which involves 'intentionally searching' for minerals, mining therefore involves 'winning', 'extracting' and even 'processing' the mineral ore. The mining right afforded by South African law is also far longer in duration: Thirty years (with the option to renew), as opposed to the five years afforded by the prospecting right (section 23(6), MPRDA). As the law currently stands, no person may mine a mineral resource without a prospecting right or an 'environmental authorisation' (section 5(A), MPRDA). At the time when the Carolina crisis unfolded, no person was allowed to mine without a mining right or an approved environmental management programme (section 5(4), MPRDA – since repealed).

Institutions

As is also the case relating to the decision to prospect, the institutions involved in the decision to mine are primarily within the ministry of mineral resources (the director-general of the department of mineral resources, various sub-divisions of the national DMR, regional managers and of various DMR's regional offices, and officials in the regional offices. State departments that administer any law relating to matters affecting the environment must be consulted. The RMDECs constituted for the different regions hear objections and advise the minister on how these should be dealt with. National and provincial environmental agencies, the national department of water and its regional offices, national and provincial heritage resources agencies, and local authorities participate in the decision to mine through the various authorisations they are empowered to administer. In the case of mining, this includes atmospheric emissions licences (particularly those relating to coal operations) and waste use management licences. The Water Tribunal plays a role in deciding appeals lodged against the granting such licences to mines, but similarly to prospecting rights, the tribunal tends to dismiss such appeals on procedural grounds.

Processes

Legal processes that deal with mining tend to mirror those for prospecting. Prior to the implementation of the single environmental system, the environmental authorisation phase for mining was divided into two stages: a scoping phase during which the applicant was required to submit a scoping report (regulation 49, MPRDA regulations), followed by an environmental impact assessment report (Regulation 50, MPRDA regulations), which laid the basis for the preparation of the applicant's environmental management programme (regulation 51, MPRDA). The law required that both the scoping report and the environmental impact assessment report involve public participation. In practice, interested and affected parties were not often involved in the scoping phase, and were then confronted by an environmental assessment phase that had, in their view, been unduly narrowed and did not take into account the full impact of mining on the social-ecological system (CER, 2011: 45). The current environmental assessment process under the NEMA will also be a two-stage process (compilation of a scoping report, followed by an environmental impact assessment report:(see chapter 4, part 3 of the 2014 EIA regulations). The shift in the statutory authority for evaluating the environmental impact of mining does not change the front-ended nature of the process. The narrowing of issues that characterises the scoping phase may also not be conducive to adaptive management.

Further aspects of concern are the timescales allowed for decision-making. At the time of the Carolina crisis, an applicant for a mining right had 180 days to compile and submit the environmental reports for consideration by the DMR regional office (Section 22(4), MPRDA). This provision was criticised on the basis that it did not reflect natural cycles: for example, the six-month window period allowed for the impact assessment of aquatic ecosystems to be conducted during the dry season, provided a skewed picture of biodiversity. This anomaly has been exacerbated by the establishment of the single environmental system.

Information

An applicant for a mining right must submit categories of information (similar to those required for the prospecting right) to obtain the right and the environmental authorisation. In addition to information on baseline conditions, impacts, and mitigatory measures, an applicant for an environmental authorisation for mining must focus on the methodology used to compile reports, cumulative impacts, and the desirability of 'reasonable land use and development alternatives' (see, for instance, regulations 49 and 50 of the MPRDA regulations). There is nothing in the law to flesh out the meaning of 'reasonable land use and development alternatives' or to link this concept to ecological infrastructure. A review of 16 cases in which objections and/or appeals were lodged against the granting of prospecting and mining licences revealed, however, that objections based on the complete omission of data from environmental management programmes most commonly centred on the cumulative effects of operations, assessment of alternative land uses and the 'no-go option', and consideration of the impact of prospecting/mining operations on the socio-economic conditions of any affected person (CER, 2011: 53). The capacity of any person or institution to predict the cumulative impacts of mining on the environment, or to assess the true value of alternative development options at the front end of a process, is highly suspect. In a number of cases this [prediction] was not even attempted.

Participation

The consultation processes applicable to the decision to mine largely parallel those for the decision to prospect. At the time of the Carolina crisis the process was (six months; as opposed to 30 days). ‘Interested AND affected parties’, participated (not only ‘affected’ parties). In all other respects, however, the consultation process was similar to that of the ‘cobbled variety’ critiqued above.

Compliance and enforcement

The description of trends in compliance and enforcement relating to prospecting similarly apply to mining.

3.2.7 Mine closure

A number of provisions relating to mine closure are scattered throughout the South African statute book. For example, Section 33 of NEMAQA requires the owner of a mine to notify the minister of environment when, given known ore resources, it can be expected that mining operations will cease in the next five years, to enable measures to be put in place to deal with dust pollution. In 2005, the DMR published a Guideline Document for the Evaluation of the Quantum of Closure-Related Financial Provision Provided by a Mine, which plays an important role in the determination of the financial provision for rehabilitation. Since the implementation of the single environmental system, there are also scattered provisions dealing with mine closure in the NEMA. The closest the MPRDA legal framework comes to establishing a frame for closure on social issues is through processes governing the social and labour plan (requiring that such a plan be submitted together with the application for a mining right (regulation 42(1), MPRDA regulations). In addition to other information, this plan must detail the manner in which the applicant intends to manage downscaling and retrenchment when closure of the mine is certain (Regulation 46(d), MPRDA regulations). The focus of this aspect of the social and labour plan is predominantly on job security and does not otherwise link with the regulatory techniques for closure on the non-human environment. The current legal framework for closure currently is therefore not conducive to a consideration of the social-ecological system, now changed by years of mining.

The statutory standard for rehabilitation of the non-human environment is that the holder of a prospecting or mining right “*must as far as it is reasonably practicable, rehabilitate the environment affected by the prospecting or mining operations to its natural or predetermined state or to a land use which conforms to the generally accepted principle of sustainable development*” (section 38(1)(d) MPRDA, subsequently repealed and replaced by section 24N7(e) of the NEMA). Such a sustainable development discourse, may also allow for a more detailed articulation of standards to govern ‘social closure’. On the other hand, this discourse is so amorphous and wide-ranging, that it could be used to justify virtually any post-closure land use having a marginal economic or social benefit while failing to offset environmental loss or deal with the most critical social issues. Significantly, there is no mention of ecosystem services or ecological infrastructure in the standard for rehabilitation (requiring, for instance, that the environment should be rehabilitated to a state where there are functioning ecosystems or where ecological infrastructure has been restored to a certain value).

Institutions

Since planning for mine closure is a function that starts prior to a mine being licensed, many of the institutions involved in deciding whether prospecting or mining go ahead, accordingly also play a role in mine closure. This is especially true of the DMR. As highlighted above, the information an applicant for an environmental plan or programme had to submit needed to include environmental and closure objectives. Both the quantum and the method of financial provision for rehabilitation also had to be specified (regulations 51 and 52, MPRDA regulations). Since the implementation of the single environmental system, institutions at the front-end of the licensing process considering closure will still be the mining authorities, now acting under the NEMA. N The minister of environment (or the MEC responsible for the environment) have been empowered to make regulations on the management and control of residue stockpiles and deposits, mine closure requirements and procedures, apportionment of liability for mine closure, and the sustainable closure of mines with an interconnected (or integrated) impact resulting in a cumulative impact, financial provision, and monitoring and environmental management programme performance assessments (section 24(5)(b)(vi), (viii), (ix) and (x), NEMA). On 31 October 2014, the minister of water affairs published draft regulations for public comment dealing with financial provision for the rehabilitation and management of negative environmental impacts associated with prospecting, exploration, mining and production operations. These have not yet been finalised.

The so-called 'future forum' could span the time between the licensing of the mine and its eventual closure. It is hoped that this development will be established as part of the local economic development plan (forming part of the social and labour plan (regulation 46(d), MPRDA regulations)).

Institutions involved in the back-end of the life of the mine identified in Section 43 of the MPRDA, include the minister of mineral resources, the regional manager, the chief inspector of mines and "*each government department charged with the administration of any law which relates to any matter affecting the environment, all of which are involved in the issuing of a closure certificate*" (Section 43, MPRDA).

A 2008 amendment to the MRPDA, which only came into effect in June 2013, established a frame for mine closure where mines are interconnected, have an integrated impact, or pose a cumulative impact. Such mines must be identified by the minister of mineral resources in consultation with the minister of environment. Thus, neighbouring owners in a particular mining locality can play an important role by coming together to formulate a regional strategy for mine closure (sections 43(10) – (12), MPRDA). Such a statutorily-induced form of co-operation could be conducive to adaptive management. Yet in the one context where it could have been applied (the KOSH basin) it appears that mine owners are not willing to work together, as evidenced from the extensive litigation ensuing from the Department of Water Affair's directive to them to formulate a joint strategy. Since the law also allows for environmental risks and liabilities to be transferred to a third party, they too will play a role in mine closure.

The Council of Geosciences also plays a role in terms of ensuring that complete and correct records have been kept (section 43(13), MPRDA).

Financiers, bankers and (increasingly) insurers, who provide or guarantee the financial provision for rehabilitation put forward by the miner can also play a role in mine closure. The courts may decide whether a company owning a mining company can be wound up, and the Companies Commission may play a role if, following a court order, it decides that a company can be deregistered and dissolved (see Humby, 2014a), an action that, essentially, extinguishes a company as a legal 'person', (that can also no longer be the bearer of rights and duties, and hence liability for pollution and ecological degradation). If this happens, the State may be forced to assume responsibility for alleviating pollution and ecological degradation.

The mine closure process is thus potentially more multi-scalar and polycentric than processes licensing for prospecting or mining, although the DMR still plays a dominant role.

Processes

Mine closure involves the following legal processes:

- Forward planning for mine closure;
- Financial provision for mine closure;
- Flexible monitoring and oversight of rehabilitation of the environment as an integral part of operations;
- State-approved final closure;

- Transfer of environmental risks and responsibilities;
- State assumption of environmental risks;
- Transfer of mining rights; and
- Winding up of mining companies.

Forward planning for mine closure has largely been covered in preceding sections and need not be further considered here. The DMR's Guideline Document sets out a process for the quantum to be determined that involves classifying the probability and severity of risks as high, medium or low, and the sensitivity of the area in which mining takes place (DMR, 2005: 10–11). It also identifies and values various 'closure components', ranging from identifying and demolishing steel buildings and structures, to river diversions and water management (ibid). Incredibly, the Guideline Document requires that the management of impacts post-closure would be limited to two to three years of 'maintenance and aftercare' (2005: 14). Since the financial provision must be assessed every year, it potentially creates a space for an ongoing re-visioning of the scope and scale of damage to ecosystems and ecological infrastructure that could allow for adaptive management. At present, this assessment is conducted solely by the holder of the right (or their consultants) who is under a legal obligation to conduct monitoring on a continuous basis, undertake performance assessments of the environmental management plan/programme, and compile and submit performance assessment reports to the minister of mineral resources (regulation 55, MPRDA regulations). Such reports inform the annual assessment of environmental liability and the holder's ongoing assessment of the adequacy of the financial provision.

Within 180 days of any of the following materialising, the holder of the right must apply for a closure certificate from the minister of mineral resources: (i) The lapsing, abandonment or cancellation of the right; (ii) cessation of the prospecting or mining operation; (iii) relinquishment of any portion of the prospecting of the land to which a right relates; or (iv) completion of the prescribed closure plan (section 43(3) MPRDA).

To obtain a closure certificate, a rights holder must submit the information (prescribed on closure in the MPRDA regulations: soon to be replaced by regulations drafted under the NEMA). The closure certificate is issued by the minister of Minerals and Energy Affairs after the chief inspector of mines, and each government department charged with the administration of any law relating to the environment, have confirmed in writing that legal provisions pertaining to health and safety, management of pollution to water resources, the pumping and treatment of extraneous water and (in future) compliance with the conditions of the environmental authorisation, have been addressed (section 43(5) MPRDA).

The primary legal significance of the closure certificate is that it absolves the rights holder from further liability for environmental damage, pollution, ecological degradation, and (since 7 June 2013), the pumping and treatment of extraneous water (section 43(1) MPRDA). However, the second MPRDA amendment Act (which has yet to enter into effect) incorporates a new section 43(1A), which states that, despite the issue of a closure certificate, the holder of a right or previous owner of works "*remains liable for any latent or residual environmental liability, pollution, ecological degradation, [and] the pumping and treatment of extraneous water which may become known in the future*". This amendment, together with statutory duties of care in section 28 of the NEMA and section 19 of the NWA, imply that closure and rehabilitation are 'continuing' rather than 'once-off' activities. The minister of mineral resources may return the holder's financial provision but may also retain any portion thereof for latent and residual safety, health or environmental impacts that may only become known in the future (section 43(6) MPRDA).

The final regulatory processes that stitch the mine closure model together are the notion of transferring environmental risks and liabilities to a competent third party and state assumption of environmental risks.

Transfer of environmental risks lies in the discretion of the holder of the right (including previous owners of old order rights) and the minister of minerals: The former must first apply for the transfer, and the minister may then approve it subject to the third-party meeting prescribed standards of qualification (section 43(2) MPRDA). The transfer relates to environmental responsibilities and liabilities as specified in the environmental management plan/programme, including the closure plan (regulation 58(2)). The regulations further specify the range of expertise, resources and experience a person to whom environmental risks and liabilities are transferred must possess. These include, for instance, expertise in the fields of integrated risk assessment, management and financing; financial resources sufficient to meet the obligations transferred; and direct access to insurance products and alternative risk financing, amongst others (regulation 59, MPRDA regulations).

State assumption of environmental risks occurs when the minister of minerals undertakes 'urgent remedial measures' to address pollution or ecological degradation that is harmful to the health or well-being of anyone, a power similar to the authority exercised by the environmental regulators under section 28 of the NEMA and section 19 of the NWA (section 45, MPRDA). Any measures taken by the minister can be recovered from the financial provision, or where this is insufficient, from taxpayer's money (section 45, MPRDA). State funds may also be used where the holder of a right has ceased to exist, has been liquidated or cannot be traced; i.e. where the mine is derelict, ownerless or abandoned (section 46, MPRDA).

Whilst not included in the regulatory model on mine closure in the MPRDA, in practice, mine closure is also affected by the power of companies to transfer rights amongst each other, and by application for the winding up of companies. The transfer of mining rights is governed by section 11 of the MRPDA which allows for a prospecting right, mining right, interest in any such right, or a controlling interest in a company or close corporation to be ceded, transferred, let, sublet, assigned or alienated provided the consent of the minister of minerals is obtained. The need for ministerial consent is at present not required for listed mining companies. There is no indication in section 11 of the MPRDA that section 43 obligations are triggered when a transfer takes place. Further, the obligations outlined in section 43, which trigger the need to apply for a closure certificate, do not apply — mainly because there is no cessation of the prospecting or mining operation (see Humby, 2014a for a case study discussion in this regard).

The winding up of mining companies is still governed by chapter 14 of the Companies Act 61 of 1973, the provisions of which establish a process for the court to appoint a liquidator, who is, in turn, responsible for drawing up a liquidation and distribution account specifying how the assets of the company should be applied to meeting the costs incurred during the process and paying the claims of creditors in a manner that approximates, as far as possible, the allocation of assets in terms of the law of insolvency. After the winding up is complete, the liquidator sends a certificate to the Companies Commission which allows for the company to be dissolved and deregistered, thus ending its existence as a juristic person and its capacity to bear legal rights and obligations.

Do these legally defined processes give effect to natural resource governance that respects the complexity and adaptability of social-ecological ecosystems? Do they address the devaluation of ecosystems and ecological infrastructure and establish mechanisms of compensation? As already intimated, the model for mine closure in South Africa rests on the fiction that 'closure' can be effected in respect of the non-human environment, which can be 'rehabilitated' to a certain degree. However, the far more intractable problem of 'social closure' — how the social systems that had developed around the mine can continue to function on the basis of ecological infrastructure that has been greatly diminished and in the vacuum created by the withdrawal of capital from the mine — is not addressed by these procedures. The law simply does not foresee, for instance, that the entire social fabric may change as artisanal miners enter the mining area and work on the now depleted mineral reserves, with further detrimental environmental consequences (a phenomenon beginning to be experienced, for example, in respect of illegal mining on the goldfields of the Witwatersrand) or in certain areas where coal reserves have been depleted (see Filitz, 2011).

The closure model, described here, is too rigid to accommodate the social processes whereby mining companies adapt themselves around closure obligations, the most important of which are the capacity to transfer rights and interests therein, and the possibility of winding up. The state is therefore left regulating an empty shell. In respect of the provisions, that are in place for closure, of impacts on the non-human environment, the standard for rehabilitation at present contains no reference to ecosystems or ecological infrastructure, despite these concepts having utility in assisting to define the type of landscape that mining companies should leave in their wake. These processes rest heavily on forward-looking assumptions about the scope and scale of risks and the costing of addressing these risks.

Despite the ongoing revision of the closure plan throughout the lifecycle of the mine, and the reassessment of the financial provision for closure, the chronic problem is that there is often a drastic shortfall in the amount of funds available to rehabilitate the non-human environment. Such funds are not even protected in the social process of winding up the assets of a mining company (see Humby's discussion of the Blyvooruitzicht mining company in Humby, 2014a). The problem, however, lies not only in the narrowness of the epistemic community constituted around quantifying closure costs (limited largely to the rights holder and the mineral authorities), but also to the manner in which the DMR's Guideline Documents identifies 'closure components' and determines the temporal scale for post-closure cost provisioning (limited to two to three years of maintenance).

Conception of the natural world

It is clear that the current model for mine closure in South Africa does not facilitate recognition of the social-ecological systems implicated in mine closure, either in terms of the severity and longevity of the ecological effects of mining, or the profound social transformations that mining effects in a particular locality. The model is oriented around impacts, impact management and risks. Theoretically this could accommodate valuation of ecosystems and ecological infrastructure but this is not explicit in the law. This is most starkly evident in the 'closure components' adumbrated in the DMR's Guideline Document, the major focus of which is directed towards demolishing or dismantling or demolishing infrastructure created by the mining operation (processing plants, steel and reinforced concrete as well as housing and related facilities structures, and buildings and rehabilitation of access roads, electrified and non-electrified railway systems. Also, the sealing of potentially dangerous shafts, adits and inclines.). Unit costs for these components are specified by the DMR and are far more easily quantifiable than the long-term devaluation of ecosystems and ecological infrastructure caused by mining. 'Closure components' centred on the loss of ecosystem structure and functioning and the devaluation of ecological infrastructure would require significantly higher levels of financial provision.

Information

The current MPRDA regulations (not yet replaced by regulations on mine closure made under the NEMA) provide in detail for the information that needs to be submitted as part of a closure application. Information requirements are framed by the closure objectives that must be specified in the environmental management plan/programme at the frond-end of mining (regulation 61, MPRDA regulations). The information submitted to regulators as part of a closure application takes the following forms:

- A final **performance assessment of the environmental management plan/programme** (regulation 55(8), MPRDA regulations): this indicates whether requirements of relevant legislation have been complied with; whether closure objectives have been met; whether residual environmental impacts resulting from the holder's operations have been identified and the risks of such latent impacts materialising have been identified and quantified and arrangements made for their management and assessment.

- An **environmental risk report** (regulation 60, MPRDA regulations) sets forth the results of a screening level environmental risk assessment, classifying risks into significant and insignificant categories, and assessing results of a second level risk assessment in respect of those risks that were classified as significant. The second-tier risk assessment should be based on appropriate sampling, data collection and monitoring, and a quantification of the risk. The environmental risk assessment must further identify risks that are 'acceptable without further mitigation', document the status of insignificant risks, identify alternative risk prevention or management strategies for significant risks, and 'agree' on management measures to be implemented to ameliorate significant risks. The latter must include the following assessments:

    - A description of the management measures to be applied;
    - A prediction of the long-term result of the applied management measures;
    - Residual and latent impacts after successful implementation of the management measures;
    - Time frames and schedules for the implementation of management measures;
    - Responsibilities for implementation and long-term maintenance of management measures;
    - Financial provision for long-term maintenance; and
    - Monitoring programmes to be implemented.

- A **closure plan** (regulation 62, MPRDA regulations). In addition to reiterating the closure objectives and how these have related to the prospecting or mine operation and its environmental and social setting, of a number of actions are required: regulatory requirements and conditions negotiated and documented in the environmental management plan/programme, summarising the results of the environmental risk report. The closure plan must provide:

    - A summary of the results of progressive rehabilitation undertaken;
    - A description of the methods to decommission each prospecting or mining component and the mitigation or management strategy proposed to avoid, minimise and manage residual or latent impacts;
    - Details of any long-term management and future expected maintenance;
    - Details of financial provision for monitoring, maintenance and post-closure management; and
    - A record of interested and affected persons consulted. If necessary, and/or available, the closure plan should be accompanied by technical appendices.

    (Also see Appendix A which outlines the legal rehabilitation standards relating to mining, and Appendix B, concerning regulations associated with Decommissioning and Closure of mines).

- **Application to transfer environmental risks and responsibilities** (regulation 58, MPRDA regulations): If the rights holder intends to apply for the transfer of environmental risks and responsibilities, details of the person to whom risks and responsibilities will be transferred should be provided.

In the light of the 'adaptive turn' in environmental and natural resources law, three points can be made. Firstly, the information to be submitted by the rights holder as part of a closure application is strong on forward-looking 'crystal ball' assumptions, identifying the range of residual and latent impacts, for instance, and is far thinner on the institutional and resource implications of examining where, when and how such impacts actually materialise. There is no explicit requirement in the legal system to even cognise closure in terms of ecosystems or ecological infrastructure and no specification of the scientific standard of the information that should be presented. Secondly, a critical flaw in the information requirements is that they require the holder to focus narrowly on its own operations, and do not explicitly oblige it to examine impacts in the context of other mining operations, thus enabling regulators to better assess cumulative impacts. Thirdly, there is a ***critical lack of transparency*** surrounding all this information, and including the financial provision for rehabilitation.

Participation

In comparison to legally required processes for consultation at the front-end of prospecting and mining, participation processes at the back end, upon closure, are thin and legally unstructured. There is no public involvement or indeed transparency in the annual reassessment of financial provisioning, for instance, and a slim reference in the regulations relating to the closure plan for the rights holder to report on 'interested and affected persons consulted'. The lack of civil society involvement in the closure certification process is of great concern. This means that the perception of risks as 'significant' or 'insignificant' for example depends almost entirely upon the perspective of the rights holder. For mine closure, the emphasis in the MPRDA falls upon consultation with "*each government department charged with the administration of any law which relates to any matter affecting the environment*". Such departments must certify in writing that the critical provisions have been addressed. Those pertaining to the following: health and safety, management of pollution to water resources, pumping and treatment of extraneous water, and compliance with the conditions of the environmental authorisation (section 43(5), MPRDA). While this may possibly provide for some degree of interagency co-operation in regulating mine closure, the certification in writing implies a signing off, which is not an act conducive to further engagement.

Participation in the decision to allow a mining company holding prospecting and mining rights to wind up is also narrowly limited to employees, trade unions and SARS, effectively excluding civil society and primary regulators. Having preceded both the Minerals Act 1991 and the MPRDA, chapter 14 of the Companies Act, 1973 places no specific obligation on the court to determine whether a company applying for a provisional liquidation order has applied for a closure certificate, ensured the transfer of environmental liabilities, or actually topped up any shortfall of funds in the chosen vehicle for financial provision. This lack of specificity is exacerbated by the narrow notice requirements, as Chapter 14 requires only that employees, trade unions and SARS should be notified of a company's intention to initiate winding up proceedings (section 346A Companies Act, 1973). Government departments charged with the custodianship of mineral resources or the protection of the environment are not required to be notified and in practice are frequently 'caught on the back foot', only becoming aware of a company's pending liquidation after a winding-up order has already been granted by a court.

Compliance and enforcement

The fact that South Africa has more than 5000 ownerless, derelict and abandoned mines is evidence enough that compliance and enforcement around mine closure has been weak. For many years, this could be blamed on a lack of a comprehensive regulatory frame and tools, but as is apparent, from the discussion above, that mineral resources, and environmental and water, regulators have a useful arsenal of administrative and criminal measures that can be directed against non-compliant rights holders. Substantive compliance and enforcement with higher level principles (for example, the NEMA principles), is weakened by the detail of rules governing determination of closure obligations in the environmental management programme/plan and the actual quantum of financial provision; the lack of transparency around both; the manner in which mining companies transfer rights and thereby also risks and obligations; and the lack controls around the winding up of mining companies. All these factors facilitate the phenomenon of ownerless, derelict and abandoned mines.

Adaptability of the law

As with the adaptability of the law around initial licensing of prospecting and mining, it may be difficult to change the trajectory of the legislative strengthening that has taken place around mine closure, which is still very much in the mould of the traditional approach to environmental and natural resources law. As discussed above, this approach does not rest upon an appreciation of the functioning of ecosystems and the value of ecological infrastructure. Two potential windows of opportunity exist however. The new regulatory powers vested in the minister and MECs for environment respectively to make regulations pertaining to mine closure, the management of residue stockpiles and deposits and other impacts, could provide opportunities for regulatory innovation. Secondly, a reformulation of DMR's Guideline Document on financial provisioning is critically needed and is not constricted by the need to comply with legal processes. It is here that the 'components' for closure could be completely restructured to take into account wetlands, biodiversity, ecosystem functioning and ecological infrastructure.

3.3 Conclusion

This overview has outlined the significance of law as a framework for decision-making, explained the 'adaptive turn' in environmental and natural resources law', outlined and elucidated South African laws framing the mining life-cycle, and elaborated upon the framing effect of laws on the decisions to prospect, mine and allow for mine closure, having regard to institutions, processes, conception of the natural world, information, participation, compliance and enforcement and adaptability of the law.

In conclusion, two general insights can be made. First, it is clear that the structure and approach of the law relating to mining is still very much in the mould of the traditional approach to environmental law and natural resource governance. There have also been a number of amendments aimed at strengthening this framework of law over the past few years, which largely entrenches this approach. While it may be difficult to change the course of this trajectory to accommodate a more adaptive approach based on solid scientific information, ongoing monitoring, and the support and strengthening of a broader epistemic community, it is not impossible: there are windows of opportunity provided. For instance, NEMA, and principles or regulations crystallising around single environmental system.

Second, this review shows that understanding how and why the Carolina crisis unfolded as it did involves having regard to the instruments framing mining companies' environmental obligations approved by the regulators, principally the DMR, even prior to their having commenced with operations. Accessing these instruments, however, is difficult due to a critical lack of transparency. The rights, duties, powers and exemptions around mine closure and their major flaws, as highlighted in the afore-going discussion, are also essential for understanding how and why the cumulative impact of the mines' operations on the water resources supplying the town of Carolina with drinking water materialised.

In light of these conclusions, the way forward in the quest for legal frameworks that calibrate the need for mining against the need to appropriately safeguard the integrity of ecosystems and ecological infrastructure, for present and future generations appears to be as follows:

- There is a need to place certain wetlands, biodiversity and ecological infrastructure beyond the realm of contestation. This places greater emphasis on regional and spatial planning tools and how these can contribute to placing certain geographical regions or particular localities off limits to mining. Rather than focusing on the mining licensing process as such, the capacity of the nation's conservation, biodiversity, water, spatial planning, and agricultural laws must be investigated to ensure that they afford authorities the appropriate forms of power to authoritatively delineate land uses that respect ecological limits, at the appropriate scale. Whilst conservation plans, biodiversity plans, environmental management frameworks and land use planning schemes abound, the legal status of many of such plans is still problematic. The potential for SPLUMA to protect wetlands, biodiversity and ecological infrastructure is worthy of further investigation.

- In addition to authoritatively determining appropriate uses, authorities must also have the power to define thresholds for uses within particular geographical areas. Decisions in this regard must bind the mining authorities. The Minister of Environment's power to prohibit the granting of environmental authorisations or waste management authorisations in particular geographical areas is a step in the right direction in this regard, but there may be a need to qualify and refine this power as well as extend it to other authorities (e.g. the Ministers responsible for water and agriculture.

- There is a need to revisit the criteria for granting prospecting and mining rights, environmental authorisations, water use licences, and waste management licences, amongst others. In particular, there is a need to give content to the criteria applied by the Minister of Mineral Resources when granting a prospecting or mining right; i.e. that the grant would not result in 'unacceptable' pollution or ecological degradation. Unacceptability in this case should be unambiguously linked to compliance with the nation's conservation, biodiversity, and probably also food security goals.

- Following from the above, there is a need to revisit the timing, assessment protocols and discourses of justification that are used when conducting site level EIAs of prospecting and mining projects. It must be recognised that site-level EIAs perform risk management functions other than the management of environmental risk. For example, frequently they are important for project financiers to assess risk exposure and are therefore formulated at a pre-design stage of the project. When finances are granted the project design changes, initiating the need for an amendment. The discourses of justification employed in an application for an environmental authorisation revolve around the activity and its impacts, rather than being centred on the ecological infrastructure at risk. Swinging the model around – i.e. focusing on licensing the use of the infrastructure rather than licensing the activity – would require applicants to change the manner in which they present their valuation of ecological infrastructure; how they justify harm and deal with the issues of substitutability and irreversible damage; how they defer decision-making on what to do with irreversible impacts; and how they present their techniques of observation and care.

- There is a need to significantly strengthen the process for s 10 objections. Where prospecting and mining are allowed to occur, the licensing of such should nevertheless allow for meaningful contestation in a forum that is transparent and does not appear to be biased toward mining interests.

4 COAL MINING AND WETLANDS IN HYDRO-CONNECTED LANDSCAPES

4.1 Introduction

Chapter 4 addresses Aim 1 of the project: *To conduct an analysis of available resource and catchment-based tools aimed at sustainable development of water resources and management.*

In South Africa, the Eastern Highveld vegetation type (highland grassland) (Mucina and Rutherford, 2006) extends over several important water catchment areas (DWS, 2014) and is characterised by network of streams and wetlands. The wetlands occur where land is inundated permanently or for protracted periods. These are ecosystem infrastructure elements that offer extensive ecosystem services, while being both vulnerable and resilient to different kinds of human impact. In this study, they were selected at the key ecological infrastructure elements through which to evaluate impacts of resource users and therefore options for sustainable water resource development and management. The highland grassland ecosystem type supports extensive livestock production. Since the area also has large coal reserves, mining activity has escalated during the past decade. The short, medium and long-term value to people, of alternative land and water protection and use, is contested (Tempelhoff et al., 2012; Munnik et al., 2015).

This chapter interrogated the value of wetlands to people, and the degree to which a serious Acid Mine Drainage (AMD) pollution event in 2012 in the X11B sub-catchment, that supplies water to the town of Carolina, affected the ecological health, and ecosystem services offered by wetlands. The chapter addresses social as well as ecological issues arising from resource contestation, presents evidence of the impact of various land-use options on the biodiversity of wetlands, and makes a firm recommendation for natural resource management in coal mining ecosystems.

In this study, wetlands are understood as aquatic ecosystems that are elements of the landscape ecological infrastructure – which is the structure and associated functions of the bio-physical world. Biodiversity (Noss, 1990) is a characteristic of ecosystems that can be used to indicate anthropogenic impact. So, we are using wetland condition, using biodiversity as one indicator, to indicate impact, and also exploring the nature of the hydro-connectivity of wetlands to better understand the biological indicator information.

The history of acid mine drainage (AMD) and land use contestation in the catchment around the town of Carolina, (the X11B quaternary catchment) made it an appropriate study area (McCarthy and Humphries, 2013; Munnik et al., 2015). Agriculture was historically the main land and water user sector with a steady acceleration of mining activities, contestation between the mining and agricultural land uses and especially their claims on wetlands and other ecological infrastructure has escalated.

Using a transdisciplinary approach, this chapter reports on:

- Social perspectives about wetlands and their value (Section 4.2).
- Assessment of wetland health and ecosystem service provision, together with a rapid assessment of wetland macro-invertebrates and water quality variables (Section 4.3).
- A bio-physical assessment using a quantitative assessment of wetland macroinvertebrate community structure in relation to quantified concentrations of a variety of water quality variables (Section 4.4).
- Relating these results to a hydro-pedology study of hydrological connectivity in the landscape (Section 4.5).
- Making a clear sustainable water resource use and protection recommendation (Section 4.6).

4.1.1 Theoretical framing

The research presented in Chapter 4 is framed by the concept and theory that river catchments can be viewed as complex adaptive systems (Cilliers, 2000). Human activities such as land-use change create modifications to ecological structure and function that affect ecosystem resilience - (Folke, 2003; Biggs et al., 2015). Interlinked and interdependent components make up complex adaptive social-ecological systems, that support and strengthen social-ecological well-being (Folke, 2003; Ison, 2010). One approach, which bridges the understanding and highlights links of Social-Ecological Systems is referred to as complex systems thinking. The approach adopts resilience, adaptability and learning in order to embrace uncertainty and change, as opposed to trying to control change (Folke, 2003; Ison, 2010). Systems thinking and practice involves considering and understanding a system with a holistic view of the multiple linkages between social and ecological elements and allowing for management that is adaptive, as a response to uncertainty (Folke, 2003; Costanza et al., 2016).

System elements include ecological and social components. Ecological components range from: cells, individual species of fauna and flora, to soil, water and ecosystems (Biggs et al., 2012). Interactions within and between components, drive cause and effect relationships, and a network of integrated and interdependent parts emerge as a system (Ison et al., 2007; Pollard & Du Toit, 2011).

Berkes and Folke (1998) term an "*integrated system of ecosystems and human society*", such as a catchment, a complex social-ecological system (C-SES). Such systems are characterised by the phenomenon of emergence, an example being the emergence of direct and indirect services humans derived from an ecosystem. These services are the result of the cumulative outcomes of interactions throughout the system, beginning from selection processes and interactions at lower levels of ecological hierarchy (Pollard et al., 2013; Biggs et al., 2015a).

By removing ecological components and reducing bio-diversity within a C-SES, the system loses the range and capacity "*to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks*" (Walker et al., 2004:2) rendering the system vulnerable (Biggs et al., 2015b). Without redundancy, changes may cause the system to cross a threshold and shift into a different state (i.e., regime) (Walker & Salt, 2012; Biggs et al., 2012). Ecological thresholds are reached when a system's drivers' (components or phenomena) quality and/or quantity are altered (abruptly or even small directional changes); and in response, the nature of the ecosystem is changed (Groffman et al., 2006).

Social factors such as perverse agendas, selective admittance and limitation of stakeholders, can limit knowledge diversity and exclude practical experience. (Cilliers et al., 2013). Thus, social thresholds within a C-SES can also be exceeded. Multiple-use of resources can result in over-use, and exclusion of less powerful users (Pollard & Du Toit, 2011; Tempelhoff et al., 2012). Conflicts then emerge between and among different stakeholders (Ison et al., 2007; Pollard & Du Toit, 2011; Tempelhoff et al., 2012). Without communication, understanding, shared knowledge and trust within and among stakeholders, conflicts and disputes arise over access and use of common pool resources, leading to despondence, animosity and trust issues (Ison et al., 2007). Ison et al. (2007), also describe the social and environmental stress arising from a mismatch of human use and ecosystem services as a "resource dilemma" that highlights the conflict, controversy, inter-dependence, and multiple perspectives that emerge from such situations.

Resources dilemmas therefore have the following characteristics: (i) There are imbalances of use resulting in conflict and controversy (competing claims) and, (ii) inter-dependence between components where users' objectives are based on other users achieving their objectives - this is difficult for stakeholders to accept, (iii) as there are multiple user perspectives (own optimisation strategies, theories and understandings) which makes resource dilemmas, (iv) complex, (v) and as a result have high levels of uncertainty (Ison et al., 2007). In addressing social-ecological systems it is useful to take a transdisciplinary approach (Lang et al., 2012). The situation in quaternary catchment X11B exhibits all the characteristics of a resource dilemma: mining claims major economic benefits and responsible ecosystem use; agriculture claims long term, sustainable economic benefit with much lower ecological impact; residents are angry about the risks they were exposed to by AMD; water diverted to a near-by power station substantively affects local water supplies and plans for this pattern of use are unclear; residents, farmers and activists claim mining is unsustainable with unacceptable social and ecological impacts.

4.1.2 Integrated Water Resource Management (IWRM)

South Africa's National Water Act (NWA) (No. 36 of 1998) aligns well with an understanding of catchments as complex social-ecological systems, and enables both scientifically robust land-water use regulation methods and participatory engagement with water users. Practical implementation of Integrated Water Resource Management (IWRM) is a real possibility. Sustainable IWRM requires that water resource use is balanced by water resource protection.

Policy-based mechanisms are described in the National Water Resource Strategy (DWA, 2013) to enable balanced protection and use: (i) classification of water resources, (ii) the determination of the Reserve (amount of water set aside to provide for basic human needs and environmental flow), and (iii) the derivation of quantified resource quality objectives. These three are Resource Directed Measures (RDMs) while the application of licenses to allocate and authorise water resource use, is referred to as Source Directed Control (SDC) (Palmer et al., 2004, DWS, 2013). Data used for RDM and SDC water quality processes include analysis of chemical and physical variables, collecting information on the presence absence and abundance of biota (biomonitoring) and responses of biota to different chemical concentrations of water (ecotoxicology) (Palmer et al., 2004). Integrating RDMs and SDCs in water resource management, as well as incorporating SAM, water resource management initiatives are more likely to support the ecological and social sustainability of C-SESs.

South Africa has established institutions to effect IWRM that support the key principles of equity and sustainability that underpin water policy and law in SA (Pollard et al., 2013). The primary national government department is the Department of Water and Sanitation (DWS). There are nine Water Management Areas (WMAs) in South Africa, each with an associated Catchment Management Agency (CMA). A first task of a CMA is to draft a Catchment Management Strategy (CMS) for the CMA. The Inkomati-Usuthu CMA used an adaptive C-SES approach to develop its CMS, which guides water resource management in this area.

4.1.3 A nexus of contestation

Across the grassland landscapes there are strong hydrological links between the aquatic ecosystems and water users, in X11B specifically, between wetlands, agriculture and coal mining (Section 4.4.). Wetlands offer vital resource-based services to various users, and their protection is a long-term goal for a sustainable landscape. Implications of impacts of land use on the hydrological quality and connectivity differ among users (Section 4.4). For instance, hydrological and water quality impacts on wetlands by open pit coal mining are more severe than agricultural use. Mining impacts on water and landscape also have consequences for the agricultural sector, whereas agriculture has minimal effects on mining. These have further implications, as the perceived values of water resources vary among users. For example, agriculture depends more heavily on wetlands as a water resource where the saturated soil features support livestock/crop agriculture, and therefore value the quality and quantity of the water. Open pit coal mining does not directly use the water source, but wetlands are located where ground water, sub-surface flow and surface water meet, and these shallow locations are ideal for open pit coal mining to occur. The wetland ecosystem and surrounding natural environment, as well as local and downstream domestic users, also depend on wetlands for support and the provision of ecosystem goods and services. Hence use and impact balances become unequal, making wetlands a clear nexus of water resource contestation.

4.1.4 Wetlands and their importance

The South African National Water Act defines wetlands as "*land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil*". This highlights the strong hydrological connectivity that wetlands have within the catchment landscape. Wetland hydrology is the major determinant of the timing and duration of flooding, chemistry of soils, the types of plants and animals, the chemistry of the water (nutrients and detrimental solutes) and the overall productivity of the wetland.

Wetlands in South Africa should, in theory, be rare, as the country's high elevation, low rainfall, high potential evapotranspiration and absence of geologically recent glaciation are not typical of supportive wetland formation (Ellery et al., 2009). Therefore, wetlands are generally associated and linked to streams. This is the case with the wetlands of the Mpumalanga Highveld (Joubert and Ellery, 2013). South African wetlands are fed by surface and groundwater inflow (sub-surface lateral drainage (> 60 %), recharge (4 %), and rainfall and water leaves via evapotranspiration) as well as surface and groundwater outflows (Section 4.4). A hydro-geomorphic unit is characterised by the way that water arrives at, flows through and leaves that specified portion of a wetland system – called HGM unit/s (Kotze et al., 2009; Ollis et al., 2013). One wetland can be made up of numerous types of HGM units that individually contribute to the functionality of the whole wetland (Ellery et al., 2009; Kotze et al., 2009; Ollis et al., 2013).

HGM units vary depending on the stream channel, slope, positioning (bottom of a valley or hillslopes), water source inflow and outflow. The six HGM unit types include floodplains, channelled valley-bottoms, unchannelled valley-bottoms, hillslope seeps feeding a stream, hillslope seeps not feeding a stream, and depressions (Ellery et al., 2009). The characteristics of each type of HGM unit provide for associated ecosystem services and their extent of delivery/provision. Altering hydrological and geomorphic aspects of an HGM unit will therefore have implications on the wetland's condition as well as further implications on the ecosystem's underlying services and the goods and services from which people benefit (Hemond & Benoit, 1988; Ellery et al., 2009).

Wetlands are among the most important, yet threatened, ecosystems (Van Vuuren, 2014). Their valuable ecosystem services are the results of interactions, composition, structure and ecological functioning of the ecosystem (Millennium Ecosystem Assessment, 2005; SANBI, 2014). These services naturally supply a range of valued benefits for humans. These benefits are based on functional outcomes encompassing numerous tangible goods/benefits and intangible provisions (Millennium Ecosystem Assessment, 2005; Pollard et al., 2013).

The Millennium Ecosystem Assessment (2005) categorises ecosystem services as provisioning, cultural, supporting and regulating. The intangible cultural services are for example: the aesthetic appreciation, spiritual connection, educational gains, and recreational values that people obtain from the presence of a wetland ecosystem (Millennium Assessment, 2005). Regulating services in well-functioning ecosystems indirectly regulate the natural environment. For example: regulation of floods, groundwater recharge, streamflow regulation, erosion control, maintenance of biodiversity, water quality regulation. Supporting services provide the fundamental structures and processes that contribute to the functioning of the ecosystem, such as nutrient cycling, soil formation, photosynthesis, respiration, and water and nutrient cycling (Millennium Assessment, 2005). Wetland ecosystems are can thus be seen as part of a system that supplies surrounding communities with food, fuel and fibre, and generally enhance human well-being (Van Vuuren, 2014).

Many people are not explicitly aware of the services that ecosystems provide, nor are they aware of their finite capacity (Pollard et al., 2013; SANBI, 2014). Conservation frameworks tend to engage with stakeholders. The connection between ecology and society that ecosystem services provide, allows for greater awareness and protection efforts (de Groot et al., 2010; Pollard et al., 2013).

Ecosystem service valuation can thus play an important role in assisting in negotiated outcomes of competition of land use and the needs of the environment. There are several methods for valuing ecosystems: monetary, aesthetic, cultural/spiritual, moral, and bequest values. Valuation efforts are complex and tend to underestimate and inadequately allocate monetary values associated with ecosystem services (de Groot et al., 2010). Nevertheless, economic and moral arguments have been used for the promotion of conservation principles (for example, to propose informed viability of land uses, or to estimate losses due to land degradation) (de Groot et al., 2010). The entry of ecosystems into the social-ecological arena allows for conservation efforts to incorporate both societal and ecological needs in socio-political decisions (Norton, 2003; Pollard et al., 2013).

4.1.5 Wetlands as ecological infrastructure

To promote a greater social awareness and understanding of the importance of wetlands and other service-providing ecosystems, the term “ecological infrastructure” has recently been adopted/implemented by conservation biologists and SANBI (Definition, Section 1.2). The term ‘infrastructure’ emphasises ecology and ecosystems as being essential for the long-term functional operation of structures of society (SANBI, 2014).

Valuing ecological infrastructure is challenging in a society where monetary value is easily quantified, and intrinsic value and cultural values such as sense of place, aesthetics, a sense, experience and location of the sacred are less so. The pitfall of comparative land use valuation on a monetary basis is that the monetarisation of ecosystem services does not include the full value of the ecosystem (Chapter 5). However, some articulation of the value of ecological infrastructure, and component ecosystems such as wetlands is vital in a country such as South Africa when, in 2012, 65 % of wetlands were categorised as threatened (SANBI, 2013 and 2014). The wetland ecosystems in the X11B catchment are the focus of this study.

4.2 Contestation of aquatic resources by users

During the 2012 AMD crisis, and currently, the many claims on the X11B catchment’s natural resources, including those from mining and agriculture, created a complex situation. Ascribing responsibility for social vulnerability and bio-physical degradation is challenging. Water is a primary driver in the social-ecological system, and changes in this system driver in 2012, caused a breach in the systems’ thresholds in 2012 (Tempelhoff et al., 2012). Some of the competing claims and varying perspectives of different natural resource users of the X11B catchment are presented in this section.

4.2.1 Local communities

Local communities (civil society organisations, groups of residents) depend on the raw water supply from the storage dam, fed by the wetlands, streams and tributaries of the catchment for basic needs and local industry (Tempelhoff et al., 2012). Rural communities make use of grasslands, wetlands, streams and tributaries for livestock, subsistence farming, and the collection of natural products such as thatching grass. The catchment community also depends on government and municipal departments to ensure and maintain sufficient water of usable quality (Tempelhoff et al., 2012). Carolina has a history of poor municipal services: inconsistent electrical power and water supply, problems lined with water sanitation, as well as poor upkeep of infrastructure. For example, the town’s water purification plant, a problem that invariably leads to poor water quality after heavy rains (Tempelhoff et al., 2012). Prior to the 2012 AMD crisis, there was already a level of distrust between the community and the town’s governance structures. The crisis impacted the whole catchment, and the lack of mitigation resources available to the municipality left the town without safe municipal water for seven months (Tempelhoff et al., 2012).

The community was reassured about numerous issues over the crisis period: that interventions were taking place to mitigate the AMD impacts on the town's water: the water purification plant's settling tanks and de-sludging processors were being fixed; investigations indicated that the mining companies were responsible for the situation and would face legal action, and that water tanks around the town provide a temporary supply solution for supply of water (Tempelhoff et al., 2012). Nevertheless, the continued poor and unreliable alternative water supply, poor communication and apparent lack of conviction from the mining industry, issues of trust emerged (McCarthy and Humphries, 2013). Stakeholders accused the municipality of being ill-equipped for dealing with AMD situations (Tempelhoff et al., 2012). For example, the town's water purification plant's settling tanks and de-sludging processes were not functioning properly, due to capacity limits with respect to dealing with high metal content (a consequence of AMD). It was argued that the municipality was responsible for the crisis as an investigation into mining activities showed that two of the four accused mining companies did not have mining licences (Tempelhoff et al., 2012). Community stakeholders began to doubt the municipality's capabilities and competency for dealing with the situation as they thought municipality was responsible for ensuring that licences were correctly administered before mining operations begin, and that adequate risk management and general infrastructure are implemented and maintained (Tempelhoff et al., 2012; McCarthy & Humphries, 2013).

Distrust of coal mining companies in the catchment also emerged. Community members expressed to Tempelhoff's team (2012) that the coal mining sector was not actively involved in the Carolina community, even though it was seen as an option for employment. The mining companies also took no responsibility for the crisis that unfolded in 2012, even though evidence suggested otherwise (Tempelhoff et al., 2012; McCarthy & Humphries, 2013). One coal mining company did, however, take the initiative to commission an environmental consultancy company to assist in identifying possible impacts of coal mining operations in the catchment. The combination of doubt and distrust in the community resulted in protests, civil unrest, and public anger and a court case against the Chief Albert Luthuli municipality for not supplying acceptable water to the residents of Carolina (McCarthy and Humphries, 2013).

4.2.2 Governance structures

The Department of Water and Sanitation (DWS) and the Inkomati Usuthu Catchment Management Agency (IUCMA) played high profile roles in responding to, and mitigating, the Carolina situation (Tempelhoff et al., 2012). It is the responsibility of these two agencies to ensure the protection, development, management, use, and control of South Africa's water resources at local government and catchment levels and to ensure high standards with respect to waste water discharge and sanitation. Neither of these institutions were fully prepared to deal with the AMD crisis. Furthermore, communication between national, provincial/catchment, and local government, mining companies, and local residents was minimal (Tempelhoff et al., 2012). Trust issues emerged between local stakeholders and government and the DWS questioned the IUCMA's functional capabilities. This because legal advisors of the mining companies communicated directly to the DWS, to express their dissatisfaction concerning the CMA's alleged failure to follow through with pre-directive water licencing processes (Tempelhoff et al., 2012).

4.2.3 Agricultural natural resource users

Agriculture is a main driver of the Mpumalanga economy, making this sector a foundational component of the X11B catchment (Stats SA, 2016). An estimated 22% of South Africa's maize is produced in Mpumalanga. In dry seasons, the province's contribution to the country's maize supply can be as high as 55 percent. (Tempelhoff et al., 2012). Carolina is historically an agricultural town, has much of the land in the X11B catchment is agricultural land from which about 40% of households derive their income (Tempelhoff et al., 2012; Stats SA, 2016). The agricultural sector claims to use grasslands, including their component wetlands, streams and tributaries, as rangelands for crop and livestock agriculture. Human settlement in the area has thus been strongly linked to water access for basic needs and farming (Folke, 2003). Water resources provide agricultural practices with services and benefits that include arable land, water provision for growth of crops and irrigation, and grazing and drinking sources for livestock, especially during periods of drought and dry seasons (Scoones, 1991; Swanepoel & Barnard, 2007).

These ecosystem services — more specifically wetland services — are described by Scoones (1991) as being vital in any mainstream and subsistence agricultural context (Egoh et al., 2012). Farming activities can however have detrimental impacts on water resources. According to Kotze et al. (2009) and Walker and Salt (2012), these farming impacts including the following:

- removal of native vegetation;
- overgrazing and trampling in and around wetlands by livestock;
- building of infrastructure (e.g., embankments and roads) within, and alterations of, water channels (dredging in order to control speed flow through the wetland and prevent flooding) on farms;
- construction leading to the fragmentation of natural biodiversity, sedimentation and erosion from bare soils within a wetland's catchment;
- the increased toxicants, nitrate, nitrite and phosphate levels from fertilisers and pesticides, thus leading to cases of eutrophication, and
- the drainage of wetlands

Maize and livestock farmers in the catchment have serious concerns involving coal mining and future agricultural activities. The Bureau for Food and Agricultural Policy (BFAP) (2012) reported that only 1.5% of South Africa is covered in soils best suited for cash crop production and 46.4% of that total area is located in Mpumalanga. Mpumalanga is also a heavily mined province and mining activities pose threats to arability of soils (BFAP, 2012). Prospective coal mining alone is estimated to transform 12% of Mpumalanga's arable land and a further 14%, once prospecting rights are administered (BFAP, 2012). These land transformations will not only impact on agricultural activities, but also affect maize meal prices (by approximately 5%) thus impacting the food supply of a large section of South Africa's population (BFAP, 2012).

4.2.4 Coal mining as a natural resource user

South Africa is the 6th largest exporter of coal in the world and the sector plays a strong role in the country's economy. The Mpumalanga Highveld geology is made up of the Karoo supergroup which sedimentary rocks layered with coal, resulting in a heavily mined landscape (McCarthy & Humphries, 2013). Mining is, however, also one of South Africa's most contentious water users and polluters. In many respects, coal has been proven to be environmentally unsustainable and destructive, for example in relation to AMD (Hallowes & Munnik, 2016). Wetlands have been targeted by coal mines as they provide a shallower geology in the landscape, making it easier to access coal seams, resulting in the destruction of the wetland (White, 2003).

Open pit coal mining impacts form the focus of mining in this study. In 2014 four operational mines, seven defunct mines, along with three functioning coal sidings and a beneficiation plant, were identified within the X11B catchment (Golder Associates, 2014). There is a fundamental connection between the natural hydrological processes of a wetland, and mining. Groundwater and water tables within landscapes are fed by precipitation infiltrating the ground. Sub-surface water can account for 60 % of the water in the landscape, important for wetland support (Section 4.5). Acid mine drainage is water affected by mining activities. Rock containing coal is characterised by the mineral pyrite, which, when exposed to oxygen and water oxides, creates sulphuric acid (McCarthy & Humphries, 2013). This oxidation is a naturally occurring process but in natural environments the acidity is typically neutralised by other minerals (for example by carbonates and by hydrolysis of aluminosilicate minerals) occurring in the ground (McCarthy & Humphries, 2013; Section 4.5). However, the extent of this rock-type that coal mining exposes, produces acid beyond natural neutralising capabilities. The sulphuric acid creates further solubility of iron (Fe) and aluminium (Al), and other heavy metals (McCarthy & Humphries, 2013). Therefore, once oxidation has taken place, waters subjected to f pyrite exposure have low pH levels, high concentrations of sulphates, Fe, Al, and other heavy metals. Contaminated water is then leached into mining sites' groundwater (water table) through infiltration and discharged into water courses; usually wetlands (White, 2003; Hallowes & Munnik, 2016). Coal mining also has impacts of increased runoff due to surface hardening at coal mining related sites. Runoff containing fine coal deposits and possible AMD, along with coal dust generated at sites, also enters water systems within catchments (White, 2003).

Once AMD enters a water system there are adverse effects on the fauna, flora and humans that use the water resource as well as the toxicant removal capacity of the ecosystem. Heavy metals that become bio-available under acid conditions cause harm to aquatic organisms where, depending on specific tolerances, ecosystem damage can occur (Dabrowski et al., 2015). The often-prevalent high acidity (low pH) of AMD also causes already stored toxicants in wetlands to become soluble in the water solution. AMD thus limits and compromises the services of wetlands and renders toxicants bioavailable in a toxic form to fauna and flora of the ecosystem (Sheoran & Sheoran, 2006).

The complex wetland processes that remove excess nutrients and store metals involve a range of biological, chemical (sedimentation and adsorption of particles and oxidation of contaminants) and physical extraction (Sheoran & Sheoran, 2006). If water is not filtered by the wetland, the water flows directly into connecting water resources, thus impacting downstream users (including the agricultural sector that needs water for livestock and irrigation) (White, 2003; Mpumalanga Tourism and Parks Agency, 2012; McCarthy & Humphries, 2013).

Restoration has become part of mining responsibilities (Hallowes & Munnik, 2016) but the layered sub-surface geology means restoration has to include layering materials that are differentially permeable. This is expensive and not routinely undertaken.

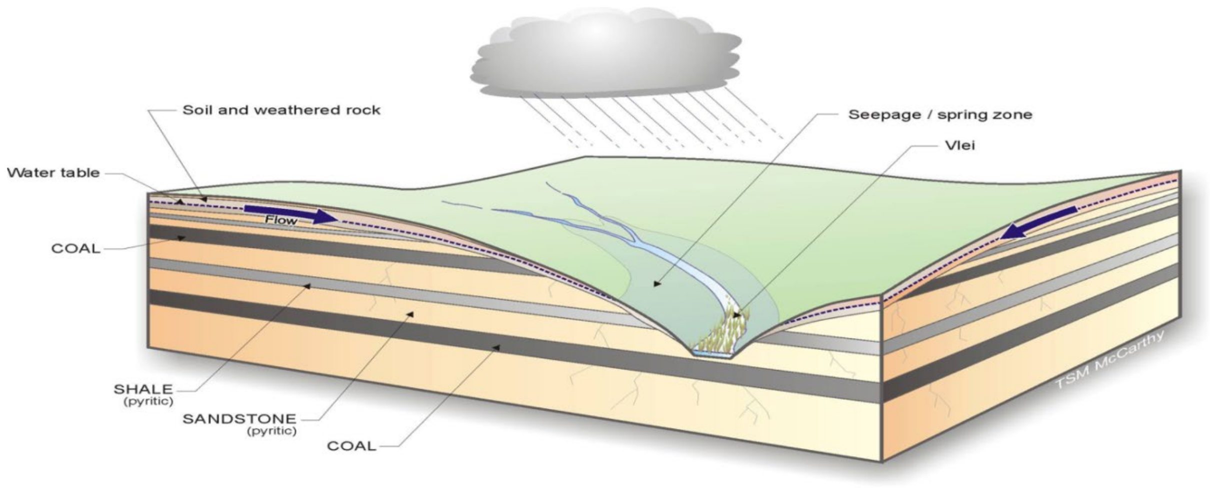

Figure 6: Relationship between surface water sources, soil water, and coal seams (diagram by Prof T. McCarthy, pers comms)

Open pit mining requires all layers of soil, shale and sandstone (including pyrite) to be removed from the landscape to expose coal seams. The ground is then purged, creating a void that intercepts the landscape's sub-surface lateral drainage (that feeds the water table). Thus, intercepting flows through soil profiles that feed wetlands and biota, resulting in drying out of ecosystems and restricting water supply to other parts of the landscape (Section 4.5).

Implications for closure of mines and restoration is that after the mine void has been repacked and filled, if the intercepted sub-surface water paths (sandstone and plinthic layers) are not reconstructed, the hydrological connectivity within the landscape continues to be compromised (Section 4.5 and Figure 6). Coal pits are usually loosely repacked with previously-exposed pyritic rock/coal. Water (including the intercepted water) percolates and accumulates in the old mine profile and discharges at the lowest point of the old mine pit, thus creating AMD issues after closure (White, 2003; Section 4.5).

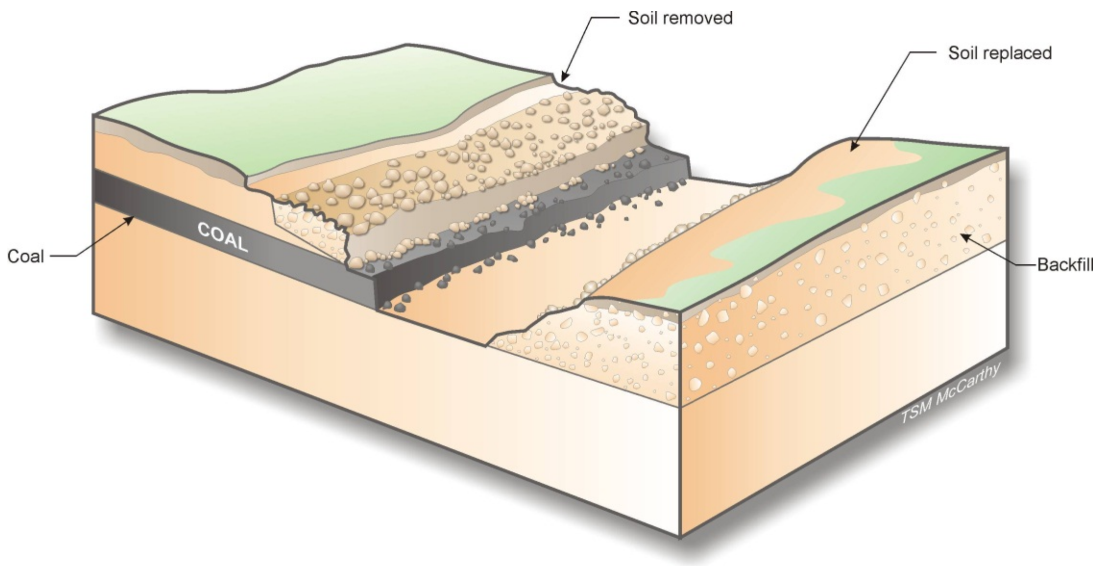

Figure 7: A diagram of open pit mining (diagram by Prof T. McCarthy pers comms)

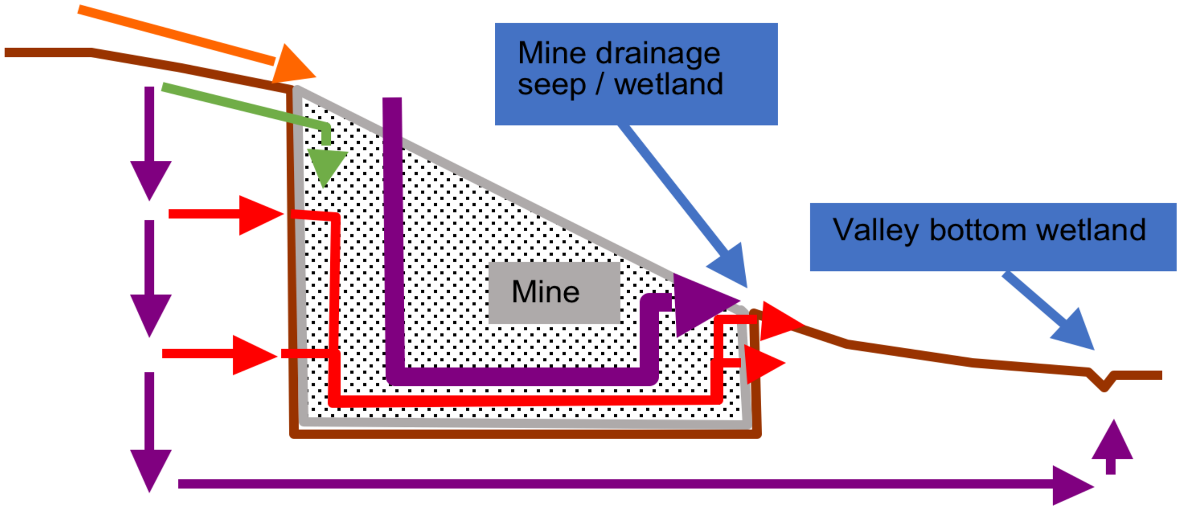

Figure 8: Underground impact of open pit mining: surface runoff (orange arrow), sub-surface shallow lateral drainage (green arrow) and recharge to a groundwater-fed wetland (red arrows) are interrupted by open pit mining, with only sub-surface deep lateral drainage/seepage (purple arrows) feeding the wetlands.

(This figure is very useful in the reading of Section 4.5).

These open pit coal mining impacts are evident in the X11B catchment and play a major role in the catchment's mining contestation. At the time of the AMD crisis, McCarthy and Humphries (2013) recorded that that the pH of the Carolina water supply was at 3.7 and concentrations of sulphate Al, Fe and other heavy metals (including magnesium) were above acceptable water standard limits (DWAF, 1996). It was also recorded that fish and plant life in the Boesmanspruit dam were dying. There were clear signs indicating AMD impact. The presence of AMD within the X11B catchment, alone, suggests that inadequate restoration has occurred, adding to the conflict and the mining legacy problems experienced in South Africa (Munnik et al., 2015b).

Nevertheless, in 2012 the mining companies took little responsibility for the situation (Tempelhoff et al., 2012). Two of the four mining companies accused of the town's contamination did not have water-use licences and mining was publicly accused of being primarily responsible for the contamination. Legal actions against the companies were, however, not taken. Nor did mining companies assist with mitigation, apart from commissioning an environmental consultation identifying possible mining impacts (Tempelhoff et al., 2012; McCarthy & Humphries, 2013; Golder Associates, 2014). Communication between mining companies, municipal officials, and local political leaders, was not fruitful. Animosity towards the catchment's mining companies and doubt in government authorities' ability to restore the water supply, emerged among stakeholders (Tempelhoff et al., 2012). Farmers, specifically, still perceive coal mining as a destructive activity that threatens the future viability of the agricultural sector in Mpumalanga.

4.2.5 Eskom

For some years until 2011, the X11B catchment was part of an Eskom water transfer scheme to provide extra water to service power stations located around the X11B catchment (Tempelhoff et al., 2012). The transfer was from a dam located in an adjacent catchment and flowed through the X11B Witrandspruit tributary and into the Boesmanspruit dam, where it then continued to the Nooitgedacht dam, north of the Catchment (Tempelhoff et al., 2012). In 2011, the transfer scheme through the catchment was discontinued when the power plant activity was interrupted. Cessation of the transfer reduced surface water input to the catchment, and reduced dilution capacity. This was an exacerbating factor in the 2012 AMD crisis (Tempelhoff et al., 2012).

4.2.6 2012 – "the perfect storm" – what now?

The 2012 AMD incident is a vivid example of stakeholders in a catchment overlooking secondary effects of resource use impacts and ignoring long-term consequences of their actions (Tempelhoff et al., 2012). The scale and extent of the AMD contamination and the limited capacity, in terms of governance and infrastructure, to deal with the situation highlighted the resource-use contestation within the catchment.

One traditional approach to assessing anthropogenic impacts on ecosystems is to use bioassessment (Bailey et al., 2004). We initiated the ecological part of this transdisciplinary investigation of mining impacts on biodiversity, using two wetland assessment tools developed particularly for South African wetlands. (This is the link to Aim 1 of the project: *To conduct an analysis of available resource and catchment based tools aimed at sustainable development of water resources and management.)*

We judged the WET-Health– which focuses on the bio-physical condition of the wetland (Kotze et al., 2009); and WET-EcoServices – which links the wetland ecosystem to the social context, and particularly the value of wetlands to people, (Macfarlane et al., 2009), as the best available resource and catchment based tools to assess "sustainable development of water resources and management" in a context of coal mining. As the study progressed, the use of these tools proved to have limitations (Section 4.3), therefore deeper, quantified, bioassessment (Section 4.4), and hydro-pedology (Section 4.5), studies were undertaken.

4.3 Qualitative wetland assessment

4.3.1 Introduction

The aim of this section is to use the WET-Health and WET-EcoServices (Macfarlane et al., 2009; Kotze et al., 2009) wetland assessments to provide an initial understanding of wetland health and potential ecosystem service provision. The above-mentioned resource- and catchment-based tools (selected for this study) were developed to promote sustainable development of water resources and management. They were selected because of the nexus role of wetlands in the contestation between coal mining and other resource users. The WET-Health and WET-EcoServices assessments are presented together with water-resource user perceptions, because of the importance of users in the contestation. The chapter draws attention to the WET-Health delineation process not indicating any threat to interruptions on ground water feeding the wetland. This is further addressed in Section 4.4

4.3.2 WET-Health and WET-EcoServices Assessment

Wetland health and ecosystem service provision assessment in South Africa is most commonly undertaken using the wetland management series "WET-Management" (Ellery et al., 2009; Kotze et al., 2009). WET-EcoServices, an assessment tool of WET-Management, is a procedure for a relatively quick, specialist/expert-based assessment of ecosystem services supplied by wetlands. Highlighting the services a wetland performs provides a perspective that increases awareness among resource users of the value of the wetland. In the assessment key, wetland traits are used to indicate value. WET-EcoServices can be undertaken at two levels. Level 1 is a desktop-based assessment on the identification of hydro-geomorphic (HGM) units, while a Level 2 assessment (used for this study) is a rapid field assessment based on HGM setting, describing key features that serve as indicators relevant to a specific service (Kotze et al., 2009).

Closely related to the WET-EcoServices tool, is the WET-Health tool for rapidly assessing wetland health. A WET-Health assessment is also conducted by specialists who assess the integrity of a wetland (the average condition of the wetland's HGM units) in relation to an unimpacted "natural reference condition" (Macfarlane et al., 2009). Designed specifically for use on South African wetlands, the tool is based on an impacts-based, risk assessment approach (Macfarlane et al., 2009). By using physical indicators (vegetation and geomorphology) of impacts, wetland conditions are related to the sum of magnitudes of different impact categories of human activity, and also provide insight into causes of degradation (Macfarlane et al., 2009). Magnitudes are estimated using the extent of the impact, assessed as a percentage, multiplied by the intensity of impact, assessed as the degree of alteration caused by impact (scored on a scale of 0-10) (Figures 15 to 20). Human activities include the following: reduced inflow quantity, potentially-altered flow patterns, canalisation and modification of streams, independence and obstruction features, and altered surface roughness. Such impacts account for direct water loss as well as creating recent deposition, infilling, or excavation.

WET-Health, like WET-EcoServices, consists of two levels of assessment: the first is a desktop assessment, the second a rapid field-based, qualitative, expert or specialist assessment of indicators of degradation that includes elements of the desktop analysis (Macfarlane et al., 2009). The Level 2 analysis was undertaken in this study. Sets of processes, interactions, and interventions of three WET-Health modules were assessed individually:

- The hydrology and the movement of water through the soil: an assessment, based on activity impacts.
- The geomorphology of the wetland units, based on indicators of loss or gain of sediment.
- The vegetation structure for each HGM unit of the wetland, based on indicators of vegetation composition and structure change.

The WET-Health assessment also allows for specialists to estimate the Present Ecological State (PES) of the wetland. The PES determination forms part of the processes for determining the Ecological Reserve (Kleynhans and Louw, 2007), contributes towards creating the Resource Quality Objectives (RQOs) of a Water Management Area (WMA) in line with the mechanisms for implementing Integrated Water Resource Management (IWRM) (DWA, 2011).

Note that these qualitative assessments do not require quantified measures of any wetland elements such as vegetation, water chemistry or aquatic macroinvertebrates.

Table 4: Impact scores and estimated categories of PES used by WET-Health to describe the integrity of wetlands (Macfarlane et al., 2009)

Impact category	Description	Impact score range	Present State category
None	Unmodified, natural.	0-0.9	A
Small	Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1-1.9	B
Moderate	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	2-3.9	C
Large	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4-5.9	D

Serious	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognisable.	6-7.9	E
Critical	Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8-10	F

4.3.3 Study area and methods

The X11B catchment experiences dry, cool-to-warm winters and warm and wet summers. The mean annual rainfall falls within the range of 700-780 mm per annum and evaporation ranges between 1,650-1,900 mm per annum. The landscapes shift between dry and mesic seasons (Golder Associates, 2014). The Highveld region of Mpumalanga is recognised as containing a large portion of South Africa’s Freshwater Ecosystem Priority Areas (FEPAs) (Nel et al., 2011). Wetlands of all types are common across this upland grassland catchment, including: non-channelled valley-bottom wetlands, channelled valley-bottom wetlands and hillslope seeps and depressions (i.e., pans) (Nel et al., 2011). These wetlands, along with the region’s threatened Highveld grassland biome, host an array of significant species worth conserving (Mbona et al., 2015).

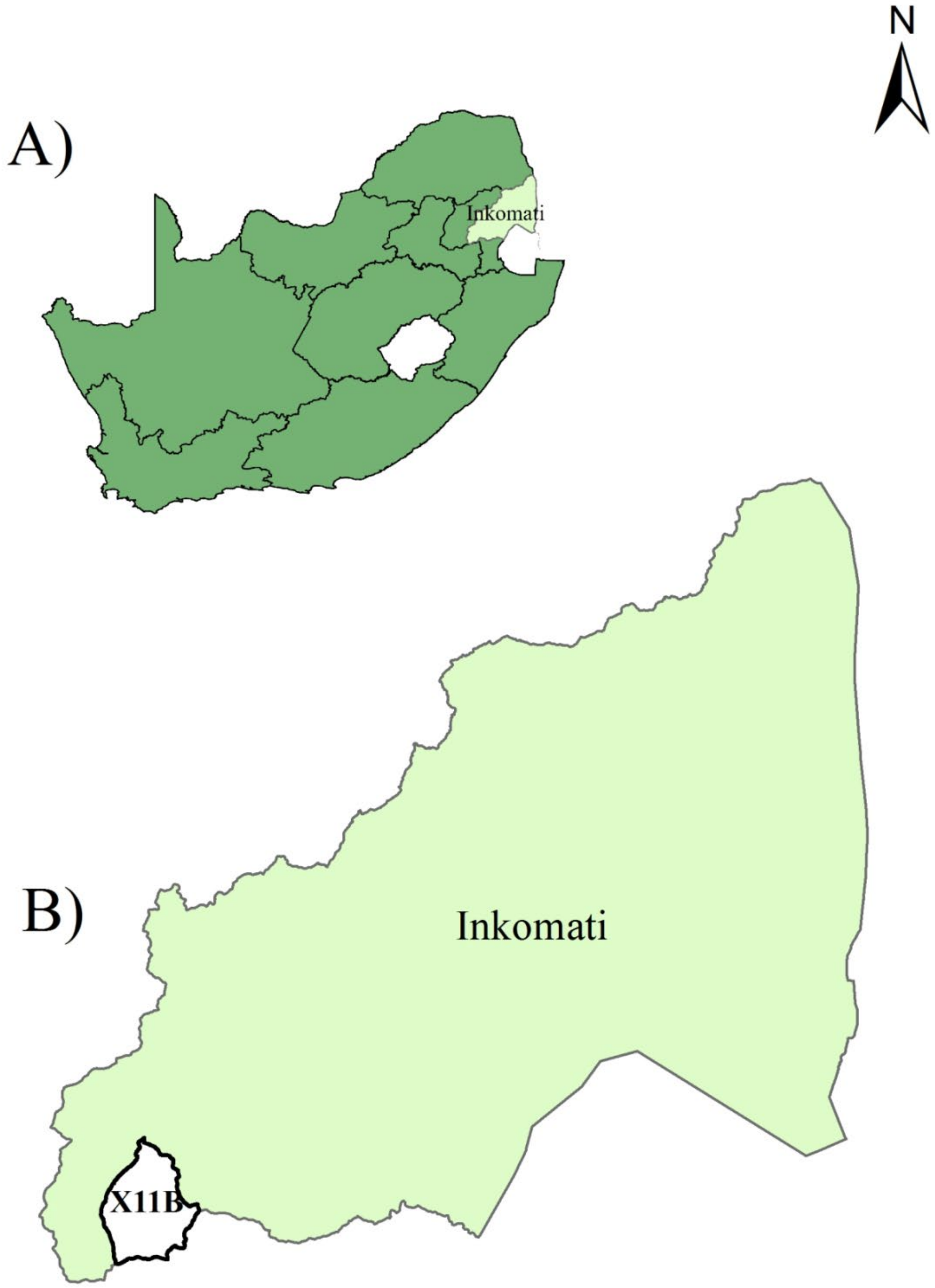

Figure 9: Location of the Inkomati River catchment and the X11B quaternary catchment A) South Africa B) Inkomati catchment showing the location of the X11B quaternary catchment located in Mpumalanga

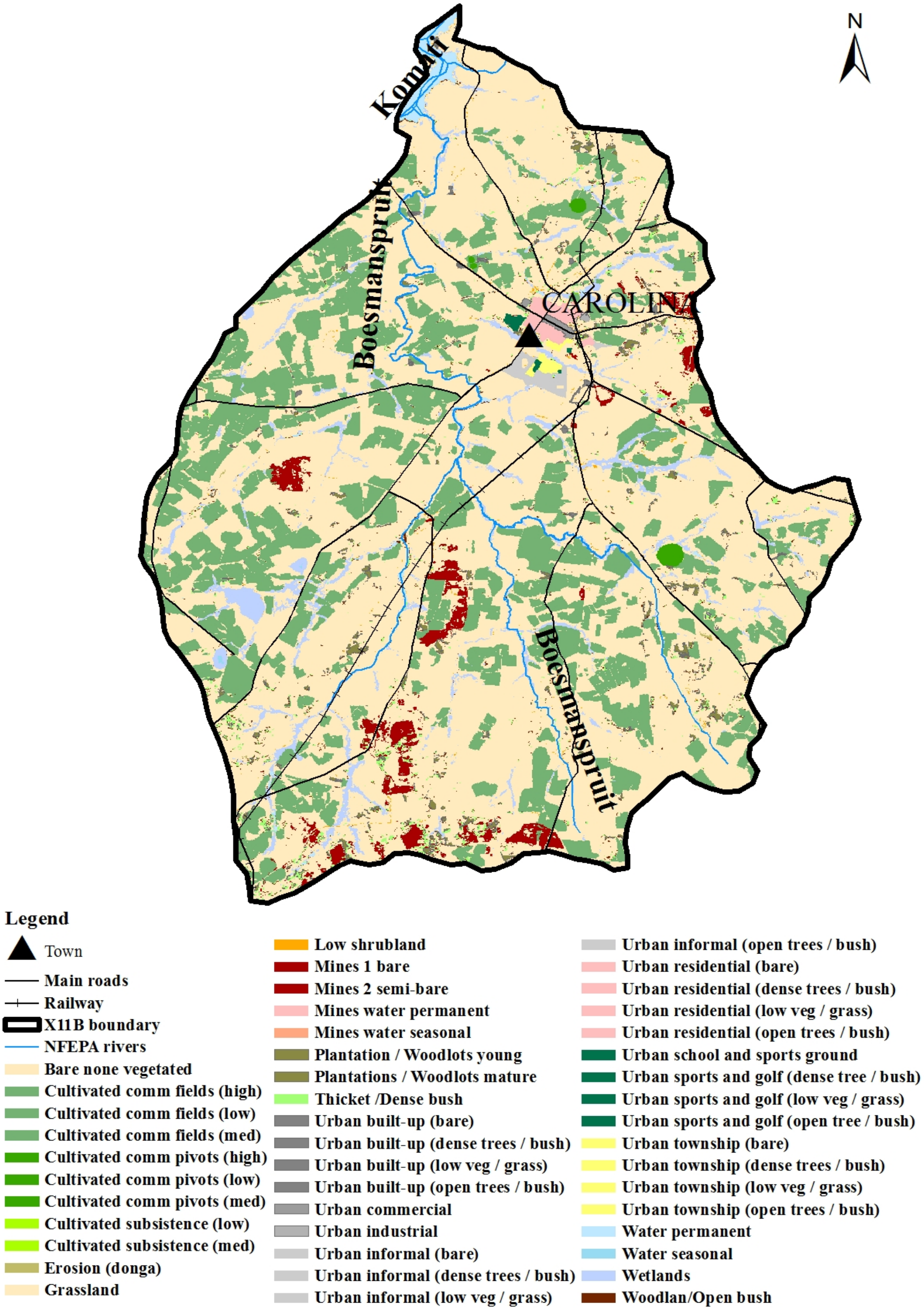

Figure 10: Land cover of X11B (Figure 4-4) catchment

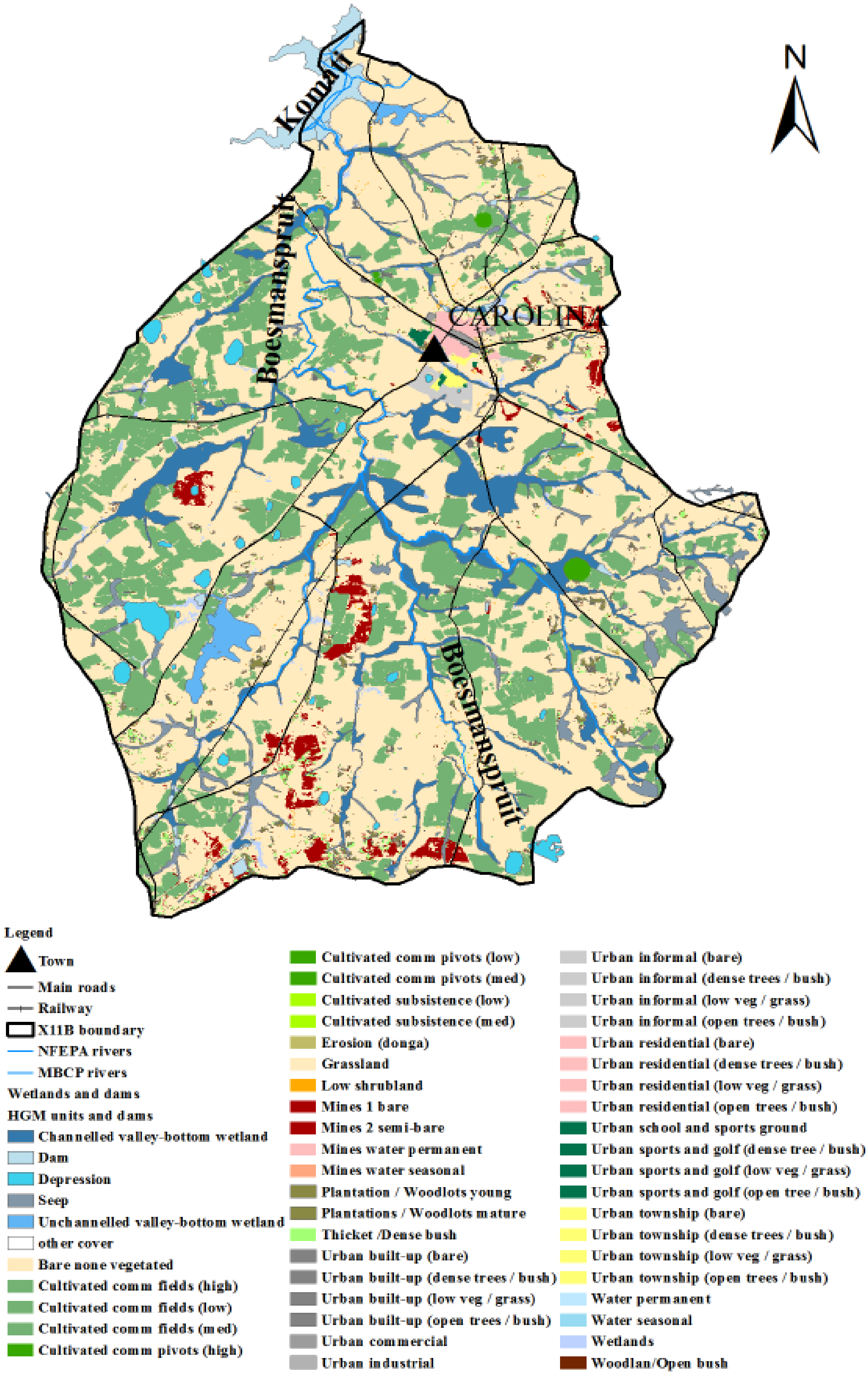

Figure 11: Delineated wetlands in the X11B catchment are shown as darker blue areas connected with rivers

Desktop preparation for WET-Health and WET-EcoServices: Wetland delineations

Wetlands and their immediate catchments (the highest lying land immediately around the wetland) were delineated prior to the field assessment using desktop programs and satellite images, such as GIS tools (ESRI, ArcGIS 10.2), Google Earth (Google Earth Pro), and 1:10 000 orthophotographs and 1:50 000 topographic photographs. From such programs and maps, the following topographic indicators were identified: low lying areas situated in between elevated land, depressions or concave features of hill slopes, morphological and vegetation features (such as floodplains and changes in vegetation identifiable by the changes in colour and shape) (Kotze et al., 2009; Macfarlane et al., 2009). From these distinguishing features, the wetlands (and, in this study, specifically those with connected channels and, located at the bottom of valleys, their HGM units) and their "immediate catchment" boundaries were identified and selected.

Channelled valley-bottom units formed the focus of the study, in order to align with the Carolina 2012 incident (Tempelhoff et al., 2012). The wetland of concern in 2012 (the Boesmanspruit wetland) was a channelled valley-bottom wetland. Therefore, all wetlands selected from the identified wetlands were selected from a main channelled valley-bottom unit (Tempelhoff et al., 2012). These wetland delineations were cross referenced with the South African National Biodiversity Institute's (SANBI) National Freshwater Ecosystem Priority Areas (NFEPA) wetland delineations, as well as with delineations of the SANBI's Mpumalanga Highveld Wetlands project (Van Ginkel et al., 2011) before mapping them using ArcGIS tools (ESRI).

During the wetland identification and selection process, land cover, infrastructure and dams within the quaternary catchment (X11B) were also mapped, and erosional features and drains were noted (Ellery et al., 2009; Kotze et al., 2009; Macfarlane et al., 2009) (Figure 4-5). Maps were constructed using spatial data (shape files) curated by SANBI, the Department of Environmental Affairs (Environment GIS), the Mpumalanga Biodiversity Conservation Plan (2006) and the South African National Land Cover Dataset (2013/2014) (© GEOTERRAIMAGE-2014), as well as polygons constructed using Google Earth Pro (Figure 4-5; Figure 4-6).

Six channelled valley-bottoms and their connected HGM units were chosen in different contexts of land use activity (Table 5; Figure 12; Figure 13), of which:

- Two are situated in a combined mining and agricultural context.
- Two are situated in an agricultural context without mining (grazing; cropland).
- One is a historical mining decant site with some gazing.
- One is situated in a community/grazing context influenced by runoff and use by the adjacent town and community and indirectly by mining (sidings runoff) (Table 5).

The selected wetlands were identified according to the farm name that the majority of the wetland was located on i.e., Boesmanspruit, Witbank, Droogvelei, Jagtlust, Roodepoort, Witbank historical decant sites (Figure 13).

This categorisation is used in this chapter to describe sites as influenced by mining or agriculture.

Table 5: Context of each wetland chosen for the study in relation to land use activities (x- slight activity present, xx- intermediate activity present, xxx- strong activity present)

Wetland	In relation to mining	In relation to Commercial agriculture		In relation to Community Agriculture
		Crops (maize fields)	Grazing (Grassland)	
Jagtlust	x Threatened by an active mining quarry located at the top of the south west of the wetland's immediate catchment	xx	xx	
Boesmanspruit	xxx The main river channel on the X11B catchment is situated adjacent and in close proximity to a coal washing plant, coal railway sidings, and an abandoned site of exposed heaps of coal. The channel is also connected to other tributary wetlands that are contaminated from active and defunct mining activities upstream	xx	x	
Witbank historical decant	xxx A decant outlet form a defunct mine flows into the wetland's main channelled valley-bottom unit		X	
Witbank	xx Mining activity situated at the south west top of the wetland's immediate catchment is connected to the main channelled valley-bottom wetland. rehabilitated mining that occurred in the south of the catchment is showing signs decanting, entering the wetland	x	xx	
Roodepoort	no mining	x	xxx	
Droogvelei	Experiences runoff from the coal railway sidings adjacent to the wetland	x		xxx Grazing

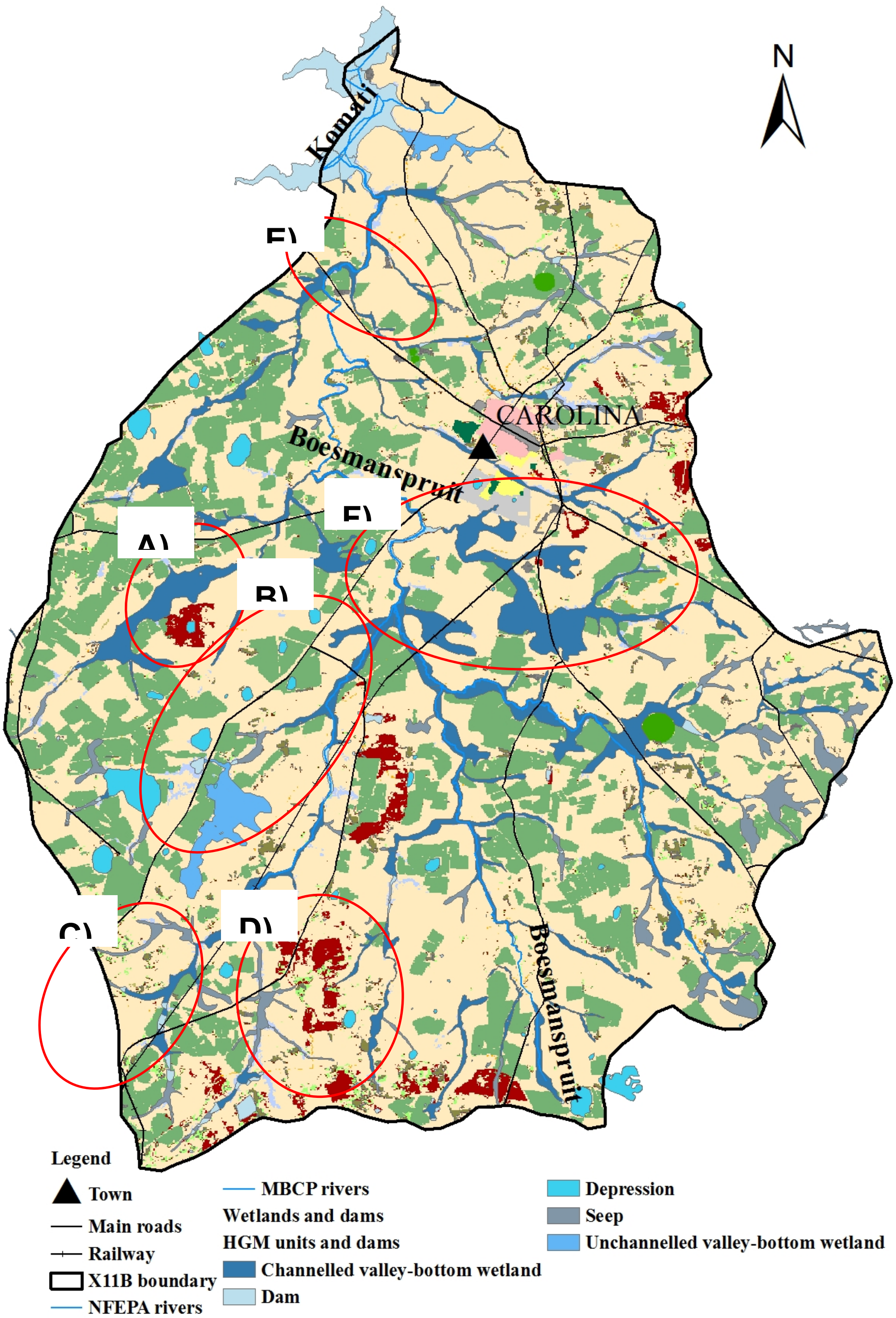

Figure 12: Selected wetlands and their associated HGM units. Wetlands are indicated by circles: A) Jagtlust, B) Boesmanspruit, C) Witbank historical decant, D) Witbank, E) Roodepoort, F) Droogvelei. These are shown at a finer scale in Figure 13

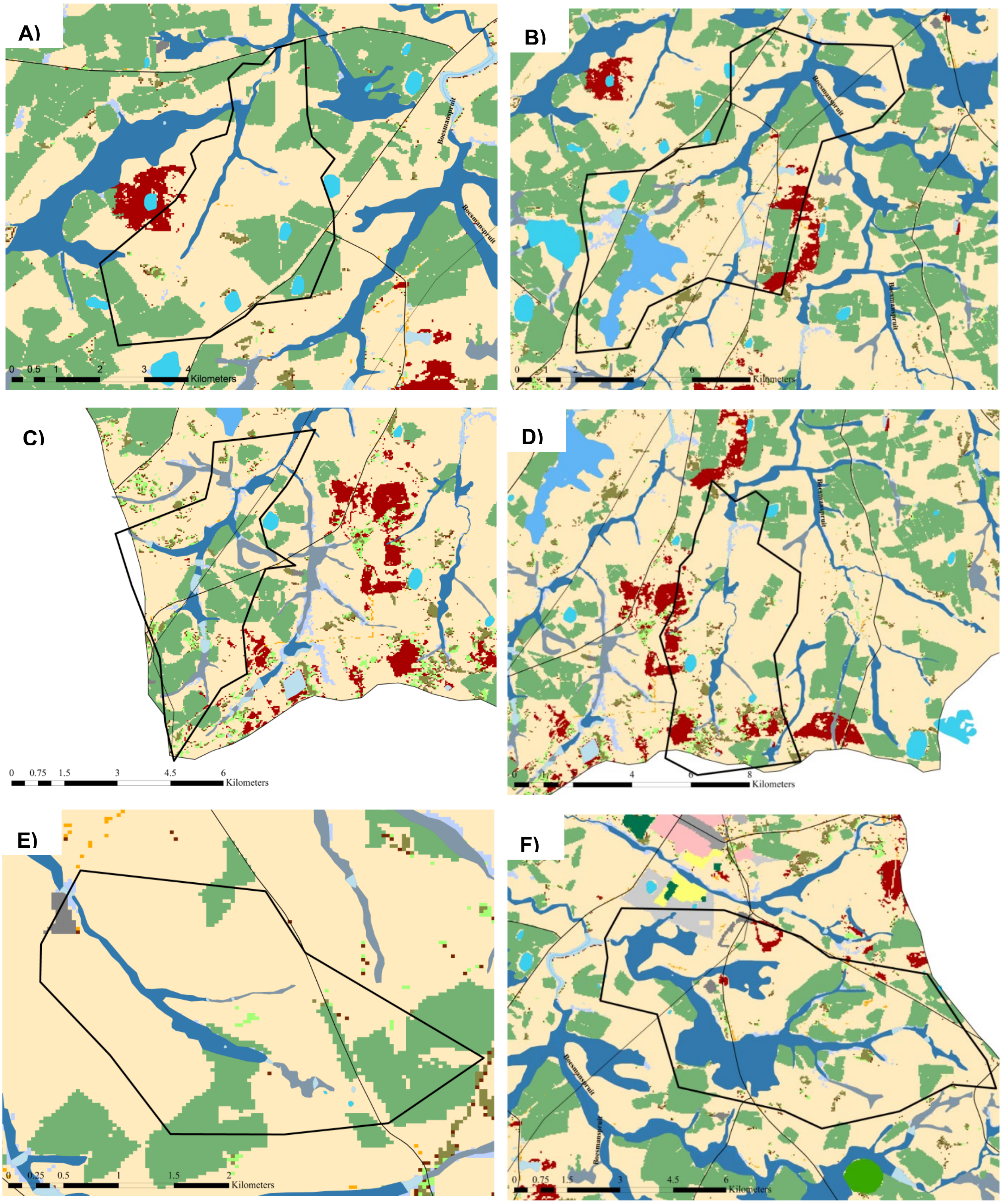

Figure 13: Studied wetlands showing the estimated immediate catchment boundary of the wetland itself A) Jagtlust, B) Boesmanspruit, C) Witbank historical decant, D) Witbank, E) Roodepoort, F) Droogvelei

Field assessments

Field assessments were carried out to validate the desktop delineations and apply the relevant WET-EcoServices and WET-Health methods to assess the current wetlands' integrity and the ecosystem services present at the selected sites (Kotze et al., 2009; Macfarlane et al., 2009). Water quality measurements (pH, dissolved oxygen, Electrical Conductivity) were taken at each site.

Wetland delineations

The HGM units were the units of assessment for the study. Delineations of the main channelled valley-bottom HGM unit of each wetland were confirmed by identifying specialised characteristics of soil morphology and vegetation types (hydrophytes) in the field (Collins, 2005; Van Ginkel et al., 2011; Ollis et al., 2013). Soil samples were collected using a soil auger at two depths: 0-10 cm and 40-50 cm (DWAF, 2005). This provided data in terms of soil mottling contrast and abundance (depends on oxygen presence in the soil). Soil mottles of rich colours (red, orange and yellow) are the result of the presence of metal precipitation and are created in areas of wetlands where flooding is more seasonal (Figure 4-9). The higher oxygen results in more mottles, therefore areas further away from the permanently saturated soils will have more mottles), and colour (Ollis et al., 2013).

The Munsell soil chart was used to assess the soil matrix hue and chroma, which indicated the magnitude of iron oxide reduction and therefore soil saturation (greyer soils indicating saturation over relatively long periods of time) (Collins, 2005; DWAF, 2005). Soils with greater saturation and less oxygen become more prevalent permanent zones of the wetland. Therefore, plant species will gradually change according to their adaptations to an anaerobic growing condition (hydrophytes), thus indicating the wetland boundary (DWAF, 2005). Random soil samples were collected at observed vegetation composition boundaries, to confirm wetland and ecological zones (i.e., permanent, seasonal and temporary zones, where the outer boundary of a wetland is defined by the outer margin of the temporary zone) (Collins, 2005). This method was repeated from an area outside the wetland, progressively moving into the wetland.

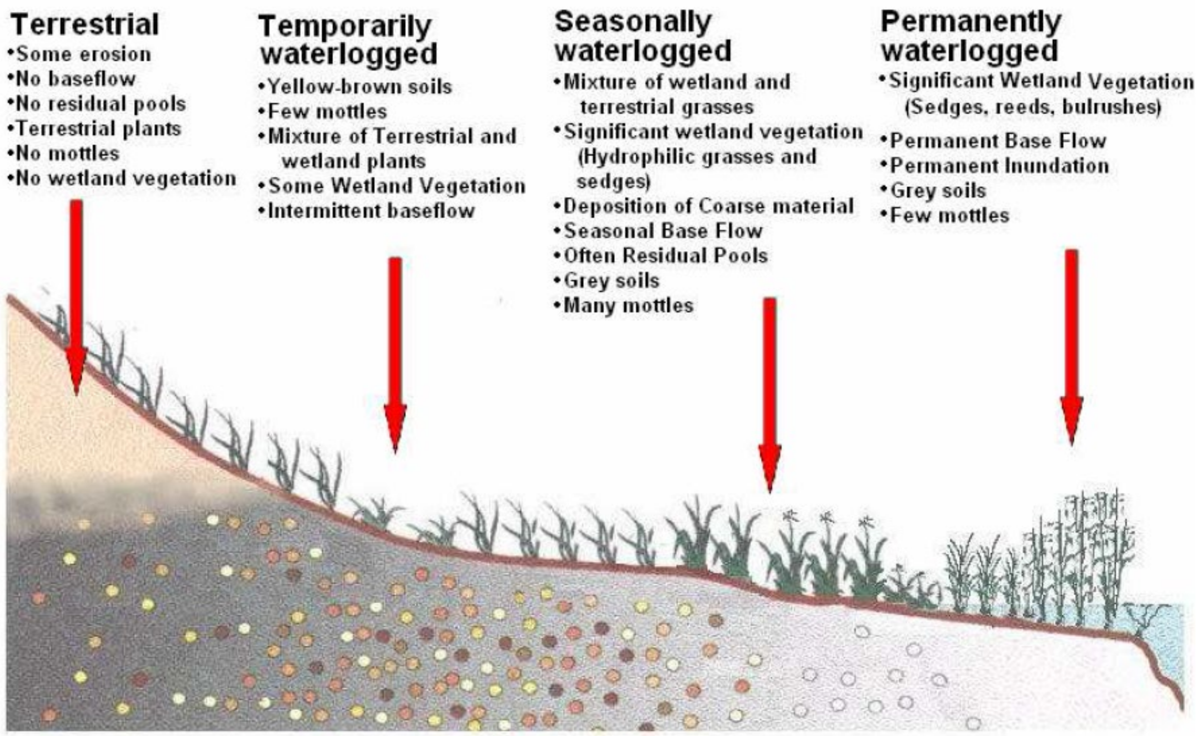

Figure 14: Schematic of a cross section through a valley-bottom wetland, indicating changes in the soil wetness and vegetation indicators, as one moves along a gradient of increasing wetness, from a terrestrial zone to the permanently-wet hydrological zone (from: Collins, 2005).

Ecosystem services assessment

Using WET-EcoServices, the assessment of individual ecosystem services was conducted using a scoring system based on a group of specialists' ratings of each service provided by the wetland HGM units (Kotze et al., 2009). The aquatic ecologist was Professor CG Palmer, Rhodes University, the grassland ecologist was Dr AR Palmer, Agricultural Research Council, assisted by three MSc and one PhD post-graduate students in water resource science from Rhodes University.

Possible service provision by each HGM was assessed using the check-sheets provided in the WET-Ecoservices manual. Scores were based on a score range of between zero (delivering an ecosystem service to a limited extent) and four (delivering an ecosystem service to the maximum extent) allocated by the specialists' judgment. Confidence scoring was undertaken in a similar manner, with a range between one and four, one being of low confidence and four being a high confidence score (Kotze et al., 2009). Individual scores from the field check-sheets were then entered into Microsoft Excel datasheets, provided with formulae as part of the WET-EcoServices electronic tool kit. The electronic tool kit formulated, calculated, and presented, overall scores of the services provided, based on the average service score allocated to each service. Some overall scores determined by the calculation of a combined average of effectiveness (of the wetland unit in supplying the service) and the opportunity (given to the wetland unit in supplying the ecosystem service) of services. The overall scores were then rated according to the likely extent of the benefit supplied (Table 6) and the scores were translated into radar diagrams for each HGM unit of each wetland.

For the purposes of this study the following services formed the basis of a level 2 assessment analysis (Kotze et al., 2009): flood attenuation, regulation of stream flow, sediment trapping, phosphate assimilation, nitrate assimilation, toxicant assimilation (include heavy metals and biocides), erosion control, carbon trapping, maintenance of biodiversity, water supply, provision of natural resources, provision of cultivated food, cultural significance, tourism and recreation, education and research.

Table 6: Categories for determining the likely extent to which a benefit is being supplied, based on the overall score for that benefit

Score	**<0.5**	**0.5-1.2**	**1.3-2.0**	**2.1-2.8**	**>2.8**
Rating the likely extent to which a benefit is being supplied	Low	Moderately low	Inter- Mediate	Moderately high	High

Wetland health assessment in current state

For each module (hydrology, geomorphology and vegetation), a table and guideline was provided as part of the WET-Health tool set, with each module having its own formatted Excel document. Local knowledge, from conversations with stakeholders and judgements made by the specialist team, were filled into the Excel documents accordingly; the extent (proportion affected by an activity), intensity (degree of alteration resulting from given activity) and the magnitude (product of extent and intensity) of the impact of each impact category were formulated (Macfarlane et al., 2009). The overall summary of modules scores, calculated in the Excel datasheets, determined the final Present State score (Note that these qualitative assessments do not require quantified measures of any wetland elements such as vegetation, water chemistry or aquatic macroinvertebrates (Table 4)).

Each module was scored on a scale from 0 (wetland un-impacted and close to the natural reference condition) to 10 (wetland critically transformed such that it has few or no wetland characteristics) and allocated a corresponding health category that corresponds to the Present Ecological State of the ecological Reserve (A-F: A representing 'unmodified' and F representing 'critically modified') (Macfarlane et al., 2009). These categories are related to categories determined in Ecological Reserve determinations. From these qualitatively estimated health category results, an average area-weighted score of each module was calculated for the whole wetland. Overall health was then calculated, using each of the whole wetland module's health scores, by adding and multiplying weighted factors according to the individual modules contribution to the health of the wetland (Macfarlane et al., 2009):

Thus: Health = ((Hydrology score) x3 + (Geomorphology score) x2 + (Vegetation score) x 2)) ÷ 7. These scores were then allocated corresponding health categories in the same manner as the previous individual scores.

'WET-Health' and 'WET-EcoServices' rely on specialist or expert knowledge, based on theoretical understanding, and do not include empirical procedures. Nor do they give an indication of the chemical impact of activities. Therefore, in order to get a more elaborate understanding of the wetlands, simple water quality measures were carried out (Macfarlane et al., 2009). In rivers, macroinvertebrate taxa have an assigned water quality sensitivity scale that is used in a biomonitoring, river health assessment method called 'SASS5' (Dickens & Graham, 2002). SASS5 has been criticised as an unreliable assessment method for wetlands (Bird & Day, 2010) but was used at this scoping level, with the justification that the wetlands selected are channelled and thus have flowing water. Macroinvertebrate community structure, as indicated by SASS5, was therefore added to the WET-Health and WET-EcoServices methods of wetland assessment.

Water quality sampling

Water pH (standard units), Dissolved Oxygen (DO; mg/l), Electrical Conductivity (EC; µS/cm), Total Dissolved Solids (TDS; mg/l), and temperature (°C) were measured at all sites using a Hanna multi-parameter meter (HI 9829).

Aquatic biota

At all wetland sites (Figure 4-7), a 1 m length of marginal vegetation was selected from the main channelled valley-bottom wetland HGM units, following the steps from the South African Scoring System (Version 5) (SASS5) method of macroinvertebrate collection (Dickens & Graham, 2002). Using a 1 mm^2 mesh on a 30x 30 -cm square-shaped frame with a sturdy handle, vegetation was pushed robustly, moving backwards and forwards around the same area (Dickens & Graham, 2002). The net was then emptied, by first washing samples down to the bottom of the net, carefully inverting and flushing (with water) the net out into a flat-bottomed tray (approximately 30 x 45 cm and 10 cm deep tray). Any specimens remaining in the net were removed with forceps and added to the tray. The sample was then fully immersed by the addition of clean water and debris was removed after checking for any attached macroinvertebrates. Using forceps, soft plastic wide-mouth pipettes, and a magnifying glass, biota were then examined and identified to family level, for 15 minutes, using a field identification book, and data was captured in SASS scoring sheets (Dickens & Graham, 2002). SASS5 results were compared among all sites, with the Roodepoort wetland being the least impacted reference site for the qualitative assessment.

Informal conversations

Informal conversations were conducted with various participants, including the owners of Jagtlust, Witbank, and Roodepoort farms. These local farmers, other local residents, and a coal washing plant manager were all interviewed. Each participant was asked questions, during which time he/she reflected on the following the past and present activities that had taken place in each wetland's immediate catchment; what impacts they were and are aware of; what dependencies they had on the wetland (including any ecosystem services and benefits they were aware of), and any other relevant local knowledge. The insights acquired were then used in the contextual introduction of each wetland. Several participants were asked about the Boesmanspruit wetland, a relatively big wetland, directly affected by the Carolina AMD crisis that spreads over a large area. It includes the Witbank historical decant wetland which, together with other parts of the larger wetland, is on land where the owner cannot be identified. The Droogvelei wetland forms part of a land claim initiative; therefore, in that case, the community elder spoke about that wetland.

4.3.4 Results: Wetland overview

Each of the selected wetlands had a different combination of use for agriculture and mining (Table 5). The sites were selected to differentiate the individual and combined impacts of agriculture and mining.

There are limitations to this qualitative assessment. Conversations were with only a small set of resource–users who were immediately available. The conversations were, therefore, used to provide a general narrative context. Wetland health and ecosystem services were assessed during a dry winter period, dictated by the time-frame of the study. Summer macroinvertebrate and water quality assessments are reported in Section 4.4.

Jagtlust wetland

The Jagtlust wetland (Figure 13A) is a channelled valley-bottom wetland that feeds the main Boesmanspruit tributary stream after the Boesmanspruit dam, leading into the Nooitgedacht reserve. Although there was no visible surface flow, a channel in the wetland was present and the ground was noticeably saturated. The wetland is located in a mainly agricultural setting with the lowest proximity to defunct mining sites, south of Carolina. There is still potential impact by new open-pit mining, currently taking place at the top of the West slope on the catchment. After desk-top scrutiny, this wetland was considered 'least impacted' by mining'. Mining operation regulations require the mines to address environmental liabilities, pollution and ecological practices through a risk assessment process (Department of Environmental Affairs, Department of Mineral Resources, Chamber of Mines, South African Mining and Biodiversity Forum, and SANBI, 2013). Therefore, the mining activity has, as yet, not shown significant impact on the wetland. If adequate closure precautions are not taken, the threat is likely to only emerge after closure.

The land owner's family has been part of the Carolina community for five generations; his family owns more than ten thousand hectares of farmland in the X11B catchment. The farm owner is aware of the high hydrological connectivity on his land, and uses the ecosystem service - provision of water - to his advantage. He is aware of a particular spring that is relatively full even in the dry season, both historically and currently. The spring feeds a channel that enters a dam downstream of the Jagtlust wetland site. The dam is used to pipe water to other areas on his farms, during times of drought and/or in the dry season. The owner is concerned about the contamination of water between his farms, due to hydrological connectivity, and he was also troubled by prospective mining plans that were said to be starting in 2016 in regions close to his land.

The wetland ecosystem services assessment (Figure 15) indicated high potential for biodiversity maintenance, nitrate removal and streamflow regulation; and moderately high toxicant removal potential. This was considered important as the wetland could be threatened by the catchment's mining activity after closure (expected in 2016/17). The effectiveness of the toxicant removal service was initially judged as being high. However, the active status of the mine lowered the likelihood scores, resulting in a moderately high potential toxicant removal score.

NOTE: All the ecosystem service scores are based on the method described in Section 4.3.3: "*Scores were based on a score range of between zero (delivering an ecosystem service to a limited extent) and four (delivering an ecosystem service to the maximum extent) allocated by the specialist's judgment. Confidence scoring was undertaken in a similar manner, with a range between one and four, one being of low confidence and four being a high confidence score"* (Kotze et al., 2009).

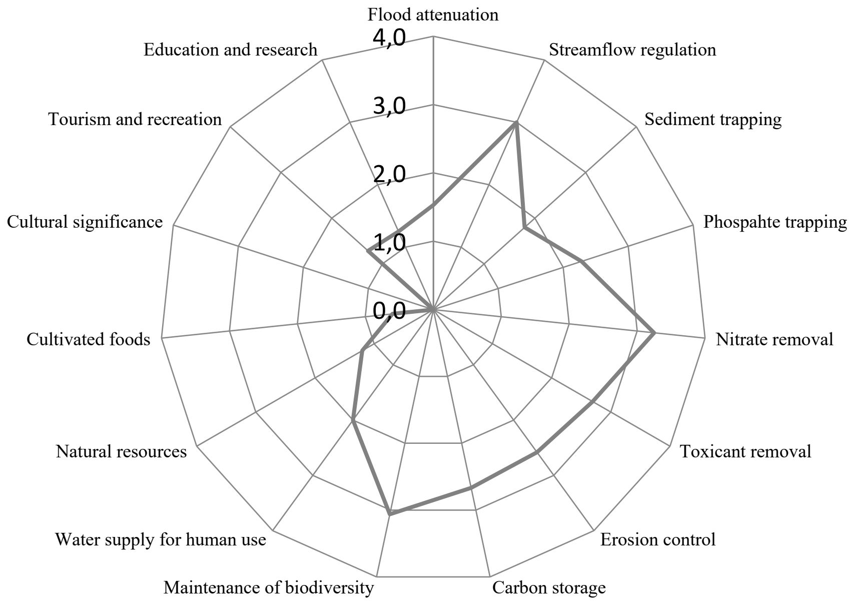

Figure 15: WET EcoServices scores for Jagtlust wetland, HGM unit one (channelled valley-bottom wetland)

Table 7: Present State category for each module and the overall Present State of Jagtlust wetland

Wetland	**Present State category**			
Jagtlust	Hydrology	Geomorphology	Vegetation	Overall Present State
	A	A	A	A

The Jagtlust wetland site had low EC and TDS (Table 14), indicating better wetland health, but pH was low (4.5), indicating the possible influence of AMD infiltration (Table 14). Therefore, there was a need to find a site, north of the town Carolina, that was unaffected by mining. Although the wetland had been categorised as "A", there is still a pending threat from the mining activity, which has resulted in concerns expressed by the farming land owner.

The SANBI National Freshwater Ecosystem Priority Areas (NFEPA) project has identified this wetland as a site of conservation importance (Nel et al., 2011) (reviewed at the NFEPA National Stakeholder Review Workshop, July 2010). This because a majority of the wetland's area is within a sub-quaternary catchment that has sightings or breeding areas for three bird species of conservation importance (Nel et al., 2011), including: Wattled Crane (critically endangered), Grey Crowned Crane (endangered) and Blue Crane (near threatened) (Chittendon, Davies & Weiersbye, 2016). Not only is the wetland significant for biodiversity, but the land owner recognised the wetland dependency on good water quality and high hydrological connectivity.

Boesmanspruit wetland

The Boesmanspruit wetland consists of a main channelled valley-bottom wetland (wetland HGM unit one) that flows throughout the year, and forks to form two arms upstream, towards the south end of the catchment. The East arm terminates at a relatively large earth dam and the West arm ends at a small earth dam, with a change in HGM unit type. The HGM unit (wetland unit two) is a hillslope seep that continues south, towards the top of the catchment where, after another dam, the wetland changes into another HGM unit (not included in this assessment) (Figure 12).

The Boesmanspruit wetland is situated in a small sub-catchment within the X11B catchment, referred to as the Witrandspruit. The relatively large wetland is situated in an agricultural setting with direct and indirect mining impacts. It is one of three catchment systems that feeds directly into the Boesmanspruit dam, supplying 31 % of the inflow to the dam (McCarthy & Humphries, 2013). The wetland is of significant importance in the catchment, as it is the main tributary of the catchment and flows into the Boesmanspruit dam. The major contaminants recorded in the 2012 incident were pollutants associated with AMD from the Boesmanspruit wetland and the connected Witrandspruit catchment. Current mining-associated sites in the Boesmanspruit wetland catchment include:

- Site 1: A railway coal siding, where the site is flattened and compacted and coal is left exposed to the elements before being loaded on trains (remnants of finer coal are left after the coal has been loaded).
- Site 2: The coal washing plant- where coal is piled and left exposed.
- Site 3: A historical coal mining site with small discarded coal heaps.

Sites 1 and 2 are situated in close proximity East of the main channel unit, towards the middle of the catchment, while Site 3 is located at the top of the West side of the wetland's immediate catchment, opposite the coal siding. The catchment is also connected further south of the primary X11B catchment, through a riparian channel that is influenced by upstream mining.

Contestation was identified among resource users of the Boesmanspruit site, between the coal washing plant manager (considered an environmentally conscious individual of the Carolina community) and another farm owner within the catchment. The manager's washing plant has in the past been accused of contributing to the high acidity and salinity of an adjacent pan/depression and the Boesmanspruit wetland, via acid mine decant and coal contaminated runoff. The manager made it clear that all the appropriate rules and regulations have been followed, and EIA studies have been carried out and accepted. Hence, he does not take any responsibility for the contamination of either wetland. The farm land owner feels strongly about the accusation, as he claims to have seen the impacts of dead vegetation where runoff from the coal washing plant channels into the Boesmanspruit wetland.

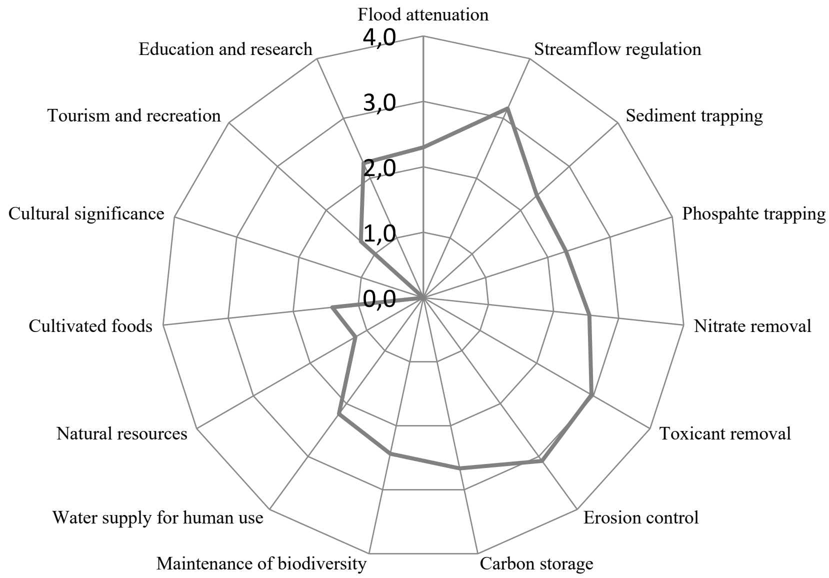

Figure 16: Boesmanspruit wetland HGM Unit 1 (channelled valley-bottom wetland) ecosystem services overall scores

Specialists assessed good ecosystem service provision by Boesmanspruit HGM unit, including: streamflow regulation, toxicant removal and erosion control (Figure 16). This is the first evidence presented of wetland recovery following the 2012 AMD event.

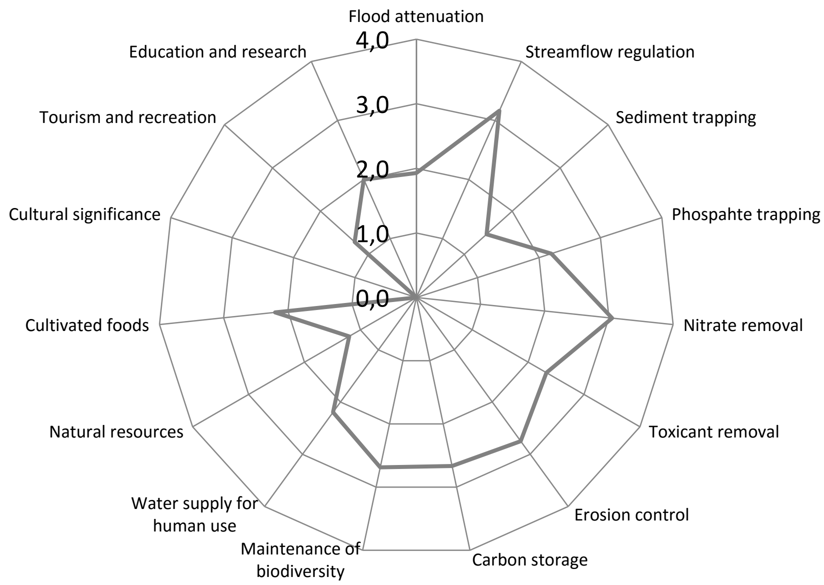

Figure 17: Boesmanspruit wetland HGM Unit 2 (hillslope seep linked to a stream channel) ecosystem services overall scores

Boesmanspruit wetland WET-Health assessment

Most impacts in the Boesmanspruit, perceived as being associated with wetland integrity, were impeding features/infilling and recent deposition (and slight gully impact) in the wetland. These affected vegetation and flow. Scores indicated that the overall influence of the immediate catchment's activities has had a negative overall impact on the wetland's health, hence receiving a "C" category, for Present State (Table 8). Water quality was also poor, with a low pH (3.86) and high EC (423 µS/cm) (Table 14). The wetland health, estimated as being poorer than the ecosystem service provision, (which indicated wetland resilience) illustrating that wetland offer ecosystem services, even at lower levels of wetland health.

Table 8: Present State category for each module and the overall Present State of Boesmanspruit wetland

Wetland	Present State category			
Boesmanspruit	Hydrology	Geomorphology	Vegetation	Overall Present State
	C	C	B	C

Witbank decant wetland

The Witbank historical decant wetland is connected to the Boesmanspruit wetland. This main channel includes a tributary fed by a hillslope seep (wetland unit two) (Figure 12). The main channelled valley-bottom wetland (unit one), in the dry season, was highly saturated with large pools of water and some flow. The wetland was historically influenced by mining activities in, and adjacent to, the channelled valley-bottom wetland (unit one). Currently, an upstream site is non-operational, has been closed, and the land has been rehabilitated. Acid mine drainage is, however, evident: decanting into the wetland as a result of the past mining activity. The decant tributary is being treated for acidity. The third unit of the wetland may also experience decant from the now-largely-rehabilitated open pit colliery, situated at high elevations upstream (Figure 12).

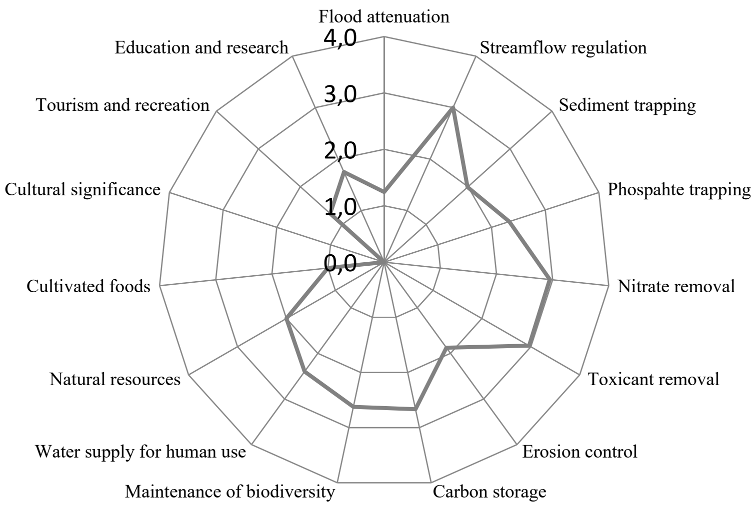

Figure 18: Witbank historical decant wetland HGM Unit 1 (channelled valley-bottom wetland) ecosystem services overall scores

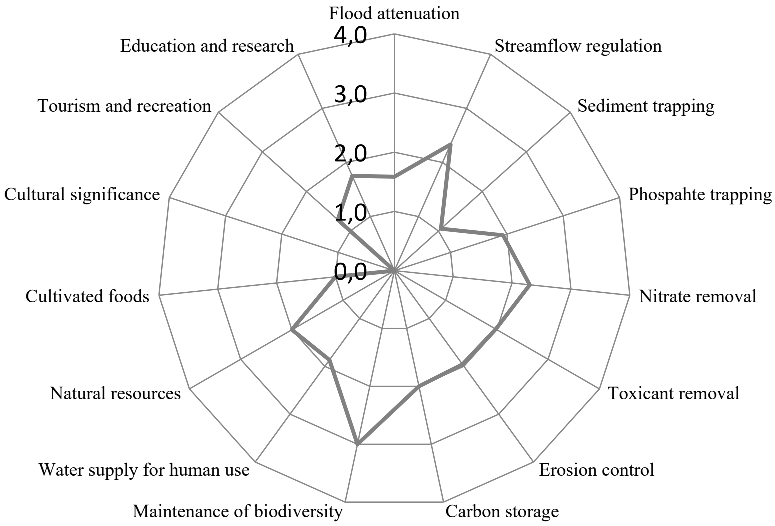

Figure 19: Witbank historical decant wetland HGM Unit 2 (hillslope seep linked to a stream channel) ecosystem services overall scores

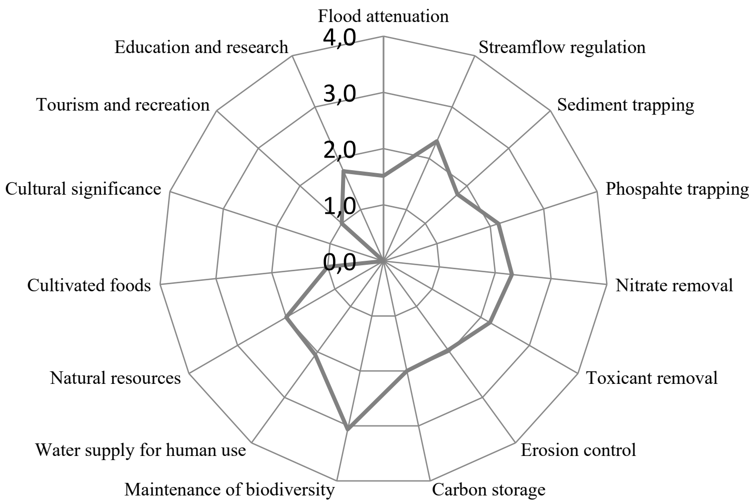

Figure 20: Witbank historical decant wetland HGM unit three (hillslope seep linked to a stream channel) ecosystem services overall scores.

The overall integrity of the *Witbank decant wetland* was categorised as an “A”, indicating a near-to-natural wetland (Table 4-6). However, the water quality revealed a low pH (3.24) and high EC (457.8 µS/cm) and TDS (Table 4-12), indicating an unhealthy aquatic system. Little information is available on this wetland’s immediate catchment; however, implications of this poor water condition include possible impacts on sightings or breeding areas of threatened crane species (Nel et al., 2011). These contradictory lines of evidence indicate the need for deeper study (Section 4.4).

Table 9: Present State category for each module and the overall Present State of Witbank historical decant wetland

Wetland	Present State category			
Witbank historical decant	Hydrology	Geomorphology	Vegetation	Overall Present State
	A	B	B	A

Witbank wetland

The Witbank wetland is made up of a main channelled valley-bottom wetland (unit one). Towards the north of this main valley-bottom wetland there is a valley-bottom wetland tributary that feeds into the channel. The tributary flows from a mining site, located West of the immediate catchment, and forms a fork in the main channelled valley-bottom wetland. The forked tributary is considered a separate valley-bottom wetland (unit six). The Witbank wetland covers an extensive portion of the total wetland area within the Boesmanspruit sub-catchment of X11B (McCarthy & Humphries, 2013). This sub-catchment is also one of the three sub-catchments that feed into the Boesmanspruit dam, supplying 60 % of the dam's inflow (McCarthy & Humphries, 2013). The Witbank wetland is situated at the southern-most point and only occupies a relatively small portion of the whole sub-catchment. The Witbank wetland is connected to the dam via the Boesmanspruit River and other connected wetlands (McCarthy & Humphries, 2013).

The main channel of the Witbank wetland flows from the south of the catchment and is fed by three hillslope seeps (wetland HGM units two, four, and five) (Figure 11; Figure 12). Wetland unit two is connected to a depression (wetland unit three). In the winter, the main channel had only small pools of water, mainly in the upper catchment, whereas downstream of the wetland the soil remained saturated, but with no pools or flow. The northern tributary wetland unit originates from a defunct mining site, increasing the chances of AMD and runoff contamination. Historically, a relatively high mining activity took place upstream of the catchment, posing possible impacts on the three seeps that feed the main channel wetland (Figure 12C). Presently, these mines are largely rehabilitated, although there are reports of concern relating to the sites' groundwater and mine decant (Golder Associates, 2014).

Witbank wetland WET-EcoServices assessment

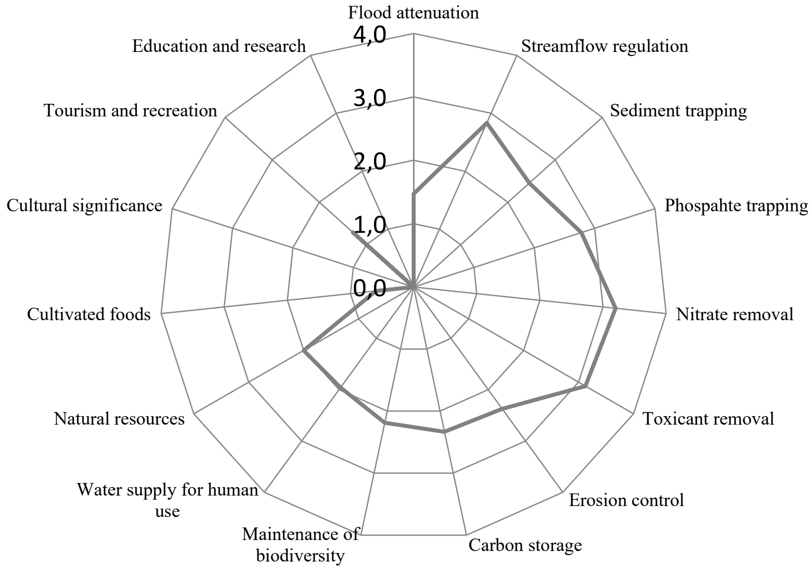

Figure 21: Witbank wetland HGM Unit 1 (channelled valley-bottom wetland) ecosystem services overall scores

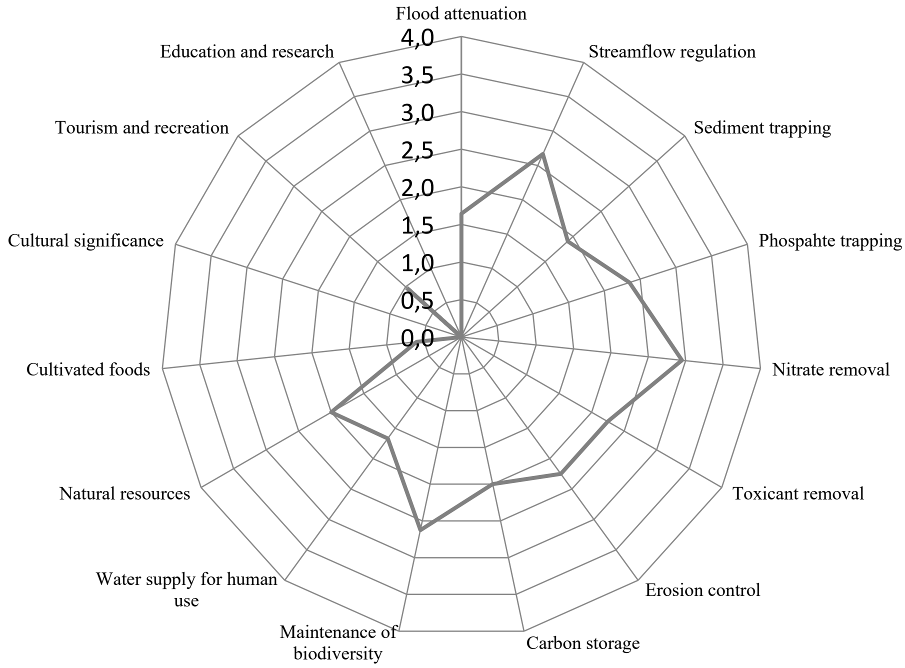

Figure 22: Witbank wetland HGM Unit 2 (hillslope seep linked to a stream channel) and three (depression) ecosystem services overall scores

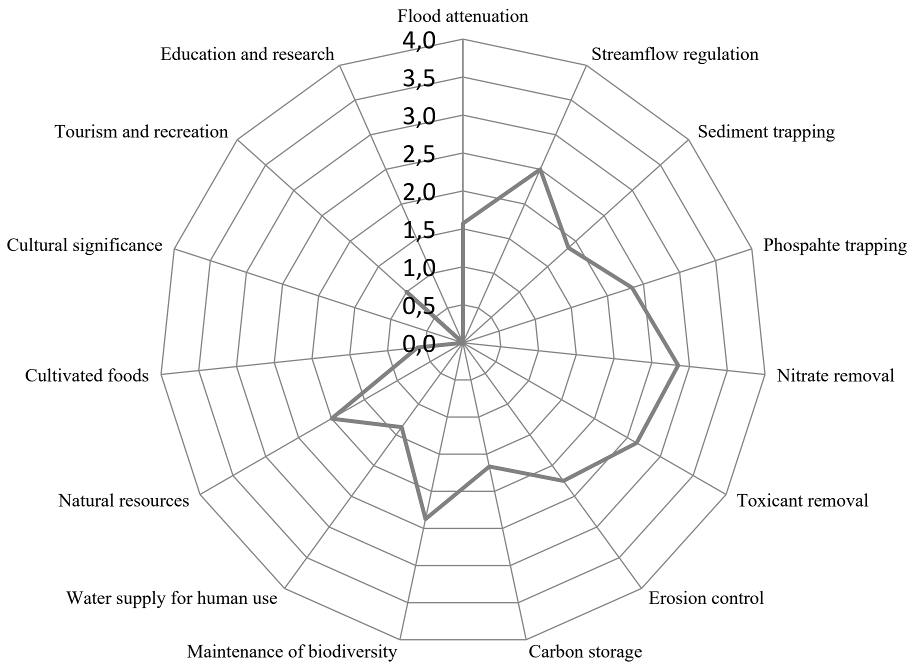

Figure 23: Witbank wetland HGM Unit 4 (hillslope seep linked to a stream channel) ecosystem services overall scores

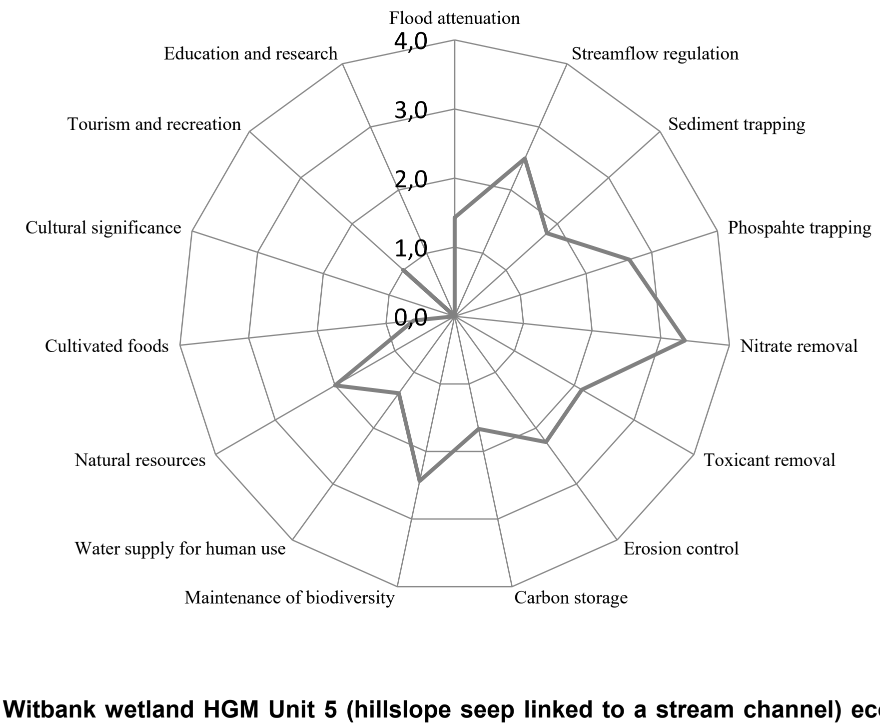

Figure 24: Witbank wetland HGM Unit 5 (hillslope seep linked to a stream channel) ecosystem services overall scores

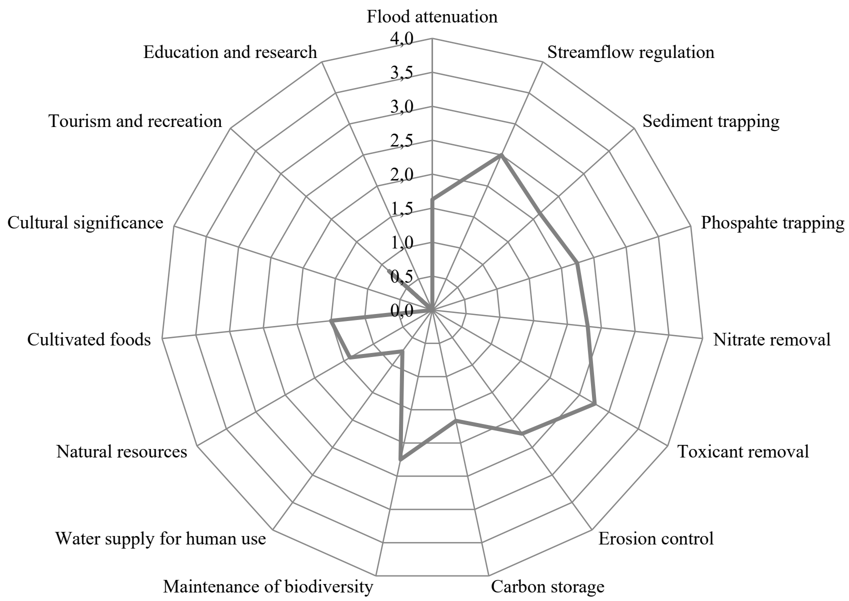

Figure 25: Witbank wetland HGM Unit 6 (channelled valley-bottom wetland) ecosystem services overall scores

The wetland's overall integrity/health impact score was categorised by specialists as an "A", indicating a near-to-natural wetland (Table 10). The water sample results indicated a relatively good quality of water. The water was, however, sampled in the middle of the main channel and, therefore, did not include possible peripheral impact by current mining occurring north of the catchment. The wetland is not identified as a NFEPA wetland, so there are few implications for conservation. The land is used for sheep grazing, and boreholes that supply water to surrounding households are located in the catchment. Again, a present state of "A" is uncertain due to indications of water quality impact(s). These results were the motivation for the quantitative investigation.

Table 10: Present-State category for each module and the overall Present State of Witbank wetland

Wetland	**Present State category**			
Witbank	Hydrology	Geomorphology	Vegetation	Overall Present State
	B	A	A	A

Roodepoort wetland

The Roodepoort wetland is comprised of a main channelled valley-bottom wetland (wetland HGM unit one) that flows throughout the year. The middle section of this main channel veers to the East into a small dam, fed by a hillslope seep (wetland HGM unit two). The main channel flows from the southern end of the catchment and is fed by another hillslope seep (wetland HGM unit three) (Figure 13). The immediate wetland catchment is situated in an agricultural setting with no visible influence by mining.

A meeting with the Roodepoort land owner indicated that she has been an active member of the Carolina community for more than 20 years. She is a passionate crop, sheep, cattle and horse farmer and owns thousands of hectares of farm land in the X11B catchment. Her farms are located north of Carolina, in an area that is less impacted by mining. She is aware of the array of natural freshwater ecological infrastructure features on the farms and practices sustainable irrigation and farming techniques. Nevertheless, she acknowledges that her cattle do cross through the wetlands located in the farm landscape, causing trampling and erosion. She has noticed that winter-season grazing of the wetland is more intense, as the cattle seek and select palatable grasses. About ten years ago she built a road crossing in the middle region of the wetland. She has strategically built dams, to supply three houses located on her land. Two of these are currently vacant so no water is being used from the dam. One house does, at present, use the water, but only in small amounts.

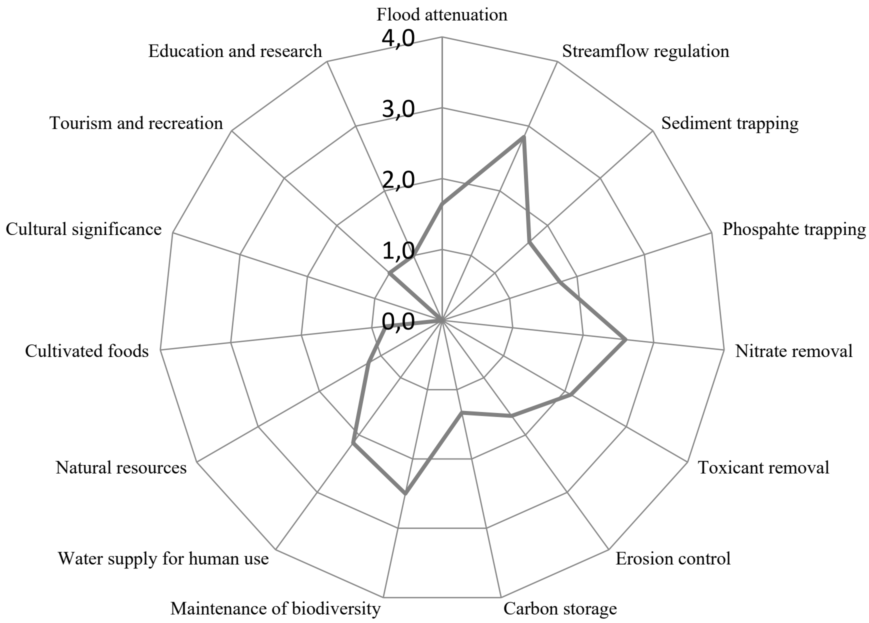

Figure 26: Roodepoort wetland HGM Unit 1 (channelled valley-bottom wetland) ecosystem services overall scores

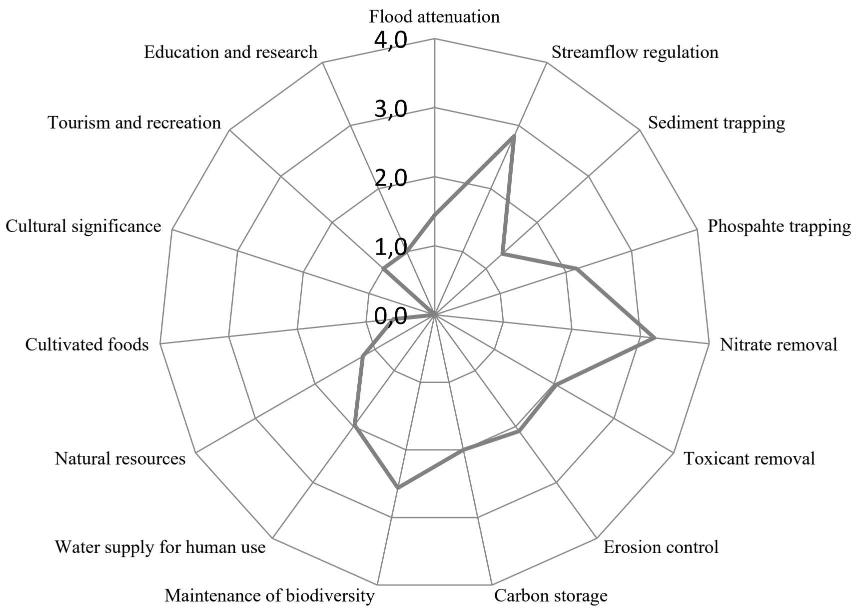

Figure 27: Roodepoort wetland HGM Unit 2 (hillslope seep linked to a stream channel) ecosystem services overall scores

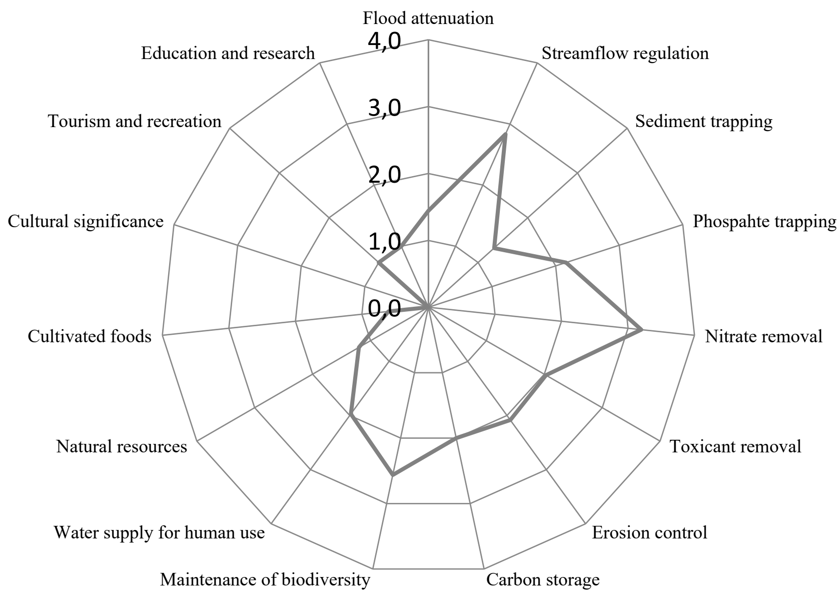

Figure 28: Roodepoort wetland HGM Unit 3 (hillslope seep linked to a stream channel) ecosystem services overall scores.

Wetland Unit 1 evidenced heavy grazing on the banks of the wetland, thus reducing vegetation cover, increasing erosion and destabilising the sides of the channel. Investigation suggested that the impacts have changed the features of the wetland, resulting in reduced ecosystem services being provided by the main-channel wetland.

Cattle-trampling and erosion effects were judged as not being great enough to reflect modification in the wetland (Table 11). The overall integrity/ health of the wetland was an “A” and the water quality appeared to be in good condition. The site is not recognised as a NFEPA, but the land owner depends on the land for an agricultural livelihood.

Table 11: Present State category for each module and the overall Present State of Roodepoort wetland

Wetland	Present State category			
Roodepoort	Hydrology	Geomorphology	Vegetation	Overall Present State
	A	A	B	A

Droogvelei wetland

The Droogvelei wetland comprises a relatively large main-chann4lled valley-bottom (unit one) and seep connected to the north east (unit two) (Figure 9; Figure 13F). The wetland's immediate catchment is the Droogeveleispruit sub-catchment (one of three) of the X11B catchment, feeding directly into the Boesmanspruit dam, supplying 3.9 % of the inflow (McCarthy and Humphries, 2013). The catchment is situated adjacent to the Silobela Township and a portion of the wetland catchment (including all the wetland units) is part of a 2010 land claim. East of the catchment (upstream), a large portion comprises agricultural crop farming, plantations and cattle grazing. The north-western part of the wetland, where the township is located, is also the site of the confluence with the Boesmanspruit dam. The middle of the catchment (north to south) is largely agricultural commonage, with some runoff-influence from the Droogvelei siding, located in the north. During this dry-season investigation, the soil of the wetland was saturated soil, with only scattered pools of water in the channel and there was evidence of flooding at some impeding features.

It was apparent, through conversation, that township residents do not use the wetland, except for grazing purposes. Community members were not aware of the importance and possible benefits of wetland services that could be sustained if the wetland were to be protected. The apparent lack of value attached to the wetland was evident from talking with a community representative who is a commonage-user, sharing a farm plot with seven households. In the commonage, members grow small patches of subsistence crops and obtain water from a borehole pump. They have cattle that graze in and around the Droogvelei wetland Unit 1, located close to their homes. This grazing apparently represents the only (acknowledged) human-use of the wetland. It may be that, with the movement of people and in the context of white-owned farms as well as land claims, cultural knowledge of wetlands and their use has been lost.

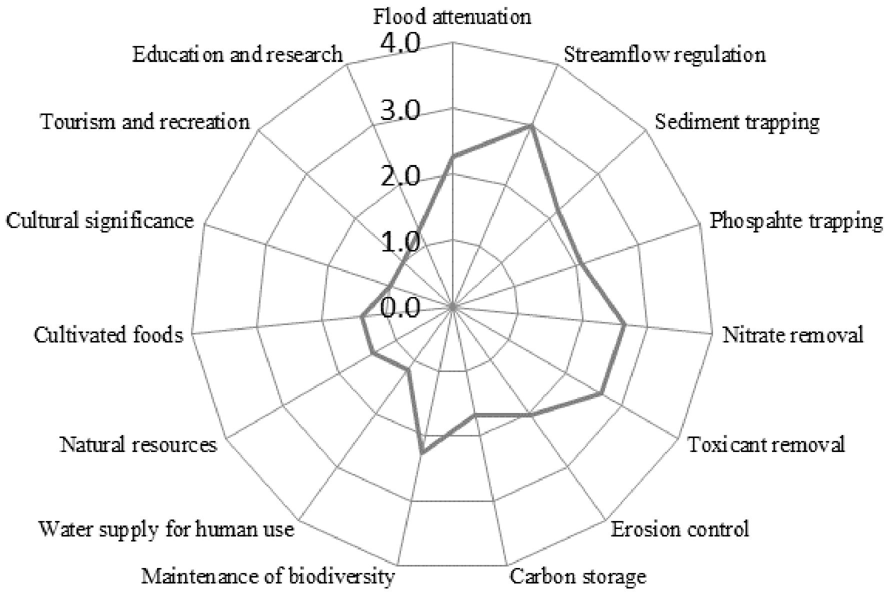

Figure 29: Droogvelei wetland HGM Unit 1 (channelled valley-bottom wetland) ecosystem services overall scores

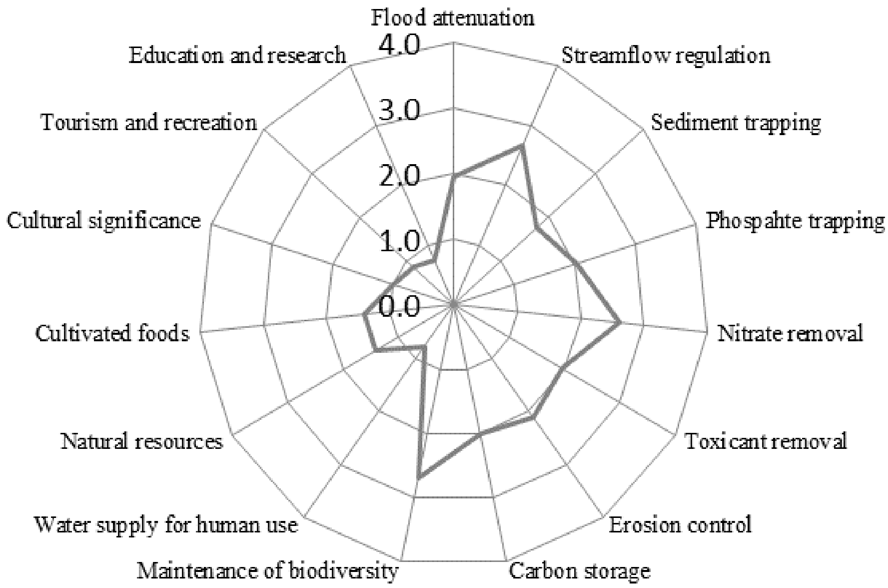

Figure 30: Droogvelei wetland HGM Unit 2 (hillslope seep linked to a stream channel) ecosystem services overall scores

The wetland ecosystem was assessed as providing a range of services, none of which were particularly high (Figure 45; Figure 46) possibly indicating that, with heavy use in the immediate wetland catchment, there is a lower provision of services from the Droogvelei Wetland).

The health of the wetland had an overall score of 'B' (Table 12), indicating that the wetland is largely natural with few modifications. Water samples (from the middle of the wetland, where the surrounding activity is largely cattle grazing) indicated relatively good water quality. Implications of these results not only cause concern for the people who depend on it, but also for NFEPAs located within this wetland area (SANBI, 2013). It is increasingly evident that the WET-Health assessment is not sensitive to water quality conditions.

The Witrandspruit sub-catchment indirectly feeds into the Boesmanspruit wetland, via a stream.

Table 12: Present State category for each module and the overall Present State of Droogvelei wetland

Wetland	**Present State category**			
Droogvelei	Hydrology	Geomorphology	Vegetation	Overall Present State
	C	B	A	B

Aquatic biota

Table 133: 2015 SASS5 and ASPT scores for each sampled wetland of the X11B catchment

Site	**Boesmanspruit**	**Jagtlust**	**Roodepoort**	**Droogvelei**	**Witbank historical decant**	**Witbank**
SASS	18	41	91	45	26	50
No. Taxa	5	9	14	11	6	10
ASPT	3.6	4.56	6.5	4.09	4.33	5

Water physico-chemistry

Table 144: Physico-chemical water quality results at each wetland

Dry season					
Site	**pH**	**DO (%)**	**EC (µS/cm)**	**TDS (ppm)**	**Temp (°C)**
Boesmanspruit	3.86	57.4	423	212	16.2
Jagtlust	4.55	77.9	25	12	21.7
Roodepoort	6.53	58.4	58.2	42.6	18.2
Droogvelei	5.15	43.3	251	124	15
Witbank historical decant	3.24	41.8	457.8	289	16.1
Witbank	5.01	59.4	186	93	15.7

Table 15: Summary of results

Wetlands and HGM units	HGM type	Area (ha)	Overall health score	Activity impact score			NFEPA	Ecosystem service scores														
				Mining	Grazing	Crop		Flood attenuation	Streamflow regulation	Sediment trapping	Phosphate trapping	Nitrate removal	Toxicant removal	Erosion control	Carbon storage	Biodiversity maintenance	Water supply	Provision of natural resources	Provision of cultivated foods	Cultural significance	Tourism and recreation	Education and research
Jag lust	CVB	47	A	1	2	1	Yes	1.5	3.0	18	2.3	32	2.6	2.6	2.7	3.1	2.0	1.2	0.6	0.0	1.3	1.3
Witbank unit one	CVB	94.08	A	2	2	1	No	1.5	2.8	25	2.8	32	3.1	2.4	2.3	2.2	2.0	2.0	0.6	0.0	1.3	0.0
Unit 2 and unit 3	HS and D	14		0	2	1		1.6	2.7	19	2.4	30	2.2	2.3	2.0	2.6	1.8	2.0	0.6	0.0	1.0	0.0
Unit 4	HS	4.84		1	1	1		1.6	2.5	19	2.3	29	2.6	2.3	1.7	2.4	1.6	2.0	0.6	0.0	1.0	0.0
Unit 5	HS	2.76		1	1	1		1.4	2.5	18	2.7	34	2.1	2.3	1.7	2.4	1.6	1.4	0.6	0.0	1.0	0.0
Unit 6	HS	11.4		0	3	1		1.6	2.5	21	2.2	23	2.8	2.3	2.0	2.3	0.8	1.4	1.5	0.0	0.9	0.0
Roodepoort Unit 1	CVB	21.54	A	3	0	0	No	1.6	2.8	22	1.9	2.6	2.2	1.7	1.3	2.5	1.8	1.2	0.8	0.0	1.0	1.0
Unit 2	HS	1.6		0	2	0		1.4	2.8	13	2.2	32	2.0	2.1	2.0	2.6	1.6	1.2	0.6	0.0	1.0	1.0
Unit 3	HS	4.71		0	2	0		1.4	2.8	13	2.2	32	2.0	2.1	2.0	2.6	1.6	1.2	0.6	0.0	1.0	1.0
decant unit 1	CVB	153	A	3	1	1	Yes	1.2	3.0	1.6	2.3	30	2.9	1.8	2.7	2.4	2.4	2.0	0.8	0.0	1.3	1.8
Unit 2	HS	35		0	1	1		1.6	2.3	1.1	1.9	23	2.0	1.8	1.7	3.0	1.9	2.0	0.8	0.0	1.3	1.8
Unit 3	HS	30		0	1	1		1.5	2.3	18	2.2	23	2.2	2.0	2.0	3.1	1.9	2.0	0.8	0.0	1.0	1.8
Droogvallei unit 1	CVB	788.67	B	1	3	2	Yes	2.3	3.0	22	2.1	27	2.6	2.0	1.7	2.3	1.2	1.4	1.4	1.0	1.0	1.3
Unit 2	HS	19.15		0	2	2		2.0	2.7	18	2.0	2.6	2.0	2.1	2.0	2.7	0.8	1.4	1.4	1.0	0.9	0.8
Boesmanspruit unit 1	CVB	206.84	C	3	1	1	Yes	2.2	3.2	23	2.3	2.6	3.0	3.0	2.7	2.4	2.2	1.2	1.4	0.0	1.3	2.3
Unit 2	HS	38.92		0	1	2		1.9	3.2	1.6	2.4	31	2.5	2.8	2.7	2.7	2.2	1.2	1.4	0.0	1.4	2.0

High

Moderately high

Intermediate

Moderately low

Low

4.4 Extending the bio-assessment

4.4.1 Introduction

The water chemistry of wetlands is naturally influenced by hydrogeomorphic (HGM) settings, surrounding land uses, and geology, among others (Ollis et al., 2013). Typical measured water chemical variables include the following: nutrients, trace elements, heavy metals, ions and system variables (Dallas & Day, 2004). Runoff from catchments and mining decant have a complex effect on the chemical composition of dissolved substances entering a wetland, which affect vegetation, microbes and sediments (Pinetown et al., 2007).

Different land uses can have distinct chemistry associations, making it possible to identify sources of pollution. For example, coal mining is strongly associated with heavy metals and ions from the elements found in coal (organic: C, H, inorganic: Al, Fe, Ca, Na, Mg, K, S, and trace elements: Be, Cd, Co, Pb, Cr, Hg, Mn, Ni, Sb, As, Se) and the chemical reactions that occur during the oxidation of pyrite, found in both functioning and defunct mines (Harding, 2005; Pond et al., 2008). Coal mining decant is also high in sulphates (SO42-) and generally has a low pH. On the other hand, intensive dryland agriculture is generally associated with higher levels of nitrates (NO31-), nitrites (NO22-), and phosphates (PO43-) due to the land-application of fertilisers, pesticides and animal manure (Bizzi et al., 2013). Wetland ecosystems are naturally adapted to the fluctuating concentrations of chemicals in the water column. This plays a vital role in the adsorption of ions on sediment particles, trapping of sediment, and (therefore) filtration of inflowing water for downstream users. Healthy wetlands can adapt to natural disturbances and remain in a healthy condition. Nevertheless, sustained human impacts often cause stressors that exceed the resilience of the wetland.

Pollutants contained in coal mining effluent are characterised by stressors that can exceed wetland adsorption capacity and have detrimental impacts on the biodiversity and functioning of the system. Biodiversity is threatened when coal mining-associated acidity leaches metals from sediments, and soluble toxicants become bio-available and toxic to organisms. Trace elements are naturally found in the tissue of living organisms: nutrients are essential for plant growth, and ions mediate metabolism functions (Na, K, Mg, Fe, Co, Zn, Mo). Nevertheless, concentrations of any variable that is above the tolerance limits of most aquatic organisms, result in toxic effects (Harding, 2005). Furthermore, the integration and bioaccumulation of contaminants in food webs poses a threat at different trophic levels within the wetland (Harding, 2005).

The DWS acknowledges water quality threats to complex social-ecological systems, and has thus derived water quality guidelines (Department of Water Affairs and Forestry,1996, 2004) to protect aquatic ecosystems. At a later stage resource protection was related to resource classification and toxicity-derived resource quality objectives (DWS, 2016).

In addition to chemical variables, the effects of pollution can be indicated by the presence, absence, and/or abundance of aquatic macroinvertebrates (Dickens & Graham, 2002). Biodiversity plays an important role in the functioning of wetland systems and in maintaining their resilience (Dugan, P.J., 1990; Hansson et al., 2005). Many wetland plants and animals are local endemics, as well as being valued by communities dependent on ecosystem services (Dugan, 1990). Biomonitoring is therefore used as a measure of ecological health, with the most useful aquatic biota being aquatic invertebrates (Palmer et al., 2004; Bizzi et al., 2013).

Index-based biomonitoring protocols like SASS5, developed for aquatic systems with higher flow, may however not be appropriate for wetlands, because the index scores were not developed for wetland taxa (Dickens & Graham, 2002). For this reason, in the quantitative study, macroinvertebrate samples collected using the SASS5 method were only used as a list of aquatic taxa. Macroinvertebrates were collected, counted and identified to family level, and subjected to multivariate analysis (Section 4.4.2), that related biotic presence and abundance to the measured water quality variable concentrations.

4.4.2 Methods

Sample collections were planned for mid-March 2016 so as to sample soon after the region's reported wet season. This would have allowed macroinvertebrates to re-establish in the wetland sites during the summer rainy season and would have facilitated a more accurate assessment (Dickens & Graham, 2002). The region was, however, experiencing the impacts of a nation-wide drought; rains were delayed and occurred during the sampling period. In addition, a seventh wetland site, Nooitgedacht, was added, north of Carolina, which was not subjected to any mining influence(s). This site was added because the Jagtlust site, used as a reference in the qualitative study, might possibly have been affected by mining. The desktop delineation method is described in Section 4.3.3., and was used for Nooitgedacht.

The qualitative assessments — WET-EcoServices and WET-Health (Macfarlane et al., 2009; Kotze et al., 2009) — were applied again so as to obtain seasonally-comparative data.

Aquatic biota

The South African Scoring System (version 5) (SASS5) was used to collect macroinvertebrate data (Dickens & Graham, 2002). After SASS data was recorded, samples were emptied into 350 ml jars containing 70 % ethanol for preservation. Labels recording the site, the replicate number and date of collection, were added. Three replicate samples were collected at each site and samples were transported back to the laboratory for identification to the family (taxonomic) level. The presence and abundance of all taxa were identified to family level using SASS identification guides (Department of Water Affairs and Forestry, 2002). SASS5 results were compared among all sites with the Nooitgedacht wetland being the chosen reference site for the study.

Water chemistry

Water samples were collected once using standard South African sampling protocols at the same time as biota sampling (Dickens & Graham, 2002; DWAF, 2005). Water sample sites were selected based on their location relative to the location of the seven main wetlands (Figure 12), with water chemistry sampling sites located upstream ('u') and downstream ('d') at each the wetlands. At Site 2, one of the upstream tributaries was labelled "ru" (railway bridge). At Site 7, tributaries were labelled "ma" (mining at site) and "aa" (agricultural at site).

Twenty-four sites were sampled in total (Figure 13). Water samples were collected in acid-washed 500 ml HDPE plastic bottles, for later laboratory analysis. Water samples were kept cool, the frozen and delivered to the Agricultural Research Council-Institute for Soil Climate and Water (ARC.LNR) certified laboratory for analysis of the following:

- **Major ions:**
  - Anions (mg/l): Fluoride, nitrite, nitrate, chloride, sulphate, phosphate, carbonate, bicarbonate, sodium carbonate and sodium bicarbonate.
  - Cations (mg/l): Sodium, potassium, calcium, magnesium and boron
- **Trace elements:** Lithium (Li), beryllium (Be), titanium (Ti), vanadium (V), chromium (Cr), manganese (Mn), cobalt (Co), nickle (Ni), copper (Cu), zinc (Zn), arsenic (As), selenium (Se), rubidium (Rb), strontium (Sr), molybdenum (Mo), cadmium (Cd), tin (Sn), antimony (Sb), tellurium (Te), cesium (Cs), barium (Ba), lanthanum (La), tungsten (W), platinum (Pt), mercury (Hg), lead (Pb), bismuth (Bi) and uranium (U)

- **System variables:** pH, electrical conductivity (mS/m), TDS, alkalinity, hardness, perm hardness and temperature (°C).

Trace elements, major ions, and system variables were compared with the Komati River System's Resource Quality Objectives (RQOs) for water resources and Water Quality Guidelines freshwater ecosystems (Department of Water Affairs and Forestry, 1996; Department of Water and Sanitation, 2016). Toxic constituents and system variables that exceeded the RQOs and Water Quality Guidelines were used to further the understanding of impacts to aquatic biota and, therefore, the health of the wetland systems.

Data analysis

Aquatic biota

To identify the strengths of relationships between the macroinvertebrate family abundances and environmental gradients (**trace elements, major ions and system variables**), the following analyses were carried out:

- Detrended Correspondence Analysis (DCA) and
- Canonical Correspondence Analysis, using CANOCO v4.55 (Ter Braak & Smilauer, 2002).

Analysis ordinations included the following: (i) sites by the presence and abundance data of macroinvertebrates families (DCA); (ii) sites by the presence and abundance data of macroinvertebrates families and the **trace elements** of each site (CCA); (iii) sites by the presence and abundance data of macroinvertebrate families and the **major ions** and **system variables** of each site (CCA) (Garcia-Criado et al., 1999). These analyses were designed to indicate which water quality variables could best explain the spatial distribution of macroinvertebrates (Faith & Norris, 1989; Kilonzo et al., 2014). Canonical correspondence analysis is a multi-variate analytical technique that prepares an initial ordination of the taxa by sample matrix. The analysis applies regression equations to these gradients, to further adjust the position of samples using environmental variables collected at each site. The position of a sample in the ordination space is determined by the accumulative contribution of each taxon in the sample (ter Braak & Smilauer, 2002). A measure of family diversity was also calculated for each of the wetland sites, using the Shannon Wiener diversity index (Spellerberg & Fedor, 2003). Statistical significances of the CCA models were determined by applying 1000 permutations in Monte Carlo permutation tests to each ordination (Faith & Norris, 1989).

Water chemistry

Principal Components Analyses (PCA) (Stewart, Butcher & Swinford, 2000; Bizzi et al., 2013; Kilonzo et al., 2014) was carried out using CANOCO v4.55 for the ordination of sites based only on 1) **trace elements** and 2) **major ions** and **system variables**.

4.4.3 Results

Summer (wet season) ecosystem services and wetland health

Ecosystem provision of different services increased in comparison with the dry season results, while some service magnitudes indicated a slight decrease. Conditions of wetland health all indicated an improvement to category 'A' with the exceptions being the Boesmanspruit and Droogvelei wetlands which improved to a 'B' category (Table 16, and Table 7 to Table 12 refer to the previous section).

Table 16: Present State category for each of three modules and the overall Present State of all wetlands assessed in the X11B catchment in the wet season. Wetland numbers and location as per Figure 13

Wetland	Present Ecological State category			
	Hydrology	Geomorphology	Vegetation	Overall Present State
Jagtlust (Wetland 3)	A	A	A	A
Boesmanspruit (Wetland 2)	B	B	A	B
Witbank historical decant (Wetland 4	A	B	A	A
Witbank (Wetland 7)	A	A	A	A
Roodepoort (Wetland 1)	A	A	A	A
Droogvelei (Wetland 6)	B	B	A	B
Nooitgedacht (Wetland 5)	A	A	A	A

Jagtlust wetland WET-EcoServices assessment

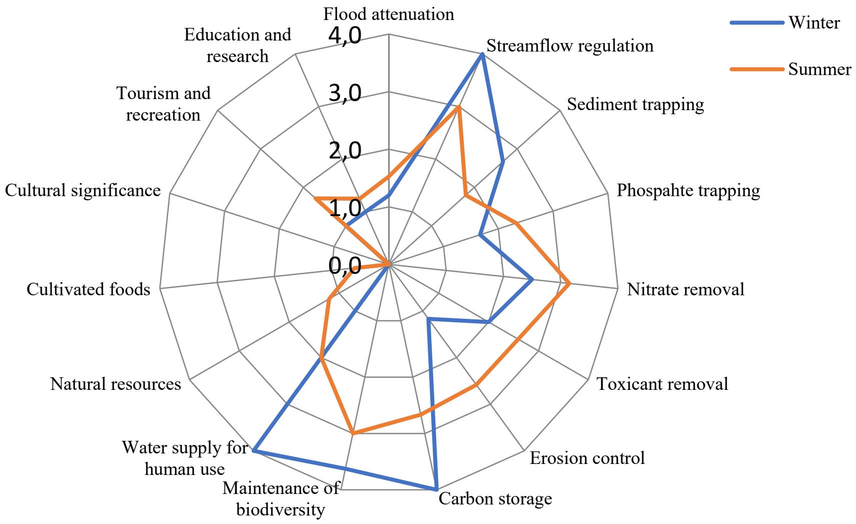

Figure 31: Jagtlust wetland HGM Unit 1 (channelled valley-bottom wetland) ecosystem services overall scores for summer and winter seasons

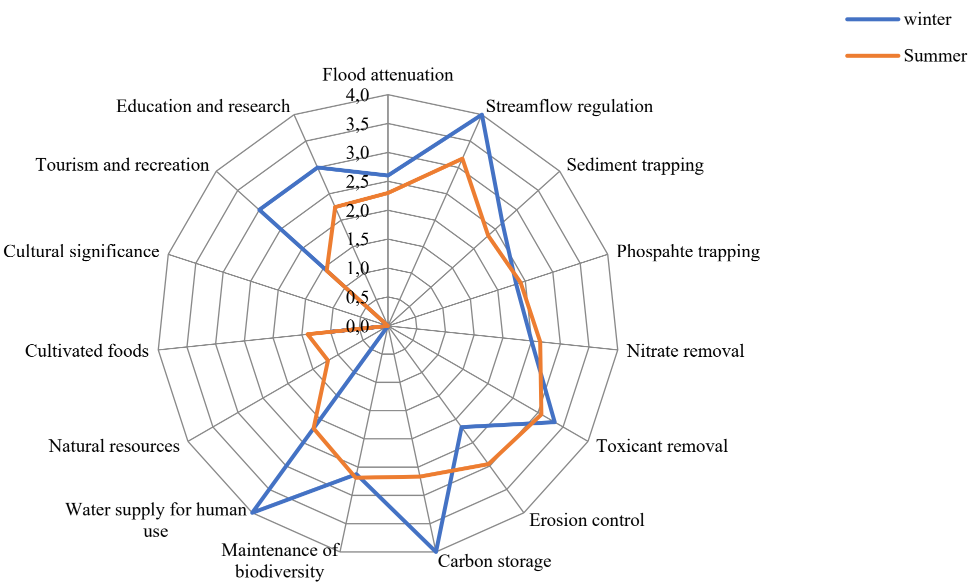

Figure 32: Boesmanspruit wetland HGM Unit 1 (channelled valley-bottom wetland) ecosystem services overall scores for summer and winter seasons

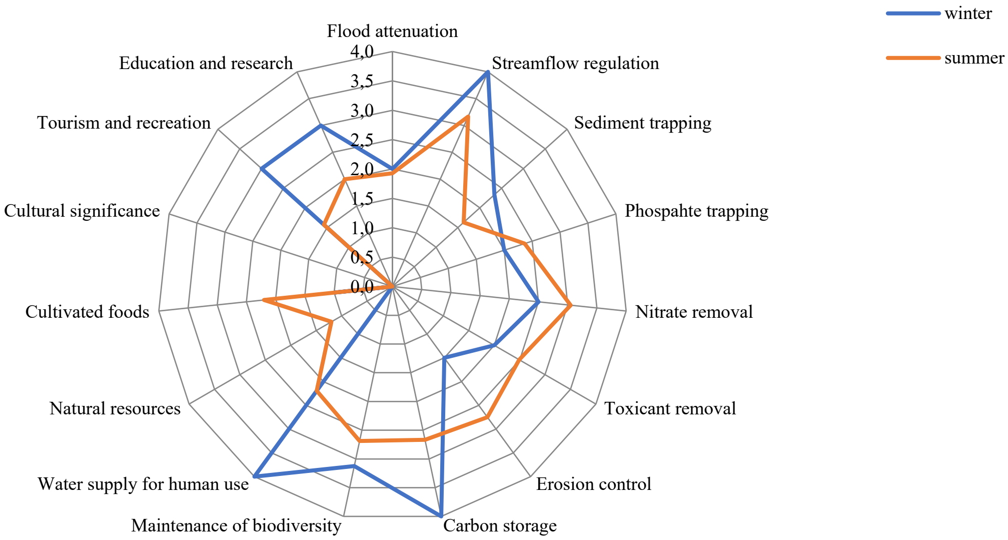

Figure 33: Boesmanspruit wetland HGM unit two (hillslope seep linked to a stream channel) ecosystem services overall scores for summer and winter seasons

Witbank historical decant wetland WET-EcoServices assessment

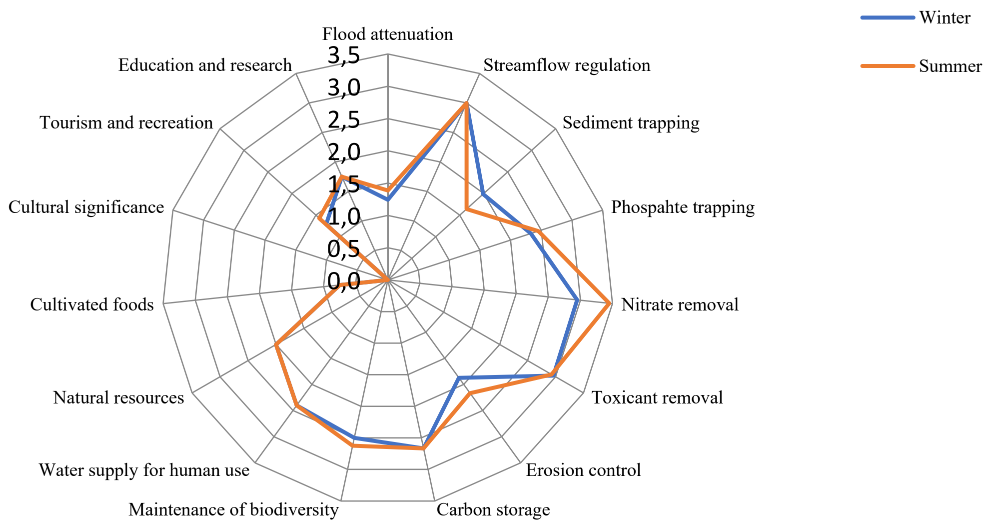

Figure 34: Witbank historical decant wetland HGM Unit 1 (channelled valley-bottom wetland) ecosystem services overall scores for summer and winter seasons

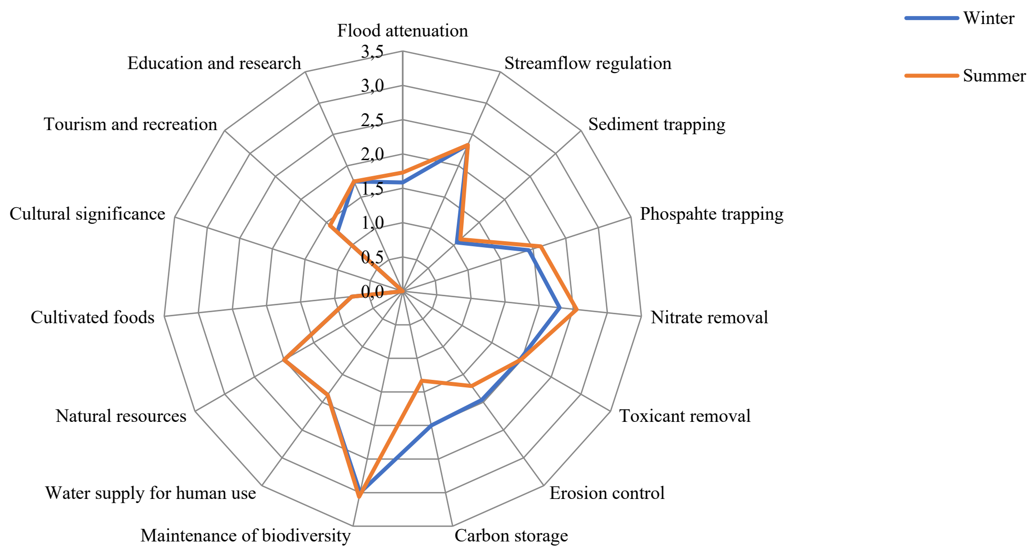

Figure 35: Witbank historical decant wetland HGM Unit 2 (hillslope seep linked to a stream channel) ecosystem services overall for summer and winter seasons

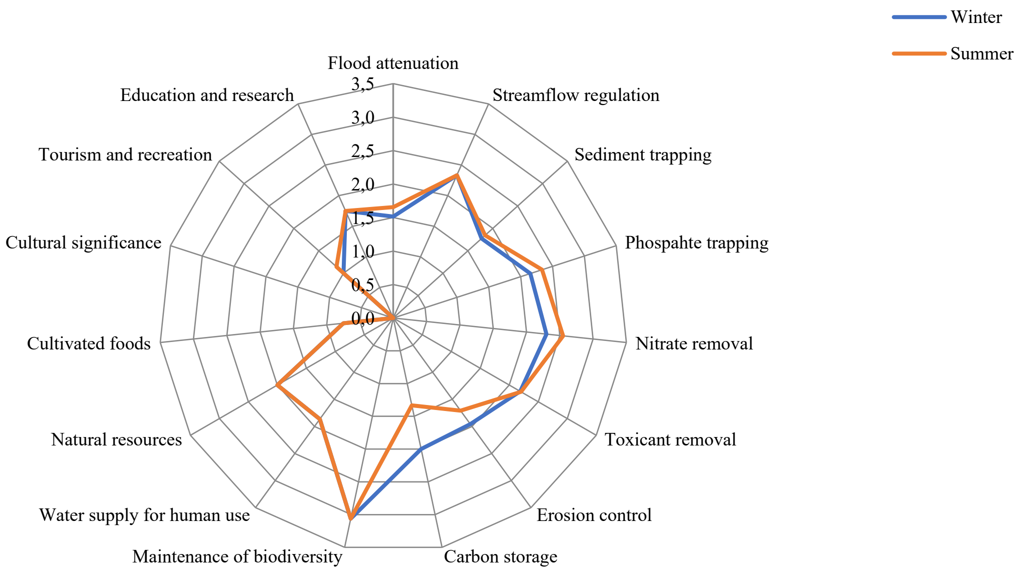

Figure 36: Witbank historical decant wetland HGM Unit 3 (hillslope seep linked to a stream channel) ecosystem services overall scores for summer and winter seasons

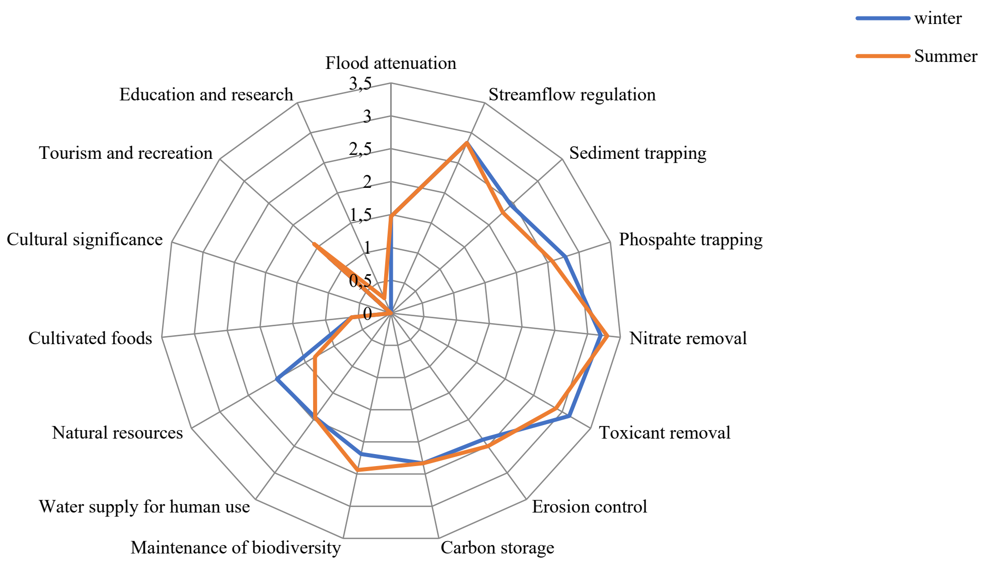

Figure 37: Witbank wetland HGM Unit 1 (channelled valley-bottom wetland) ecosystem services overall scores for summer and winter seasons

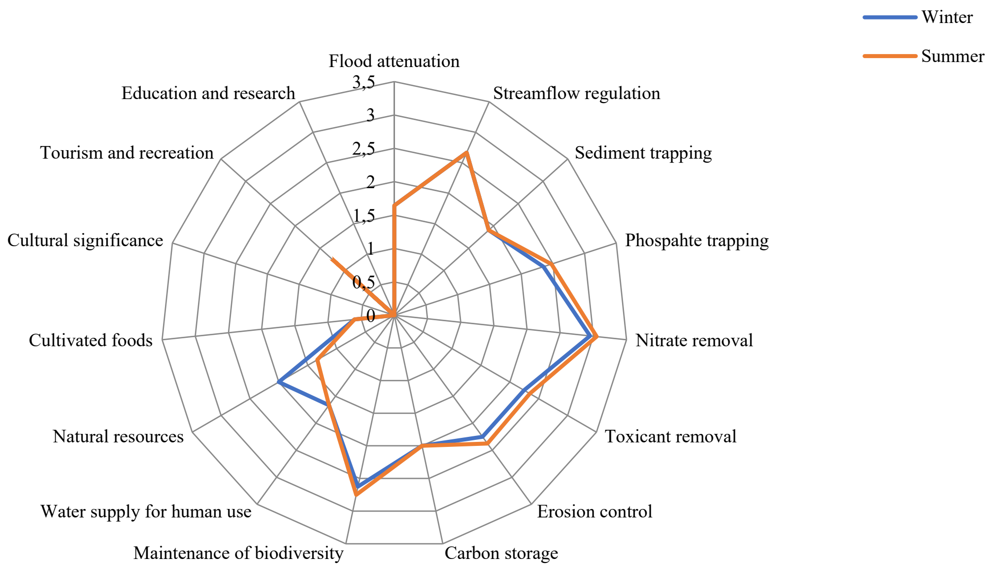

Figure 38: Witbank wetland HGM Unit 2 (hillslope seep linked to a stream channel) and three (depression) ecosystem services overall scores for summer and winter seasons

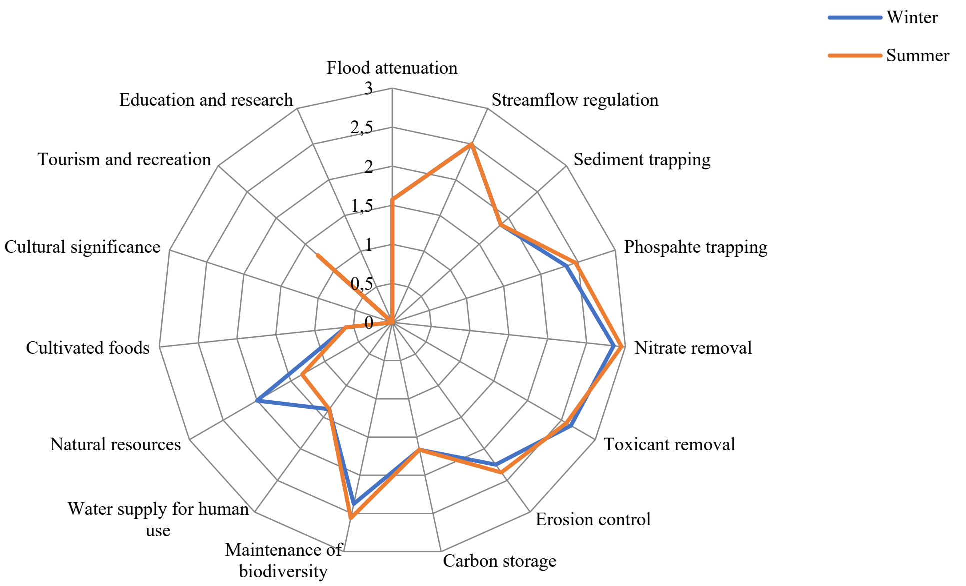

Figure 39: Witbank wetland HGM Unit 4 (hillslope seep linked to a stream channel) ecosystem services overall scores for summer and winter seasons

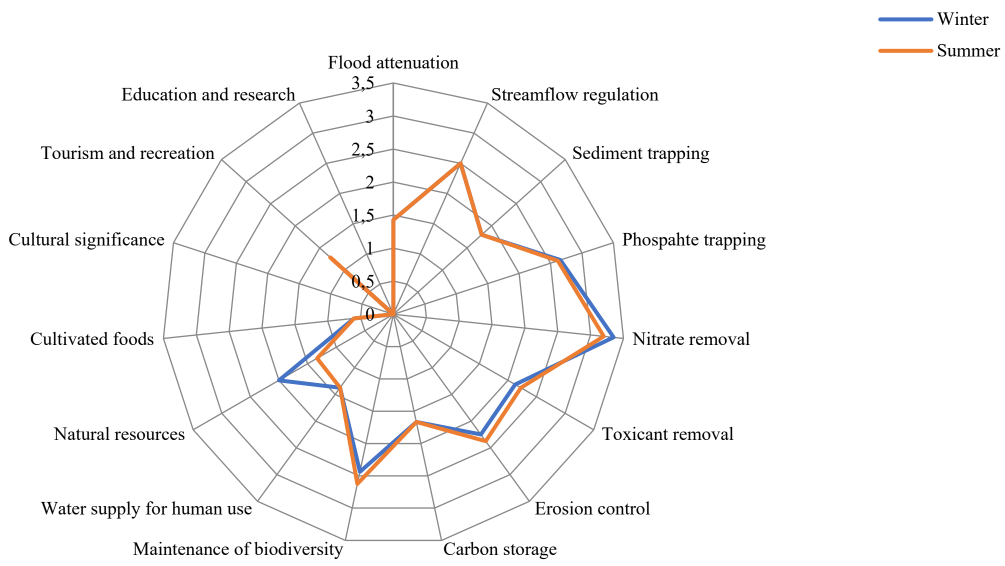

Figure 40: Witbank wetland HGM Unit 5 (hillslope seep linked to a stream channel) ecosystem services overall scores for summer and winter seasons

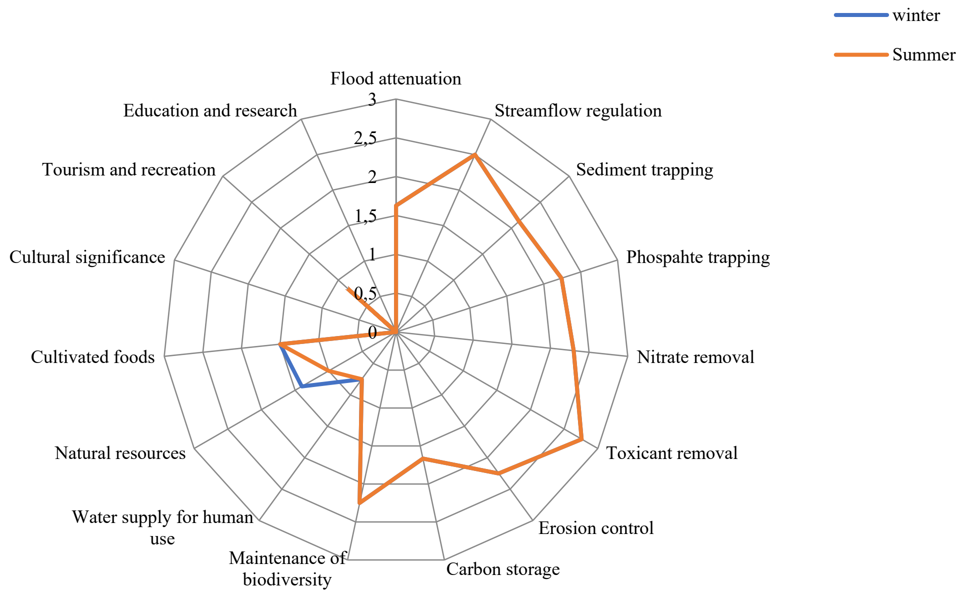

Figure 41: Witbank wetland HGM Unit 6 (channelled valley-bottom wetland) ecosystem services overall scores for summer and winter seasons.

Roodepoort wetland WET-EcoServices assessment

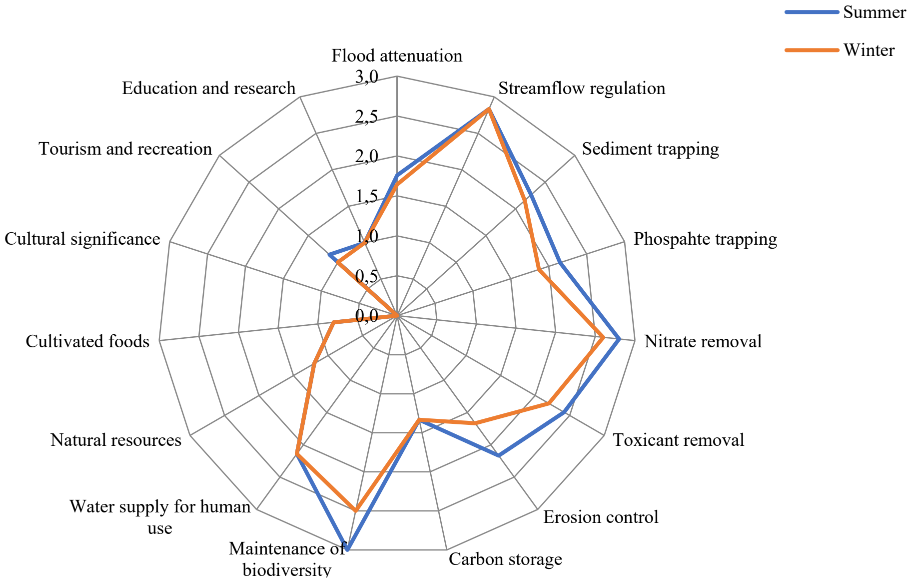

Figure 42: Roodepoort wetland HGM Unit 1 (channelled valley-bottom wetland) ecosystem services overall scores for summer and winter seasons

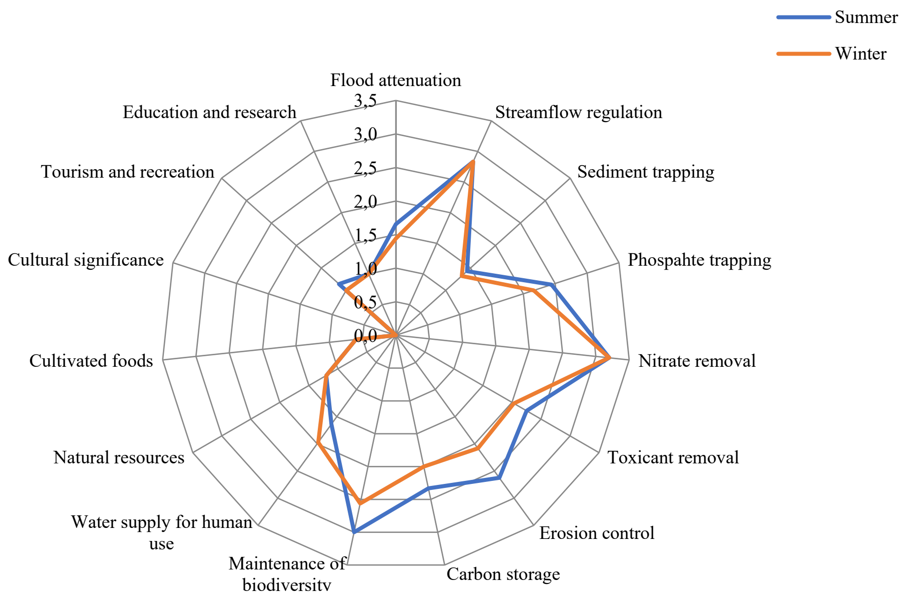

Figure 43: Roodepoort wetland HGM Unit 2 (hillslope seep linked to a stream channel) ecosystem services overall scores for summer and winter seasons

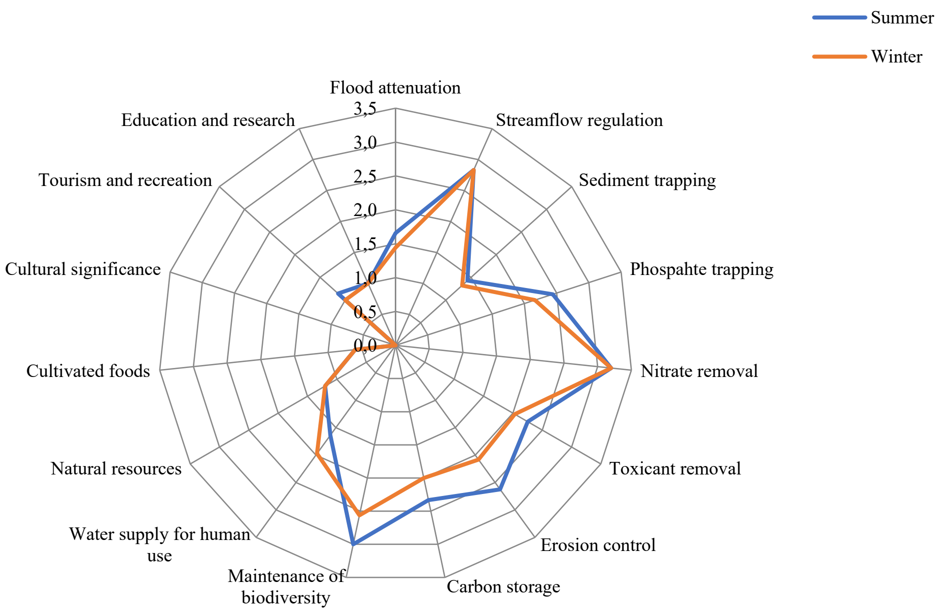

Figure 44: Roodepoort wetland HGM Unit 3 (hillslope seep linked to a stream channel) ecosystem services overall scores for summer and winter seasons

Droogvelei wetland WET-EcoServices assessment

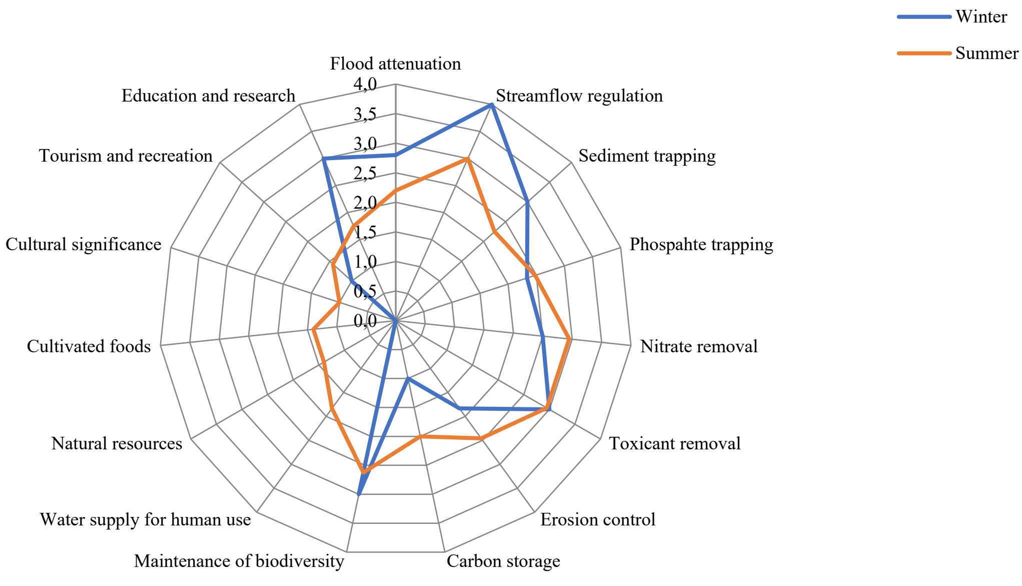

Figure 45: Droogvelei wetland HGM Unit 1 (channelled valley-bottom wetland) ecosystem services overall scores for summer and winter seasons

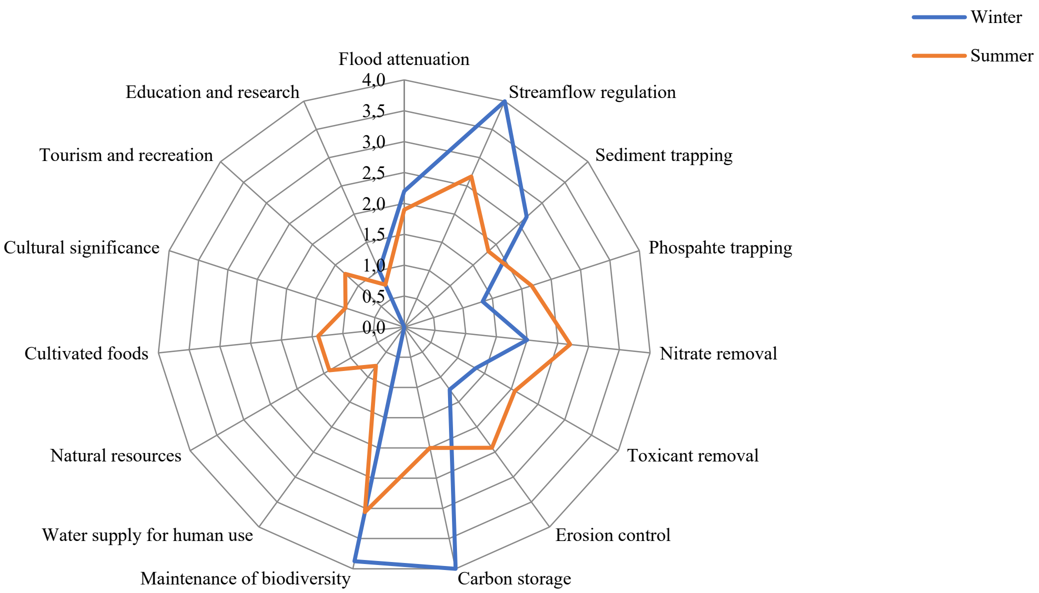

Figure 46: Droogvelei wetland HGM Unit 2 (hillslope seep linked to a stream channel) ecosystem services overall scores for summer and winter seasons

Nooitgedacht wetland WET-Health assessment

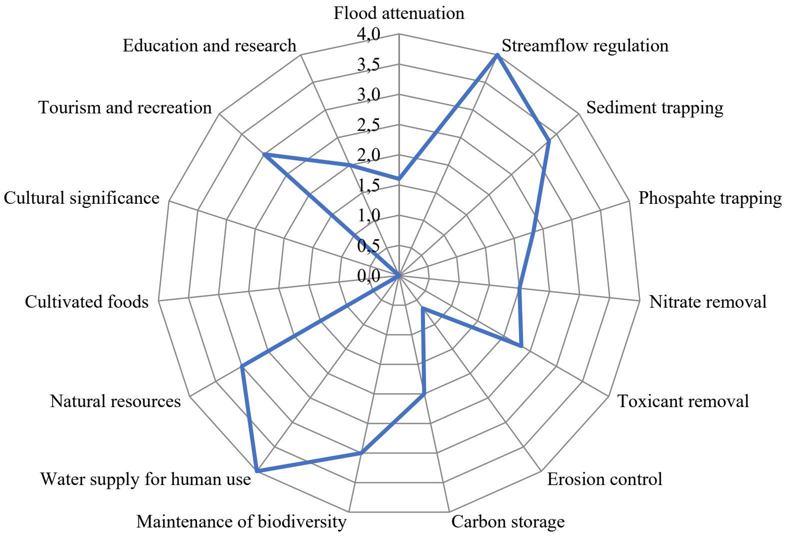

Figure 47: Nooitgedacht wetland HGM Unit 2 (channelled valley-bottom wetland) ecosystem services overall scores for summer and winter seasons

Aquatic biota

CCA

An DCA was carried out using macroinvertebrate families, their abundances, and sites (with no environmental variables). Following the addition of both sets of environmental data (firstly, major ions; secondly trace elements and system variables) to the analysis, and the application of CCA, there was no appreciable change in the position of both families and samples from the DCA biplot. This indicated that the addition of environmental data did not materially affect the final position of families and sites in the bi-plot. The CCA bi-plot (family x site x major ions) is presented for all further interpretation (Figure 48).

Environmental gradients did not contribute further with respect to the elucidation of the gradients, and macroinvertebrate families had dominant effects with respect to position (Ter Braak, 1988).

Macroinvertebrate associations with water chemistry parameters are consistent with each wetland (Figure 48, Figure 49 and Figure 50). Trace elements, major ions, and system variables are consistently linked with particular suites of macroinvertebrate families. Results of the CCA using macroinvertebrate taxa presence and major ions, showed 53% of total variation explained by the first two axes (33% - first axis, and 20% on the second), (Figure 48). There is a strong correlation between the water quality parameters and the species axes. The abundances of taxa in families *Gerridae, Sphaeriidae, Ceratopogonidae, Gomphidae, Corbiculidae, Psychodidae* were greater in the site 3a wetland. Sites 2a and 6a had high abundances of *Simuliidae, Planorbinae, Physidae, Thiaridae* and *Hydracarina* families. Sites 4a,7ma and 7aa had high abundances of *Tabanidae, Veliidae, Pisulidae, Nepidae, corduliidae, Platycnemidae* families, and sites 1a and 5a (reference site) had high abundances of *Oligochaeta, Culicidae, Chironomidae, Potamonautidae, Belostomatidae, Corixidae, Coenagrionidae, Dytiscidae, Gyrinidae, Hydrophilidae, Tipulidae, Naucoridae, Lestidae, Protoneuridae, Aeshnidae* families.

Although four distinct groups could be identified, no associations can be attributed to a particular land-use, or combination of land uses. There are some specific organism associations, but these do not follow patterns indicating that more sensitive organisms were absent from land associated with mining, agriculture, or conservation. One may, therefore, argue that there is no clear pattern of macroinvertebrate family distribution based on direct impacts from either agriculture or mining. It is likely that this classification of the eight wetland sites reflects, more generally, the broad ecological attributes of each catchment and its associated soils, lithology and water chemistry.

Macroinvertebrate families are presented in Figure 4-43 with their associated sensitivities to polluted water (Dickens and Graham, 2002), and listed in full: Oligoch (*Oligochaeta*), Culicid (*Culicidae*), Psycho (*Psychodidae*), Chiron (*Chironomidae*), Potamo (*Potamonautidae*), Belost (*Belostomatidae*), Corix (*Corixidae*), Nepid (*Nepidae*), Noton (*Notonectidae*), Lymnae (*Lymnaeidae*), Physid (*Physidae*), Planor (*Planorbinae*), Thiari (*Thiaridae*), Sphae (*Sphaeriidae*), Baetid (*Baetidae*), Coenag (*Coenagrionidae*), Libellu (*Libellulidae*), Pleid (*Pleidae*), Hydrops (*Hydropsychidae*), Gerrid (*Gerridae*), Veliid (*Veliidae*), Dytisc (*Dytiscidae*), Gyrin (*Gyrinidae*), Hydrop (*Hydrophilidae*), Ceratop (*Ceratopogonidae*), Simul (*Simuliidae*), Corbicu (*Corbiculidae*), Gomph (*Gomphidae*), Nauco (*Naucoridae)*, Hydra (Hydracarina), Lestid (*Lestidae*), Protone (*Protoneuridae*), Aeshni (*Aeshnidae*), Ecnomi (*Ecnomidae*), Elmid (*Elmidae*), Hyraeni (*Hyraenidae*), and Platye (*Platycnemidae*).

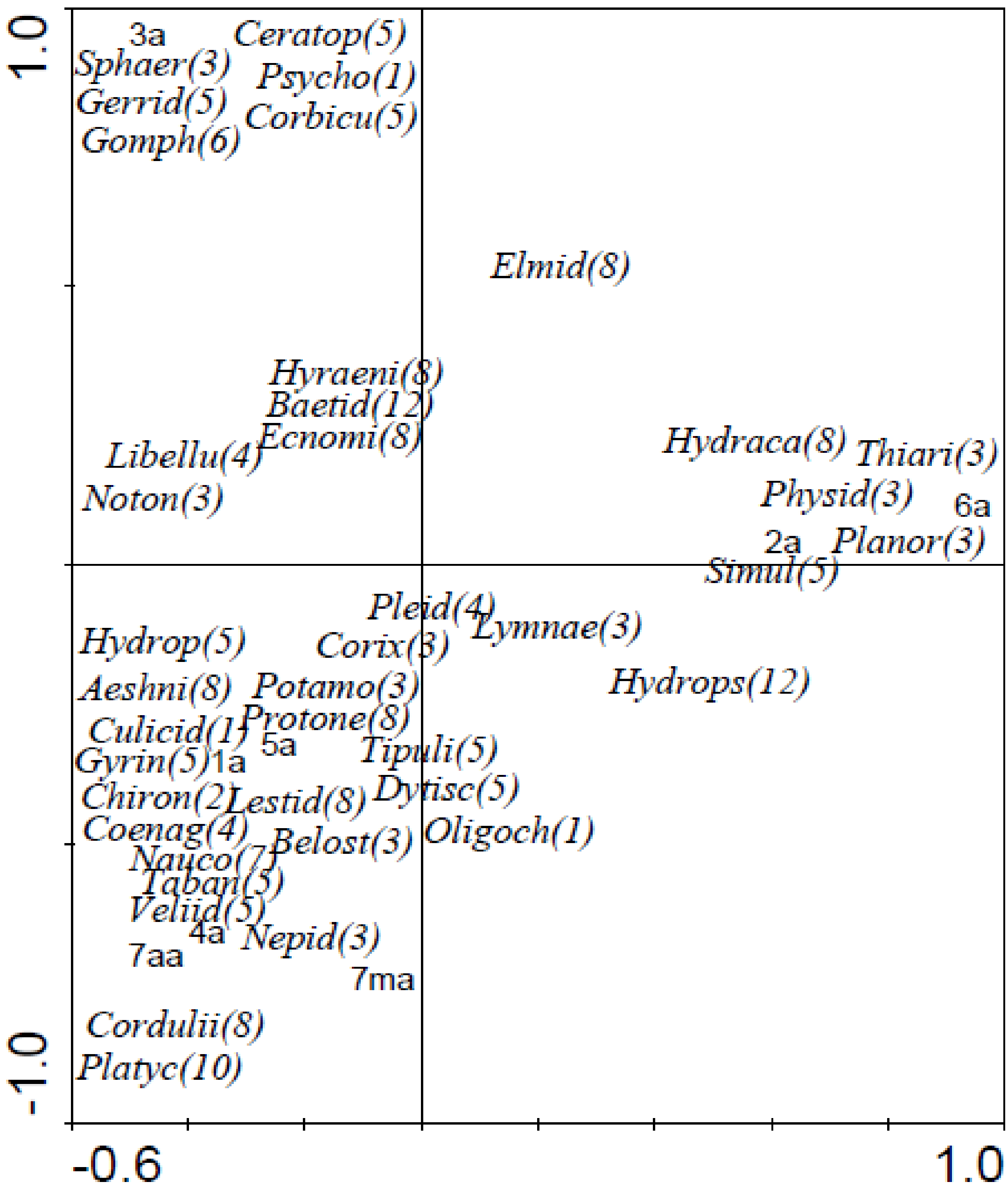

Figure 48: CCA ordination bi-plot for macroinvertebrates families by samples by major ions at the eight wetland sites sampled in the X11B catchment. Samples used in this ordination are 1a, 2a, 3a, 4a, 5a, 6a, 7aa and 7ma

Results of the CCA of macroinvertebrate taxa presence and major ions and system variables showed 54 % of total variation was explained by the first two axes, 33 % on the first and 21 % on the second axis). Site 3 had high concentrations of nitrate, potassium, bromine and sodium adsorption rate (SAR). Sulphate, fluorine, and TDS concentration levels were high in sites 2 and 6. Phosphate concentrations in these sites were lower in comparison to those recorded from other sites.

Sites 1a, 4a, 5a, 7aa and 7ma had high concentrations of nitrite (Figure 49).

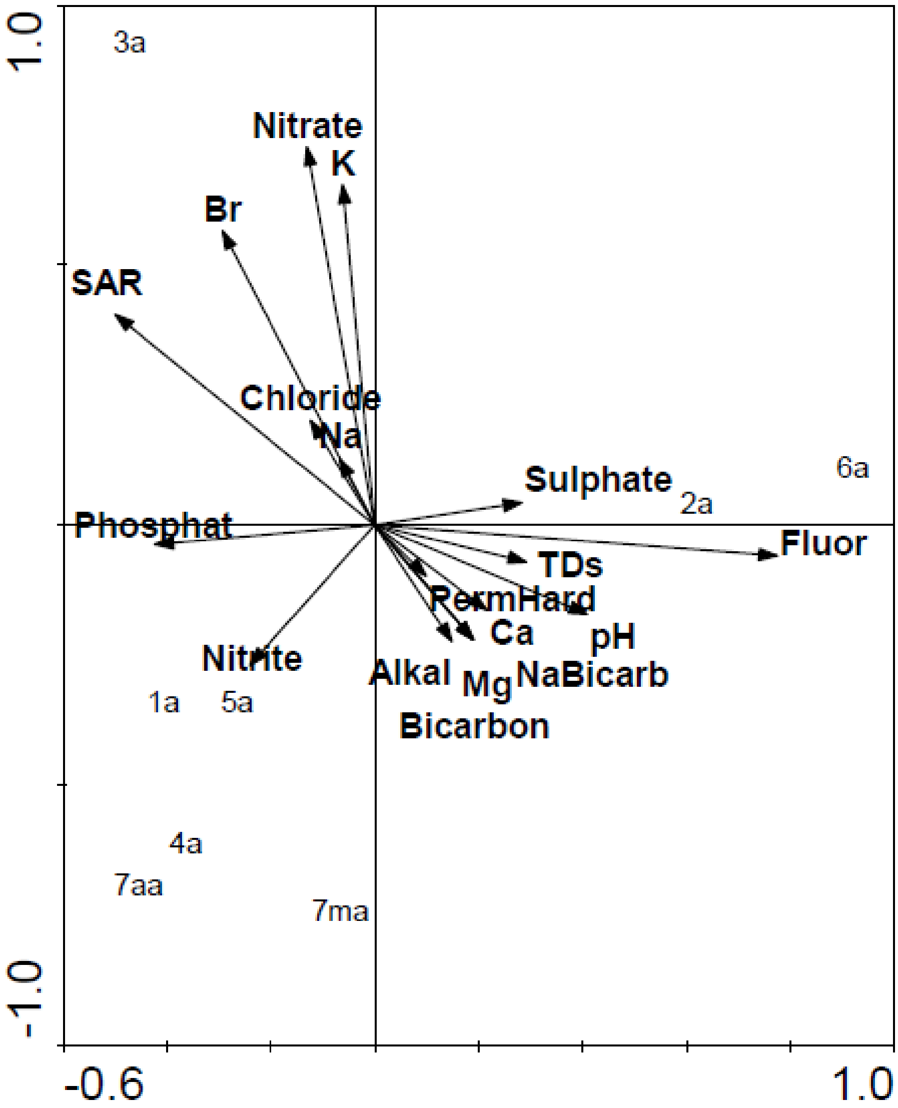

Figure 49: CCA ordination bi-plot for macroinvertebrate family abundances and the major ions and system variables at the eight wetland sites sampled in the X11B catchment. Arrow lengths indicate the strength of the relationships between taxa abundances and the major ions and system variables.

CCA results of macroinvertebrate taxa presence and the trace elements, showed 53% of total variation explained by the first two axes (20% on the first 33nd; 20.1% on the second). Site 3a had the highest concentrations of lithium (Li), barium (Ba), rubidium (Rb), Tellurium (Te), whereas the sites with the most human activity (2a and 6a), had higher concentrations of caesium (Cs) strontium (Sr), mercury (Hg), but low trace elements overall (Figure 50).

Titanium (Ti), vanadium (V), lanthanum (La), beryllium (Be) concentrations, were higher at sites 1a and 5a and copper (Cu), arsenic (As), selenium (Se), molybdenum (Mo), tin (Sn), antimony (Sb), platinum (Pt) concentrations were higher at sites 4, 7ma and 7aa (Figure 50).

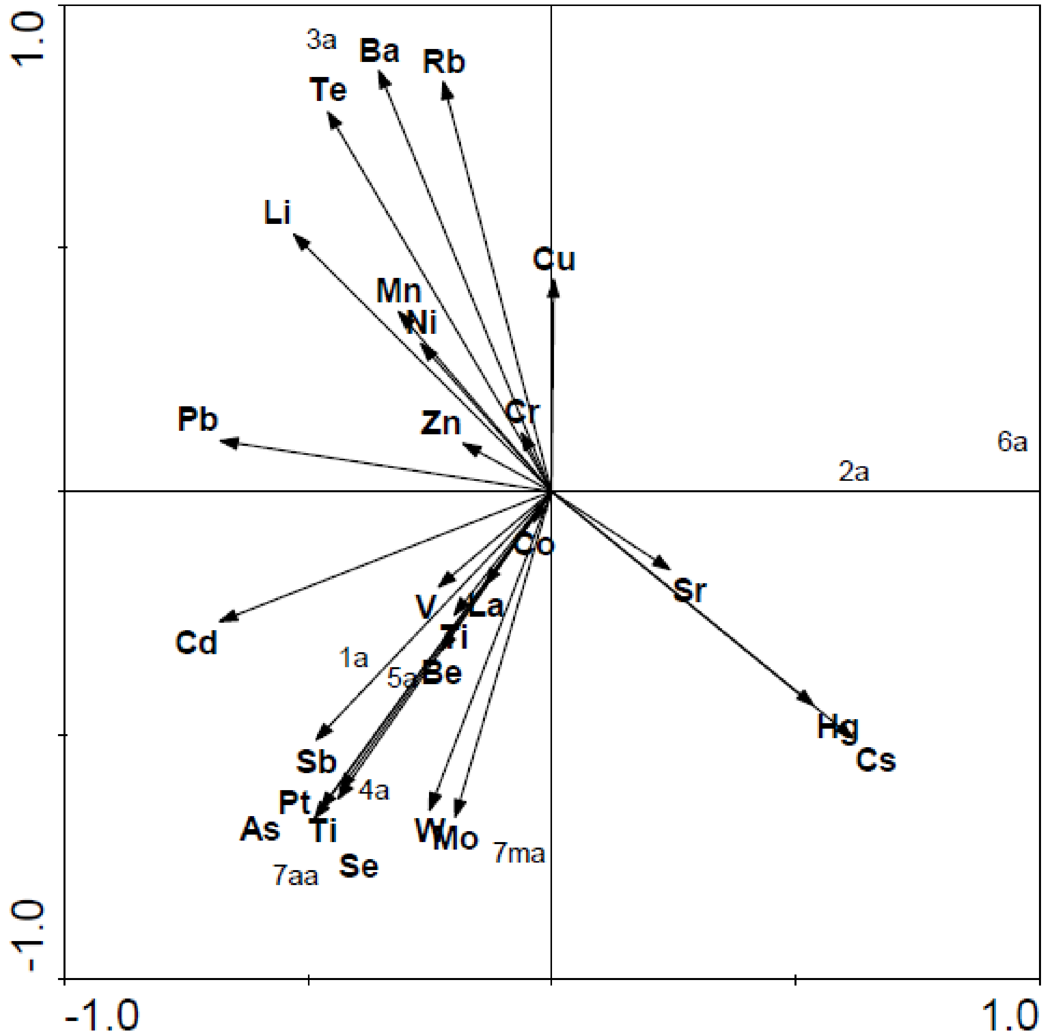

Figure 50: CCA ordination bi-plot for macroinvertebrate family abundances and the trace elements at the eight wetland sites sampled in the X11B catchment. Arrow length indicates the strength of the relationships between taxa abundances and the major ions and system variables.

Since the ordination analyses did not reveal a clear correlation between land use or water chemistry and macroinvertebrate sensitivities, a Shannon Weiner analysis was undertaken. The mining-impacted sites had the lowest Shannon Weiner diversity index score (Figure 51). The Witbank mining tributary (site 7ma) and the Witbank historical decant site (site 4a) both had lower index scores than those from other sites. The wetlands of two tributaries flowing into wetland 7 (7a in an agricultural landscape and 7m in a mining landscape) indicated distinct differences in macroinvertebrate family diversity, insinuating mining influence.

The 5a reference wetland had the most sensitive taxa, as well as the most taxa found, among the wetlands.

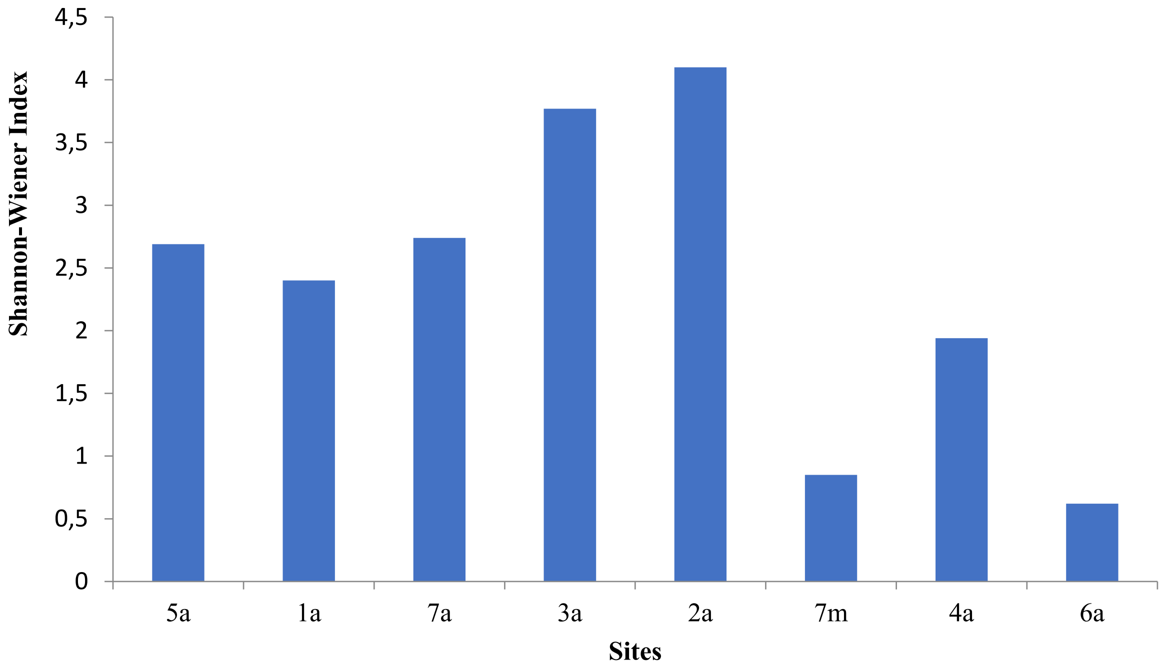

Figure 51: Shannon-Wiener diversity index scores for macroinvertebrates at the eight wetland sites sampled in the X11B catchment

Table 17: Jagtlust wetland HGM unit one (channelled valley-bottom wetland) ecosystem services overall scores for summer and winter seasons

Site	2a	3a	1a	6a	4a	7a	7m	5a
SASS	25	35	23	34	10	19	10	66
No. Taxa	6	9	5	4	3	4	2	13
ASPT	4.17	3.89	4.6	4.8	3.33	4.75	5	5.08

Water chemistry

Mining impacted sites have more clearly distinguishable chemistry characteristics, and cluster together (Figure 53). Trace elements and major ions characterise sites 7ma and 4a, and site 7ma as more dissimilar from other sites. Other sites' impacts are difficult to distinguish. The PCA results of trace metals at each site showed 96% of total variation explained by the first two axes (59% on the first and 37% on the second axis). Figure 52 shows three distinct groupings, namely: the large numbers of sites near the centroid, with sites 4 (4a, 4d, 4u) and 7 (7ma, 7d, 7u) forming two separate clusters. This reflects the same mining impact pattern previously identified within the macroinvertebrate analysis (Figure 48).

Site 4 (4u, 4a, 4d) contained high concentrations of strontium, whereas site 7ma, 7d contained the highest concentrations for nickel, lithium, lanthanum, zinc, beryllium, cobalt, and manganese (the sites around the centroid most likely represent characteristics of relatively normal wetland trace element measures, implying relatively normal concentrations) (Figure 51).

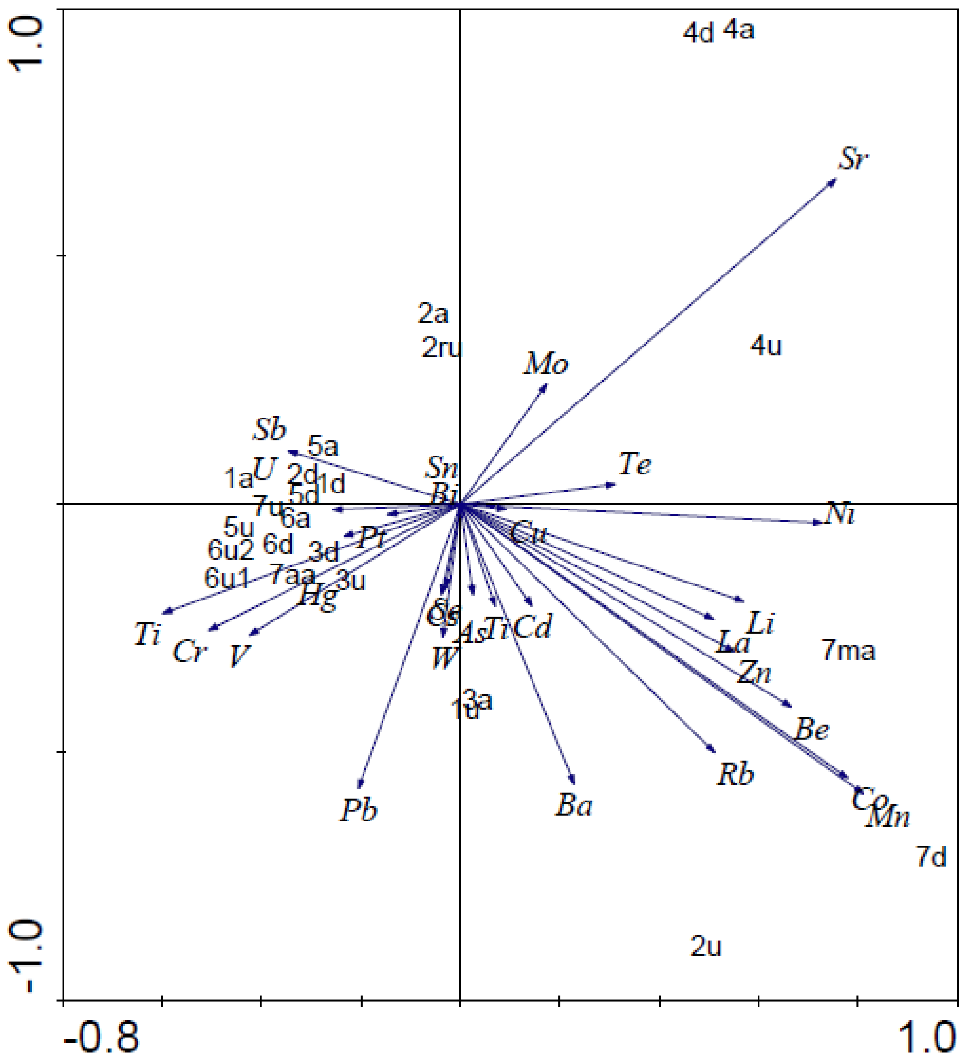

Figure 52: PCA ordination bi-plot for trace metals at 24 water samples sites in the X11B catchment, in comparison with the other sample sites. Arrow length indicates the strength of the relationships between taxa abundances and the major ions and system variables

PCA results of major ions and system variables at each site showed 92 % of total variation was explained by the first two axes (59 % on the first and 33 % on the second). PCA ordination showing major ions and environmental variables (Figure 53) shows the same pattern where sites 7 (7ma and 7d) and 4 (4a, 4u, 4d) were located away from the centroid, where all the other sites are located. Site 7d had high concentrations of Sodium bicarbonate, Fluoride, and Sodium which contributed to high EC. Whereas sites 4 (4a, 4u, 4d) and site 7ma's contained high concentrations of Magnesium, Sulphate, Calcium, and Bromine (contributors to the high TDS) as well as high Nitrate and Nitrate and Phosphate (nutrients).

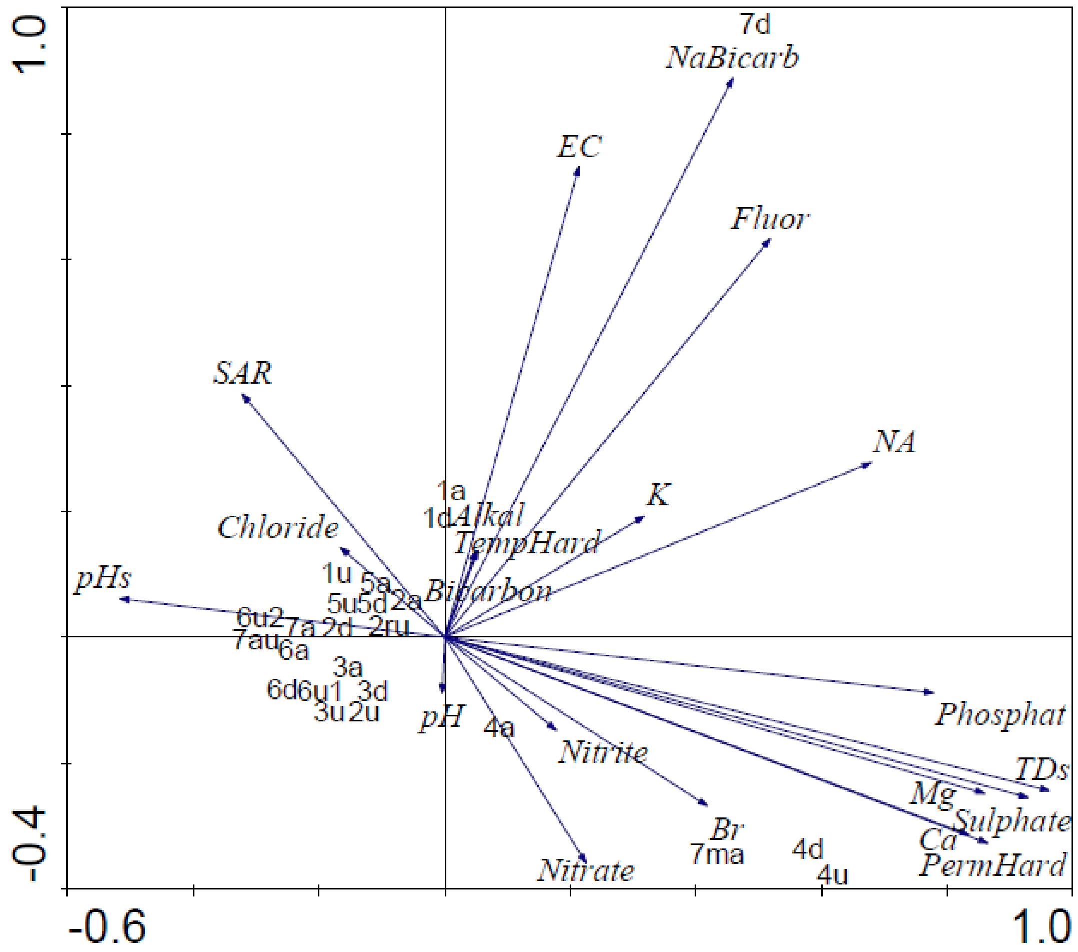

Figure 53: PCA ordination bi-plot for major ions and system variables at 24 sites in the X11B catchment. Arrow length indicates the strength of the relationships between taxa abundances and the major ions and system variables

In summary: it was only the Shannon-Weiner diversity index analysis that provided clear evidence of the 2012 mining-related AMD crisis.

Table 18: Comparisons of water quality results at each wetland sampled in the X11B catchment and Water Quality Guidelines (DWAF, 1996) and RQOs of the Komati River System (DWS, 2016). Water quality concentrations and levels exceeding RQO limits are represented in bold.

	South African aquatic acute	South African aquatic chronic	Inkomati-Usuthu RQOs and South African target quality ranges	1a	2a	3a	4a	5a	6a	7ma	7aa
Mn	1300	370	180	4.06	0.76	**227.10**	34.45	0.45	1.17	**906.13**	5.26
Cu	1.6	0.53	0.3	**3.48**	**1.8**	**2.85**	**2.74**	**2.51**	**3.95**	**2.9**	**1.3**
Zn	36	3.6	2	0.82	0.025	**11.88**	**13.42**	**10.47**	**12.48**	**73.74**	**2.95**
As	130	20	10	0.33	0.19	0.21	0.32	0.44	0.31	0.16	0.43
Se	30	5	2	0.01	0.01	0.01	0.01	**2.63**	0.01	0.01	**3.75**
Cd	3	0.3	0.15	0.01	0.005	0.10	0.03	0.05	0.03	0.13	0.2
Hg	1.7	0.08	0.04	**0.50**	**1.12**	**0.21**	0.04	0.04	**0.46**	**0.4**	**0.93**
Pb	4	0.5	0.2	0.05	0.01	0.06	0.01	0.03	0.06	0.04	0.06
pH			5.9-6.5	**7.4**	**6.84**	**5.4**	**6.67**	**6.75**	5.54	4.1	5.46
EC (mS/m)			30	**40**	**31**	13	9	25	8	8	6
Fluoride (µg/l)	2.540	1.500	0.75	0.13	**0.8**	0.1	0.32	0.24	0.17	0.33	0.15
Sulphate (mg/l)			80	30.28	**90.91**	53.58	1.06	57.28	19.51	**436.42**	12.22
Phosphate (mg/l)			0.025	**0.04**	**0.06**	**0.69**	**2.57**	**0.23**	**0.03**	**3.33**	**0.5**

4.4.4 Discussion

Evidence of perceived increased wetland ecosystem service delivery are consistent with the wetter summer condition. Winter seasons in the X11B catchment are characterised by low rainfall and cold temperatures. Flow through wetlands is minimal and crop farming is discontinued, leaving the soils bare (Ometo et al., 2000). Livestock grazing dependency on wetlands as a water resource is also higher during winter (Scoones, 1991). Therefore, trampling and overgrazing of banks and surroundings is prevalent. The dependency on wetlands results in disturbance and erosion of soil, as well as exposure and hardening of the landscape surface (in areas surrounding wetlands). These seasonal characteristics contribute towards lower vegetation cover and hydrological flow, which can ultimately lead to changes in the geomorphology of a wetland (Macfarlane et al., 2009) and a general decline in ecosystem services normally provided by wetlands, distinctive of these features (Scoones, 1991). The opposite effects are found with the change in season from winter to summer, when increased rainfall results in an increase in hydrological flow, vegetation cover, and crop growth, as well as an overall increase in modules used to measure the extents of wetland services provision. Considering the positive hydrological and vegetation influences that the summer season holds, one can therefore infer a seasonal variation in the extent of wetland ecosystem services that benefit humans and the natural environment.

The use of quantified macroinvertebrate community structure and more detailed water quality analysis, as well as the multivariate analysis (which brings these aspects together), did not provide greater insights into impacts of mining compared with agriculture. There were interesting macroinvertebrate community structure responses correlated with chemical attributes, but these did not correlate with site-related land use, or the sensitivity of the biota. This means that more detailed quantitative studies corroborated the qualitative assessments in showing little evidence of 2015/6 impacts after the 2012 AMD incident. Such results provide an indication of the resilience of wetlands.

There was, however, some indication of mining impacts, in that the biodiversity index results for mining-related sites were lower than from other sites. This was particularly evident where for wetlands on two tributary arms flowing into a downstream Witbank wetland (Site 7). The tributary in a landscape with mining and no agriculture has a lower biodiversity score than one in an agricultural landscape with no mining.

When these results are compared with those of Tate and Husted (2015), the 2016 Boesmanspruit SASS5 scores all reflect poor values in comparison to the high flow data collected in Tate and Husted's November 2013 study. The low numbers of taxa, and sensitive species, reported here may indicate that the Boesmanspruit has not recovered from the 2012 AMD event. Figure 53 indicates high concentrations of sulphate and TDS – both indicators of mining impact.

In addition to mining, the X11B catchment is characterised by dryland crop agriculture, a land use associated with elevated nutrients, pesticides, Manganese, Phosphate and Zinc Copper and Selenium in pesticides (DWAF, 1996). These trace elements and ions accumulate in aquatic systems due to runoff from the surrounding landscape.

With continued exposure to pollutants there is a possibility that the wetlands' capacity to absorb toxins will be exceeded and the functionality of the wetlands impaired: potentially threatening the overall functioning of impacted wetlands, downstream users (humans and natural resource users) and the ecological infrastructure services. All sites are, however, presently in good condition and there is a strong basis to argue for systematic wetland protection by primary land-users, especially at mining-impacted sites, and during the winter season.

Constituent water quality values exceeded RQOs and chronic and acute limits, indicating the continued contamination by land uses. This, along with the limited recovery of the Boesmanspruit wetland condition, infers an urgent need for management intervention, to protect and conserve these wetlands of the Mpumalanga Highveld region.

We suggest the following interpretation of the effect of the 2012 AMD crisis: The AMD event could have flushed the sediment of the wetlands, removing toxic ions, and “resetting” the adsorptive capacity of the ecosystem. Now, toxic constituents would be building up again, so that in case of a future event low flow period, followed by heavy rainfall, another AMD event could occur.

4.4.5 Summary conclusions after the qualitative and quantitative studies

The overall aim of this chapter was to report on the contestation between mining, and agriculture, using wetlands as indicators, a nexus of ecological infrastructure. Past investigations indicate that open pit coal mining, taking place in the X11B catchment, is a destructive land-use activity for both the ecology and stakeholders (Tempelhoff et al., 2012; McCarthy & Humphries, 2013). After the AMD crisis IUCMA and local government were blamed for the event, based on the perception of the CMA and government’s inability to prevent the Acid Mine Drainage (AMD) situation, due to the lack of regulation and enforcement (Tempelhoff et al., 2012; McCarthy & Humphries, 2013). Two of the four mining companies operating without valid water use licenses, and even knowing this, government agencies were unable to prosecute mining companies (Tempelhoff et al., 2012). Mistrust grew, protests occurred, and an (unsuccessful) court case against the government was initiated (Tempelhoff et al., 2012). The water quality was eventually improved by reinstating the Eskom water transfer scheme which raised the pH of the Boesmanspruit dam to 7 and diluted the dam’s heavy metals and major ions. The transfer scheme has, however, again been stopped, possibly creating a similar situation of a build-up of concentrated toxicants in the system, as hypothesised by McCarthy and Humphries (2013). Despite failure of regulation and enforcement, ultimately the legacy of coal mining could be responsible.

According to South African law (see Chapters 2 and 3), mining companies need to go through an elaborate process to gain the right to mine; this includes the process from construction to closure and rehabilitation of the land, post-mining. Mining in South Africa however, has an apparent legacy issue of inappropriate sign-off of prospecting sites, as well as the lack of enforcement by municipalities, and uncontrolled mining (Tempelhoff et al., 2012; Chapter 3). Once in a production phase, -mining companies make use of reductionist, command-and control, styles of resource management, as opposed to more complexity-based approaches (Pollard & Du Toit 2011; Cilliers et al., 2013; Houdet & Chikozho, 2014).

In a South African case study by Cilliers et al. (2013) on the mining sectors in the Mpumalanga region, it was highlighted that mining companies do little to embrace diversity and have a linear standardised modelling approach to management. Instead, mining companies designed and predicted future occurrences with little unexpected emergence and there is little need for flexibility in constructing rules and goals (Deloitte & Touche, 2009). Therefore, it is more likely that secondary effects (such as limiting ecosystem services) and unpredicted extreme events are not considered in mining management programmes and reports. Furthermore, rehabilitation of opencast mining sites (replacement of soils and impermeable layers to restrict percolation of water into the filled void) are expensive if executed appropriately and, therefore, this option is mainly not implemented (Section 4.5).

The main concern that emerged for researchers in this study is our experience and perception of impunity of the mining sector. Indicators of this included the absence of the Department of Mineral Resources officials at ANY of the stakeholder processes that were organised as part of the study, and mines operated without necessary regulatory compliance.

It is clear that there is limited capacity among stakeholder to engage with the complexity and resilience characteristic of C-SESs. Walker and Salt (2012) and Ison et al. (2007) suggest that by collaboratively focusing on how the resource dilemma (experienced in the catchment) arose, understanding the thresholds present in the system, evaluating the driving factors, strengthening links between social hierarchy scales, and knowing what feedbacks are likely, stakeholders could co-operate to increase system resilience to external shocks.

The multi- and limited transdisciplinary approaches reported in this chapter give a deeper understanding of the ecological aspects of wetland contestation in the X11B complex social-ecological system. Based on McCarthy and Humphries (2013) claim of coal mining being the main culprit of wetland contamination in the X11B quaternary catchment, water chemistry variable concentration variables have been presented, macroinvertebrates were identified to a family level and statistically analysed in order to identify any links to water chemistry impacts on abundances and diversity. Although distinct abundance and diversity measures (according to different land uses) were expected, the abundance results did not reveal any clear patterns based on the types of macroinvertebrates present at the different sites. Biodiversity, on the other hand, did reflect a difference, where sites associated with high mining use had lower biodiversity index scores in comparison with other sites. This, read in conjunction with the next section (Section 4.5), suggests that geology and resultant hydrological connectivity play a critical role in the health of the wetlands, as proposed by Jolly et al., (2008). Section 4.5 will elaborate on the implications and importance of soil stripping, stockpiling and placement execution pre-mining and post-mining, as well as the near-impossible rehabilitation of the landscape's hydrological functioning (i.e., flow regimes and wetland feeding processes, after puncturing the landscape).

Section 4.5 provides a critique of wetland management definitions (e.g., the National Water Act's definition of wetlands) and tools for wetland assessment and characterisation.

This chapter highlights the limitations of conventional disciplinary approaches and supports a more transdisciplinary approach that offers concurrent knowledge-building across disciplines. Here, natural science (ecology, chemistry and geology) together with social science (law, economics, political ecology and social engagement) provides insights into the whole system, as suggested by Audouin et al. (2013).

To protect wetlands and ecological infrastructure, it would be useful to construct maps that illustrate the hydro-connectivity of intact wetlands. This could provide a foundation for delineating aquatic ecosystem health classification. At the same time, stakeholders and affected Government Departments should jointly lobby for, and promote, the declaration of "no mining" zones in hydrologically-pristine areas. Such a challenge to mining-sector impunity would provide a foundation to the long-term survival of the Highveld wetland ecological infra-structure.

4.5 Systemic landscape approach (hydropedology)

Notes:

- This section was written solely by JH van der Waals (excluding "4.5.1 Introduction". Copyright is being negotiated. The section should be attributed solely to JH van der Waals, (see full text in Appendix C).
- Figures referenced in this section refer to figures drawn in Appendix C. They are noted for the reader who would like to find them. For the reader of this report only: Figure 6, Figure 7 and Figure 8 all illustrate the concepts in this section.

4.5.1 Introduction

Transdisciplinarity includes the concurrent building of knowledge from different perspectives (Palmer et al. 2015). While conventional wetland delineation and assessments, using WET EcoServices and WET Health (Ellery et al., 2009; Kotze et al., 2009), were being undertaken, the research team became aware of the importance of understanding the hydropedology of the layered landscape of catchment X11B (Figure 10). This section, referred to extensively in the previous sections, offers insights into the long-term sustainability of Highveld wetlands and their dependence on a continuity of un-punctured sandstone layers, along which water flows horizontally. The section that follows was commissioned as a unit of work to provide a particular perspective on wetland health and persistence in the Highveld grassland landscape.

4.5.2 Background to hydropedology

The identification and delineation of wetlands rests on several parameters that include topographic, vegetation and soil indicators. The concept of wetland delineation implies an emphasis on the wetlands themselves and very little consideration of the processes driving the functioning and presence of the wetlands.

The discipline of 'hydropedology' encompasses a number of tools that help to elucidate landscape hydrological processes (Lin, 2012). Hydropedology (or "Pedology") is the science of soil classification, on the basis of morphology, which is the result of hydrological, physical and chemical processes. Soil morphology plays a role in, and intimately influences, the hydrology of the landscape. Soil is therefore both an indicator and a participator in wetland processes.

Wetlands are those areas in a landscape where morphological indicators point to prolonged or intensive saturation near the surface, which influences the distribution of wetland vegetation. Wetlands therefore form part of a larger hydrological entity from which they cannot be separated.

The crux of a hydropedology assessment should be the accurate contextualisation of morphological properties of soils (used in describing and classification – pedology) as well as the physical properties that will determine the hydrological functioning of the soils.

4.5.3 Hydropedology – Proposed approach

To provide detailed pedohydrological information, both detailed soil surveys and hydrological investigations are needed. In practice, these intensive surveys are expensive and very seldom conducted. Nevertheless, with the understanding of soil morphology, pedology and basic soil physics parameters, as well as the collection and interpretation of existing soil survey information, assessments at different levels of detail and confidence can be conducted. In this sense four levels of investigation are proposed.

1. A **Level 1 Assessment** includes the collection and generation of all applicable remote sensing, topographic and land-type parameters to provide a "desktop" product. This level of investigation rests on adequate experience in conducting such information as well as collection and interpretation exercises that provide a broad overview of dominant features.

   Hydropedological parameters: within this context, the presence, distribution and functioning of wetlands will be better understood than without such information.

2. A **Level 2 Assessment** makes use of data generated during the Level 1 assessment stage and I includes a reconnaissance soil-and-site survey, to verify the information as well as elucidate many of the unknowns identified during the Level 1 assessment.

3. A **Level 3 Assessment** builds on the Level 1 and 2 assessments and will consist of a detailed soil survey, with sampling and analysis of representative soils. The parameters to be analysed include soil physical, chemical and mineralogical parameters, to elucidate and confirm the morphological parameters identified during the field survey.

4. A **Level 4 Assessment** makes use of the data generated during the previous three levels and will include the installation of adequate monitoring equipment and measurement of soil and landscape hydrological parameters for an adequate time period. The data generated can be used for the building of detailed hydrological models (in conjunction with groundwater and surface hydrologists) for the detailed water management on specific sites.

For most wetland delineation exercises, a Level 2 or Level 3 assessment should be adequate. For this investigation, a Level 2 assessment was conducted.

4.5.4 Pedogenesis

Pedogenesis is the process of soil formation, which is a function of five factors (Jenny, 1941): parent material; climate; topography; living organisms; and time.

These factors interact, leading to a range of different soil forming processes that ultimately determine the specific soil formed in a specific location. Central to all soil forming processes is water and all the reactions (physical and chemical) associated with it. The physical processes include water movement onto, into, through, and out, of a soil unit. The movement can be vertically downwards, lateral or vertically upwards through capillary forces and evapotranspiration. The chemical processes are numerous and include dissolution, precipitation (of salts or other elements) and alteration through pH and reduction and oxidation (redox) changes. In many cases, the reactions are promoted through the presence of organic material that is broken down through aerobic or anaerobic respiration by microorganisms. Both these processes alter the redox conditions of the soil and influence the oxidation state of elements such as Fe and Mn. Under reducing conditions, Fe and Mn may become more mobile in the soil environment. Oxidising conditions, in turn, lead to the precipitation of Fe and Mn and, therefore, their immobilisation. The dynamics of Fe and Mn in soil as well as their zones of depletion through mobilisation and accumulation through precipitation, play an important role in the identification of the dominant water regime of a soil and could therefore be used to identify wetlands and wetland conditions.

4.5.5 Water movement in the soil profile

(All figures can be accessed in Appendix C; see also Figure 6, Figure 7 and Figure 8)

In a specific soil profile, water can move upwards (through capillary movement), horizontally (owing to matric suction) and downwards, under the influence of gravity. The background information outlined below needs to be taken into account when discussing water movement in soil.

- 'Capillary rise' refers to the process where water rises from a deeper lying section of the soil profile to the soil surface or to a section closer to the soil surface. Soil pores can be regarded as miniature tubes. Water rises into these tubes owing to the adhesion (adsorption) of water molecules onto solid mineral surfaces and the surface tension of water.

  The height of the rise is inversely proportional to the radius of the soil pore and the density of the liquid (water). It is also directly proportional to the liquid's surface tension and the degree of its adhesive attraction. In a soil-water system the following simplified equation can be used to calculate this rise:

$$\text{Height} = 0.15/\text{radius}$$

Usually, the eventual height of rise is greater in fine textured soil, but (in such a case) the rate of flow may be slower (Brady & Weil, 1999; Hillel, 1982).

- Matric potential or suction refers to the attraction of water to solid surfaces. Matric potential is operational in unsaturated soil above the water table while pressure potential refers to water in saturated soil or below the water table. Matric potential is always expressed as a negative value and pressure potential as a positive value.

  Matric potential influences soil moisture retention and soil water movement. Differences in the matric potential of adjoining zones of a soil results in the movement of water from the moist zone (high state of energy) to the dry zone (low state of energy) or from large pores to small pores.

  The maximum amount of water that a soil profile can hold before leaching occurs is called the soil field capacity. At a point of water saturation, a soil exhibits an energy state of 0 $J.kg^{-1}$. Field capacity usually falls within a range of -15 to -30 $J.kg^{-1}$ with fine textured soils storing larger amounts of water (Brady & Weil, 1999; Hillel, 1982).

- Gravity acts on water in the soil profile in the same way as it acts on any other body; it attracts towards earth's centre. The gravitational potential of soil water can be expressed as:

  $$\text{Gravitational potential} = \text{Gravity} \times \text{Height}$$

  Following heavy rainfall, gravity plays an important part in the removal of excess water from the upper horizons of the soil profile and recharging groundwater sources below.

  Excess water, or water subject to leaching, is the amount of water that falls between soil saturation (0 $J.kg^{-1}$) or oversaturation (> 0 $J.kg^{-1}$). In the case of heavy rainfall resulting in a pressure potential, and field capacity (-15 to -30 $J.kg^{-1}$), this amount of water differs according to soil type, structure and texture (Brady & Weil, 1999; Hillel, 1982).

- Under some conditions, at least part of the soil profile may be saturated with water, resulting in so-called saturated flow of water. The lower portions of poorly-drained soils are often saturated, as are well-drained soils above stratified (layers differing in soil texture) or impermeable layers after rainfall.

  The quantity of water that flows through a saturated column of soil can be calculated using Darcy's law:

  $$Q = Ksat.A.\Delta P/L$$

  Where Q represents the quantity of water per unit time, Ksat is the saturated hydraulic conductivity, A is the cross-sectional area of the column through which the water flows, ΔP is the hydrostatic pressure difference from the top to the bottom of the column, and L is the length of the column.

  Saturated flow of water does not only occur downwards, but also horizontally and upwards. Horizontal and upward flows are not quite as rapid as downward flow. The latter is aided by gravity (Brady & Weil, 1999; Hillel, 1982).

- Mostly, water movement in soil is ascribed to the unsaturated flow of water. This is a much more complex scenario than water flow under saturated conditions. Under unsaturated conditions only the fine micropores are filled with water, whereas the macropores are filled with air. The water content, and the force with which water molecules are held by soil surfaces, can also vary considerably. The latter makes it difficult to assess the rate and direction of water flow. Matrix potential is the driving force behind unsaturated water flow in the system. Water movement will be from a moist to a drier zone (Brady & Weil, 1999; Hillel, 1982).

The following processes influence the amount of water to be leached from a soil profile:

- Infiltration is the process by which water enters the soil pores and becomes soil water. The rate at which water can enter the soil is termed infiltration tempo and is calculated as follows:

$$I = Q/A.t$$

Where, I represents infiltration tempo ($m.s^{-1}$), Q is the volume quantity of infiltrating water (m^3), A is the area of the soil surface exposed to infiltration (m^2), and t is time (s).

If the soil is quite dry when exposed to water, the macropores will be open to conduct water into the soil profile. Soils that exhibit high (2:1) clay content (swelling-shrinking clays) will exhibit a high rate of infiltration initially. However, as infiltration proceeds, the macropores will become saturated and cracks, caused by dried out 2:1 clay, will swell and close, thus leading to a decline in infiltration (Brady & Weil, 1999; Hillel, 1982).

- Percolation is the process by which water moves downward in the soil profile. Saturated and unsaturated water flow is involved in the process of percolation, while the rate of percolation is determined by the hydraulic conductivity of the soil.

  During a rain storm, especially of heavy rain, water movement near the soil surface mainly occurs in the form of saturated flow in response to gravity. A sharp boundary, referred to as the wetting front, usually appears between the wet soil and the underlying dry soil. At the wetting front, water moves into the underlying soil in response to both matrix and gravitational potential. During light rain, water movement at the soil surface may be ascribed to unsaturated flow (Brady & Weil, 1999; Hillel, 1982).

  The fact that water percolates through the soil profile by unsaturated flow has certain ramifications when an abrupt change in soil texture occurs (Brady & Weil, 1999; Hillel, 1982). A layer of course sand, underlying a fine textured soil, will impede downward movement of water. Macro-pores of the coarse textured sand offer less attraction to the water molecules than the micro-pores of fine textured soil. When the unsaturated wetting front reaches the coarse sand, the matrix potential is lower in the sand than in the overlying material. Water always moves from a higher to a lower state of energy. The water can, therefore, not move into the coarse textured sand. Eventually, the downward moving water will accumulate above the sand layer and nearly saturate the fine textured soil. Once this occurs, the water will be held so loosely that gravitational forces will be able to drag the water into the sand layer (Brady & Weil, 1999; Hillel, 1982).

  A coarse layer of sand in an otherwise fine textured soil profile will also inhibit the rise of water by capillary movement (Brady & Weil, 1999; Hillel, 1982).

Field observations and laboratory-based analysis can aid in assessing the soil-water relations of an area. The South African soil classification system (Soil Classification Working Group, 1991) comments on certain field observable characteristics that shed light on water movement in soil. The more important of these are:

- Soil horizons that show clear signs of leaching such as the E-horizon – a horizon where predominantly lateral water movement has led to the mobilisation and transport of sesquioxide minerals and the removal of clay material;
- Soil horizons that show clear signs of a fluctuating water table where Fe and Mn mottles, amongst other characteristics, indicate alternating conditions of reduction and oxidation (soft plinthic B-horizon);
- Soil horizons where grey colouration (Fe reduction and redox depletion), in an otherwise yellowish or reddish matrix, indicate saturated (or close to saturated) water flow for at least three months of the year (Unconsolidated/Unspecified material with signs of wetness);
- Soil horizons that are uniform in colouration and indicative of well-drained and aerated (oxidising) conditions (e.g. yellow brown pedal B-horizon).

4.5.6 Water movement in the landscape

Water movement in a landscape is a combination of the different flow paths in the soils and geological materials (Figure 6). The movement of water in these materials is dominantly subject to gravity and, as such, it will follow the path of least resistance towards the lowest point. In the landscape, there are a number of factors determining the paths along which this water moves. Figure 5 in Appendix C provides a simplified schematic representation of an idealised landscape (in "profile curvature". The total precipitation (rainfall) on the landscape from the crest to the lowest part or valley bottom is taken as 100 %. Most geohydrologists agree that total recharge, the water that seeps into the underlying geological strata, is less than 4 % of total precipitation for most geological settings. Surface runoff varies considerably according to rainfall intensity and distribution, plant cover and soil characteristics but is taken as a realistic 6 % of total precipitation for our idealised landscape.

The total for surface runoff and recharge is therefore calculated as 10 % of total precipitation. If evapotranspiration (from plants as well as the soil surface) is taken as a very high 30 % of total precipitation it leaves 60 % of the total that has to move through the soil and/or geological strata from higher lying to lower lying areas. In the event of an average rainfall of 750 mm per year it results in 450 mm per year having to move laterally through the soil and geological strata. In a landscape, there is an accumulation of water down the slope as water from higher lying areas flow to lower lying areas.

To illustrate: If the assumption is made that the area of interest is 100 m wide it follows that the first 100 m from the crest downwards has 4 500 m^3 (or 4 500 000 litres) of water moving laterally through the soil (100 m X 100 m X 0.45 m) per rain season. The next section of 100 m down the slope has its own 4 500 m^3 of water as well as the added 4 500 m^3 from the upslope section to contend with, therefore 9 000 m^3. The next section has 13 500 m^3 to contend with and the following one 18 000 m^3. It is therefore clear that, the longer the slope, the larger the volume of water that will move laterally through the soil profile.

Flow paths through soil and geological strata, referred to as "interflow" or "hillslope water", are very varied and often complex due to difficulty in measurement and identification. The difficulty in identification stems more from the challenges related to the physical determination of these in soil profile pits, soil auger samples and core drilling samples for geological strata. The identification of the morphological signs of water movement in permeable materials or along planes of weakness (cracks and seams) is a well-established science and the expression is mostly referred to as "redox morphology". In terms of the flow paths of water large variation exists but these can be grouped into a few simple categories.

Figure 6 in Appendix C provides a schematic representation of the different flow regimes that are usually encountered. The main types of water flow can be grouped as:

- Recharge (vertically downwards) of groundwater.
- Lateral flow of water through the landscape along the hillslope (interflow or hillslope water).
- Return flow water that intercepts the soil/landscape surface (referred to as response zone or soils).
- Surface runoff.

Significant variation exists with these flow paths and numerous combinations are often found. The main wetland types associated with the flow paths are:

- Valley bottom wetlands (fed by groundwater, hillslope processes, surface runoff, and/or in-stream water).
- Hillslope seepage wetlands (fed by interflow water and/or return flow water).
- Wetlands associated with surface runoff, ponding and surface ingress of water anywhere in the landscape.

Amongst other factors, the thickness of the soil profile at a specific point will influence the intensity of the physical and chemical reactions taking place in that soil. Figure 7 in Appendix C illustrates the difference between a dominantly thick and a dominantly thin soil profile. If all factors are kept the same except for the soil profile thickness it can be assumed with confidence that the chemical and physical reactions associated with water in the landscape will be much more intense for the thin soil profile than for the thick soil profile. Stated differently, the volume of water moving through the soil per surface area of an imaginary plane, perpendicular to the direction of water flow, is much higher for the thin soil profile than for the thick soil profile. This aspect has a significant influence on the expression of redox morphology in different landscapes of varying soil/geology/climate composition.

4.5.7 Free draining versus inflowing systems

Free draining systems in this case refer to typical hillslopes where water drains towards the lowest point in the landscape and the flows out in a drainage feature or watercourse. Inward draining systems have no outflow (such as pans) and the dominant water removal is therefore through evaporation losses. Figure 8 in Appendix C provides a topographic wetness index (TWI) of a mining area in which free draining (linear features) and inwardly draining (circular features) are indicated. The blue lines indicate concentration of water flows. The implication of the two systems on rehabilitation planning will be discussed later in the report.

The dominant hydrological functioning of landscapes can be assumed to be very similar if only the side slopes are considered. Figure 9 in Appendix C provides an indication of the hydrological processes experienced in such landscapes. The hydrological difference between the two systems is seen in the fact that the free draining systems reaches a maximum water content soon and releases water downstream in drainage features. The inwardly draining system accumulates water and, theoretically, can do so until it overflows, or the water seeps away through more porous soils.

4.5.8 The catena concept

This concept is one of a topographic sequence of soils in a homogenous geological setting where the water movement and presence in the soils determine the specific characteristics of the soils from the top to the bottom of the topography. Figure 10 in Appendix C illustrates an idealised topographical sequence of soils in a catena for a quartz rich parent material. Soils at the top of the topographical sequence are typically red in colour (Hutton and Bainsvlei soil forms) and systematically grade to yellow further down the slope (Avalon soil form). As the volume of water that moves through the soil increases, typically in midslope areas, periodic saturated conditions are experienced and consequently Fe is reduced and removed in the laterally flowing water. In the event that the soils in the midslope positions are relatively thin and the resultant soil colour will be bleached or white due to the colour dominance of the sand quartz particles. The soils in these positions are typically of the Longlands and Kroonstad forms. Further down the slope, there is an accumulation of clays and leaching products from higher lying soils and this leads to typical illuvial and clay rich horizons. Due to the regular presence of water, the dominant conditions are anaerobic and reducing and the soils exhibit grey colours often with bright yellow and grey mottles (Katspruit soil form). In the event that there is a large depositional environment with prolonged saturation, soils of the Champagne form may develop (typical peat land). Variations in this sequence (as is often found on the Mpumalanga Highveld) may include the presence of hard plinthic materials instead of soft plinthite, with a consequent increase in the occurrence of bleached soil profiles. Extreme examples of such landscapes are discussed below.

4.5.9 Convex versus concave landscapes in an idealised catena

An additional factor of variation in all landscapes is the shape of the landscape along contours (referred to a "plan curvature"). Landscapes can be either concave or convex, or flat. The main difference between these landscapes lies in the fact that a convex landscape is essentially a watershed with water flowing in diverging directions with a subsequent occurrence of "dryer" soil conditions. In a concave landscape water flows in converging directions and soils often exhibit the wetter conditions of "signs of wetness" such as grey colours, organic matter and subsurface clay accumulation. Figure 11 in Appendix C presents the difference between these landscapes in terms of typical soil forms encountered in an idealised catena. In the convex landscape the subsurface flow of water removes clays and other weathering products (including Fe) in such a way that the mid-slope position soils exhibit an increasing degree of bleaching and relative accumulation of quartz (E- horizons).

In the concave landscapes clays and weathering products are transported through the soils into a zone of accumulation where soils start exhibiting properties of clay and Fe accumulation. In addition, coarse sandy soils in convex environments tend to be thinner due to the removal of sand particles through erosion and soils in concave environments tend to be thicker due to colluvial accumulation of material transported from upslope positions. Similar patterns are observed for other geological areas with the variation being consistent with the soil variation in the catena.

These concave and convex topographical environments often occur in close proximity or in one topographical sequence of soils. This is often found where a convex upslope area changes into a concave environment as a drainage depression is reached (Figure 12 in Appendix C). The processes in this landscape are the same as those described for the convex and concave landscapes above.

4.5.10 BA and AB plinthic catena

The plinthic catena specifically found on the Mpumalanga Highveld is dominated by Ba and Bb land types. The Ba land types denote areas where red soils dominate and are conceptually the same as the idealised catena described above. The Bb land types denote areas where yellow and bleached soils dominate (Figure 13 in Appendix C). Additional variation is found in the form of soil depth as well as the extent of soft versus hard plinthic material occurrence.

Due to the emphasis placed on soil colour (and colours associated with wetness) in the wetland delineation guidelines (DWAF, 2005), the difference between the red- and yellow/bleached- soil-dominated land types leads to a slight over representation of wetlands in the Bb land types as the bleached colours are used as wetland indicators. This difference is considered an artefact associated with a less intense influence of dolerite in certain landscapes. The subsequent exaggeration of wetland spatial extent in these landscapes is not considered to be significant in terms of the mining impacts discussed later in the report.

4.5.11 Wetland-terrestrial soil linkages and agricultural potential conundrum

The soils and landscapes discussed in the previous sections can be divided into terrestrial and wetland soil areas (Figure 14 in Appendix C). Although the main discussion in this document centres around wetlands and hydrological linkages, it is important to note that the terrestrial area has 1) high agricultural potential and 2) functions as the recharge area for the wetlands. The conundrum in this discussion is evident when one considers the mining authorisation process often conducted by consultants/specialists and adjudicated by the specific competent authority. Due to the intense emphasis on wetlands, wetland areas can be classified as follows: 1) identified: 2) delineated: and 3) conserved with a buffer. The tragedy in this process lies in the fact that the terrestrial areas are often perceived to be the most impacted parts of the site (due to historical agricultural use, tillage and ecological alteration) and therefore easily sacrificed for opencast mining, therefore completely compromising the headwaters and feeding areas of the wetlands. It follows, therefore, that the exact process followed to protect the wetlands is so flawed that it leads to a drastic decrease in water supply and therefore a significant degradation in the functioning of the wetland. (See Figure 8 in Appendix C).

4.6 Implications for wetland conservation in opencast mining environments

4.6.1 Free draining systems

Whether or not an area is designated a wetland loses some of its relevance once drastic influences on landscape hydrology are considered. If wetlands are merely the expression of water in a landscape due to proximity to the land surface (viz. the 50-cm mottle criterion in the delineation guidelines) it follows that potentially large proportions of the water moving in the landscape could fall outside of this sphere – as discussed in detail above. Figure 15 in Appendix C provides a schematic representation (as contrasted with Figure 6 in Appendix C) of water dynamics in an opencast mining environment in a free draining system. Figures 16 in Appendix C to 23 indicate examples of the flow regimes on a specific mine indicated schematically in Figure 15 in Appendix C.

In typical opencast mining, the topsoil and overburden rock is stripped to access the ore body at depth. The topsoil often includes the entire weathered zone (entire soil profile). As indicated earlier, it is within these soil layers that a large proportion of water in the landscape flows. The stripping of overburden rock destroys further flow paths. Once the void is "rehabilitated", it is filled with loose unconsolidated material with vastly different physical properties (porous and unconsolidated versus solid or sparingly permeable bedrock). Due to the drastic change in physical properties, the filled-in mine void area becomes an area of drastically increased recharge. Some workers in the field indicate a 10 to 20-fold increase in recharge. The recharge into the filled-in material implies that water will percolate down to the original mine floor, with a subsequent filling of the void, until it decants at the lowest point. If there is an elevated pyrite content associated with rock layers (that have now been broken up, resulting in a drastically increased surface area), these voids start generating sulphates and acid. Drainage water, exiting the mine area at the decant point, then establishes an acid- and/or sulphate- rich seep. These seeps have many wetland characteristics, but with the difference that they are highly altered chemically and biologically.

The same principles (as above, but in this case for an inward draining system) are illustrated in Figure 24: Appendix C. In cases where the landscape around the depression (pan) has been mined up to the "wetland buffer" (or often the 1:100 flood line) there is 1) a decrease in ground level, due to a volume decrease through coal removal and 2) a raising of the depression above the surrounding landscape. The consequence is a depression (pan) system with a drastically decreased catchment that leads to a significant drying out of the system and concomitant change in ecological character over time. This aspect is illustrated by the pan system illustrated in Figures 25 and 26 in Appendix C, with the wetland area making up only a small section of the entire catchment. The drop in ground level surrounding the pan (Figure 24b: Appendix C) decreases water supply.

Complete mining of terrestrial and wetland zones

In the case where the entire landscape is mined, a complete destruction of the hydrological processes is experienced and the entire landscape is “rehabilitated”. The complete mining of a pan system requires a change in hydrology to a free draining system in order to minimise stability risks on the post-mining site. A three-dimensional model of the pan system before mining, and a conceptual re-establishment design, is provided in Figure 19 in Appendix C.

In a pan system, the pre-mining hydrology is inward-draining and therefore saturated with water, with free water standing in the pan basin (Figures 28 and 29 in Appendix C). The soil profiles indicate depression conditions with an accumulation of salts and weathering products – often in the form of specific clay minerals having formed in the accumulation environments over millennia (Figure 30 in Appendix C). The chemistry of the pan basin floors (data not presented here) usually indicate and accumulation of Na to very high levels, which is indicative of poor or non-existent drainage in a landscape such as the Eastern Highveld that usually exhibits very low Na levels in free draining environments. A distinct example of this phenomenon is the soil profiles (Figure 30 in Appendix C) that indicate soil morphology similar to vertical properties, but where the dominant clay mineral is kaolinite in the presence of very high Na levels. The swelling property, erroneously attributed to smectite clay dominance, was afterwards correctly assigned to the effect of Na dispersion of kaolinitic clays. The high Na levels impart dispersive properties to the clay minerals with a subsequent instability and distinct tendency for erosion, should these soils be deposited on slopes.

4.6.2 Geotechnical, soil stability and hydrological function considerations in wetland rehabilitation

The re-establishment of plinthite layers is often proposed as a means to ensure the hydrological functioning of a post-mining landscape. At the outset, it needs to be emphasised that the stripping of soils before mining is a process that is described in the “soil utilisation guide” provided with the EIA and EMP for mining applications. These guides are based on detailed soil surveys and provide stripping, stockpiling and soil placement guidelines. In practice, these plans are difficult and financially restricting to execute. Most, if not all, mining operations therefore fail to execute the plans.

The establishment of plinthic layers poses another challenge since these are the products, rather than the cause, of landscape hydrological processes. The same applies to extensive E horizon profiles that act as lateral conduits for water in most plinthic landscapes. It is therefore counter-intuitive to promote the re-establishment of such layers in the post-mining landscape without being able to re-establish the hydrological functioning of the landscape. as discussed in the previous section.

4.6.3 Soil and material handling planning for rehabilitation

To plan and execute a mine stripping, storage and placement plan for mined material the assessment of a proposed mining site should, ideally, consist of the following parameters:

1. Conduct a detailed soil survey to identify, classify and map, the soils of the site.
2. Conduct a detailed geological assessment of the coal bearing strata and overlying material, to determine material characteristics.
3. Generate a mine plan.
4. Generate a soil stripping, stockpile and placement plan, in line with the mine plan.
5. Generate a rehabilitation plan in line with national guidelines and / or requirements of the competent authority.
6. Implement the rehabilitation plan and conduct monitoring with interventions where required. Due to the cost associated with the above exercise, most mines only execute components of the above. Detailed wetland rehabilitation requires a higher level of intensity

than that described above. It is, therefore, even more costly than generic rehabilitation processes.

4.6.4 Geotechnical considerations

If the process set out above is followed in detail, then the geotechnical stability of the materials comes in to play, with respect to the long-term integrity of rehabilitation efforts and planning. A pre-mining landscape consists of a hard temporally-stable geological base with the weathered zone (soils and wetlands) at the surface. The hydrological functioning of the landscape is a function of the hardness and permeability of materials in the various layers. As indicated in Figures 15 and 24 in Appendix C, the mine voids are filled with unconsolidated materials with a permeability that is rather homogenous, with variation in depth. Alteration in permeability is the main cause of the increased recharge characteristics of the landscape. However, the unconsolidated materials are not stable and will undergo different degrees of settling and consolidation as a function of dry and wet conditions of the material, with the wetness changing over time, due to the increased recharge. A decrease in material volume is therefore inevitable, but difficult to predict, because of several factors that introduce variability in the material characteristics: cohesion between particles, and loading of overlying layers. Additionally, the settlements may differ spatially. Total settlement and consolidation will continue for many years, with a decrease in intensity over time (Figure 31 in Appendix C).

4.6.5 Soil stability and hydrological functioning considerations

Hydrological functioning in a post-mining landscape is significantly different to that of the pre- mining landscape, with a consequent drastic alteration in flow regimes and wetland feeding processes. Interested and affected parties, as well as the regulator, often indicate that the pre- mining landscape's hydrology should be mimicked with the rehabilitation design. This requirement is near-impossible as the re-establishment of pre-mining hydrological processes would require the construction or installation of impermeable liners to counteract, and arrest, the high permeability of the newly-placed unconsolidated materials. These liners have to remain intact in order to maintain functionality. The significant settling and consolidation, and the spatial variability of such processes, preclude the successful long-term functioning of such liners. The only way to increase the probability of success and maintenance of integrity of the liners is to significantly increase the compaction and shaping of the underlying spoil layers. The cost of such intensive exercises often exceeds the value of the coal in the mine and these approaches are therefore never implemented.

A compounding factor in the above consideration is that the post-mining landscapes have to be free-draining to prevent accelerated consolidation, failure of containment structures due to compromised integrity upon settling differentially, as well as adverse human safety and environmental impacts and processes, such as sediment generation. Whereas the planning and rehabilitation of wetlands require minimal professional certification, the design and construction of stable structures requires the sign-off of a professional engineer. In practice, engineers are very loathe to sign-off on structures of which the integrity and stability poses uncertainties.

Additionally, the placement of pan basin soils on slopes is risky due to the dispersive nature of clay soils that have elevated Na levels that, in comparison to Ca levels, lead to a distinct instability of the clays due to dispersion induced by the Na. On slopes, these soils therefore have no cohesion when wet and will readily erode and "flow" downslope.

4.6.6 Re-establishment of plinthic layers

An argument often put forward is that if plinthic layers can be re-established, the hydrological functioning of the post-mining landscape can mimic that of the pre-mining landscape. The argument rests on a number of exaggerated expectations, however. The following aspects are of critical relevance to the above argument.

1. That the occurrence of plinthic layers is not a function of the soil itself, but rather of the underlying weathered and hard rock materials. The plinthic layers originate predominantly due to return flow of water out of the landscape where the lateral flow paths in fractured or stratified rock layers intercept the topography. It, therefore, follows that these flow paths have to be established first in the filled-in spoil, before the plinthic layers will function in a similar way as in the pre-mining landscape.

2. Establishment of lateral flow paths in unconsolidated spoil material is not feasible, due to the design, placement, compaction and sealing efforts required to attain such. These lateral flow paths pose significant geotechnical stability challenges that are too costly and risky to address.

3. Consolidation and settlement characteristics of the spoil material leads to a constantly-changing material environment, from a physical strength and void-characteristic perspective. It is inevitable that deliberately-constructed seals and flow paths will be severed or compromised through shifts in layers and material.

4. The lateral movement of water within a plinthic landscape is often characterised by slow, almost horizontal, seepage through sandy E-horizons. These soils are stable *in situ,* as they are in equilibrium with the hydrological processes that dominate the landscape.

5. The construction of such seepage zones, with similar flow rates and stability, is not readily performed and these lateral seepage areas will require significant maintenance and stabilisation.

Taking into account the above challenges regarding the establishment of plinthite-type lateral flow paths, lead to the preferred option of keeping water flows on the surface in post-mining landscapes. On the surface, the water is visible, treatable and erosion and stability impacts can be managed more efficiently if these flow paths are buried.

4.6.7 Implications for post mining land capability

In the EMP process for a standard opencast mine there is a distinct irony. Whereas these mines are often licensed to mine in “terrestrial” areas that comprise high potential agricultural land, the relevant authorities (DAFF) require the land to be rehabilitated to ‘as close to the original land capability’ as possible. For crops to grow, the infiltration of the soil must be at a maximum to ensure sufficient water in the soil profile. On the other hand, DWS would require that the water infiltrating into the porous material should be at a minimum, to minimise acid and sulphate generation in the porous spoil material – the aim therefore being to minimise acid mine drainage decants. The above description indicates that there is a distinct conflict in what is advised and required for mines during the EIA/EMP process. This issue is not adequately addressed at regulator level and the mines are often provided with conflicting guidelines.

4.6.8 Implications for post mining water quality management

As indicated in Figure 15: Appendix C, the seepage of mine-impacted water from spoil deposits is a distinct risk in mining environments. The implications are that 1) new wetlands can occur in mining environments as water drains out on to seep areas; or 2) wetlands that are established can experience ingress of poorer quality water in terms of acidity, metals and sulphates. The change in water quality has an adverse effect on the ecological characteristics of the wetland systems into which the water flows. The extent of the effect is determined by difference in pH and salt loads of the polluted water compared to those of the natural wetland water.

4.7 Conclusions and recommendations

This chapter contributes biophysical knowledge and understanding to the project, and specifically addresses the objective: "*To conduct an analysis of available resource- and catchment-based tools aimed at sustainable development of water resources and management*."

Four assessment tools were used, and their value was judged as outlined below.

1. Qualitative wetland assessments: WET Health and WET EcoServices.

    - The WET Health assessment indicated that the wetlands were in a 'reasonable to good' state of health and there were no recognisable differences between wetlands in mining and agricultural landscapes, as well as no clear evidence of impact from the 2012 AMD crisis.
    - The WET health assessment was inadequate for assessing water quality
    - The WET ecosystem service assessment provided a knowledge base to share with users that stimulated discussion of the experienced value of the wetlands in the landscape. There were differences in the value to different users, with mining-, agriculture- and subsistence-use eliciting different value statements.
    - Both assessments were placed in context with stakeholder narratives, the surfaced tensions, and the reality of a "resource dilemma", defined by Ison et al. (2007) as follows

        "Resource dilemmas do not lend themselves easily to scientific analysis and solutions. In fact, they are complex in that a great many factors, bio-physical, social, economic and political, interact in processes that are only partially path-dependent and usually unpredictable."

2. Quantitative assessment of aquatic macroinvertebrate community structure and biodiversity, in relation to water chemistry.

- The great detail of macroinvertebrate and chemical sampling and analysis revealed interesting ecological information about communities of macroinvertebrates associated with different sites – but the groupings could not be correlated with either mining or agricultural landscapes.
- There were no strong groups of macroinvertebrate taxa associated with "mining" or "non-mining" sites, nor were there groups of taxa that are classified in a SASS Scoring System as having higher or lower ecological sensitivity, associated with "mining" or "non-mining" sites.
- There was, however, biodiversity evidence of longer-term impacts from the 2012 AMD crisis, with the mining site having lower biodiversity scores, and a tributary wetland in a mining-influence landscape, having a lower biodiversity core than a tributary in an agricultural context.
- The single set of water chemistry samples showed evidence of water chemistry impacts from mining, with characteristic elevations in salinity (particularly sulphate ions) and acid pH conditions. These are AMD signatures.

3. Hydropedology
    - The key biophysical data from the hydropedology study showed that the conventional wetland delineation of the first two studies would not reveal wetland impact until it was too late. We need hydropedological and hydrological connectivity studies to identify places where mining puncturing of the sandstone layers cause wetlands to "leak away". Similarly, we need to map un-punctured landscape units and seek to make them "no mining zones". Without this, the Highveld wetlands are gravely at risk.

An emergent finding of the study was the recognition of the relative power of the mining sector that leads to "mining impunity". There was inadequate engagement, or absence, of the sector at participatory meetings. This was particularly true of the DMR. This was confirmed by various water governance institutions active in the catchment.

The following recommendations are proposed, as a means of ameliorating the situation, as described above.

1. Publish the limitations of the widely used WET Health delineation process as an indicator of wetland condition, noting that the wetland perimeter that is currently delineated may not indicate a threat from puncturing impermeable layer.

2. Use hydropedology to delineate Highveld wetlands and use this information to lobby for effective wetland protection.

3. The Departments of Water and Sanitation, Environmental Affairs and Mineral Resources need to engage at the highest political and administrative levels to address impunity and co-operative governance.

4. Since Recommendation 3, above, is unlikely to eventuate within the foreseeable future, water activism seems the most effective avenue for wetland protection.

5 ECONOMIC EFFECTS OF LAND USE CHOICES INCLUDING AGRICULTURE AND COAL MINING, A STUDY IN RESOURCE ECONOMICS[12]

5.1 Background and introduction

In the context of rapid land use changes that lead to biodiversity losses (Ferrar & Lötter, 2007), increased water use and pollution (for example, acid mine drainage due to mining activities (Aurecon and SRK Consulting, 2014)) and perceptions that coal mining activities negatively affect current and future livelihoods, for example, in the Carolina area. Munnik et al., 2009), this study aimed to understand how different land uses and practices change natural capital (NC) stocks and flows, now and into the future (up to 50 years from now).

What are the net impacts of past, existing, and future land uses on natural capital stocks, flows and values of the ecosystems in the Carolina area? What are the associated economic benefits and costs? What are the policy implications for policy- and decision-making, with respect to land-use change and for on-site management of natural capital stocks, flows and values at the property (e.g. farm, mine) and catchment levels?

The WRC Project K5/2355 project team selected the Boesmanspruit wetland, upstream from the Boesmanspruit dam, as one of the project study sites. It was seriously affected by acid mine drainage in 2012, which lead to drinking water problems for Carolina inhabitants (Mpumalanga Tourism and Parks Agency, 2012). The study area, for this specific study, is located in the agricultural-mining landscape mosaic near Carolina, Mpumalanga (Figure 54).

According to the Mpumalanga Biodiversity Conservation Plan (Ferrar & Lötter, 2007), the terrestrial and aquatic biodiversity in the catchment of the Boesmanspruit is highly significant for the Komati catchment. It contains red data fauna and flora species and probably sustains the last biodiversity centre in the area Figures 54 and Figure 55).

5.2 Natural capital as stocks, and ecosystem services as flows

"Natural Capital' can be defined as the stock of renewable and non-renewable natural resources (e.g., plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people" (Natural Capital Coalition, 2016). In other words, it is from natural capital stocks or assets that companies – as well as individuals, communities, governments and other land users – derive a wide range of services (aka 'ecosystem services') which enable the viability of their business models (Haines-Young & Potschin, 2013; Landers & Nahlik, 2013; Millennium Ecosystem Assessment, 2005; Nahlik et al., 2012).

According to the Common International Classification of Ecosystem Services (CICES-1) (Haines-Young & Potschin, 2013), ecosystem services can be classified into three categories: 1) provisioning services which generate beneficial goods, such as food and water; 2) regulating services which generate tangible benefits derived from ecosystem processes, such as flood, erosion and disease control processes; and 3) cultural services which generate social benefits obtained from experiencing ecosystems, such as recreation opportunities and spiritual values.

[12] Our gratitude goes to:

Nyiko Magoro and Brian Jackson from the Inkomati Usuthu Catchment Management Agency (IUCMA), for their help with compiling a map of the study area;

Mr Combrinck for welcoming us to his farm and sharing his experiences and information with us; and

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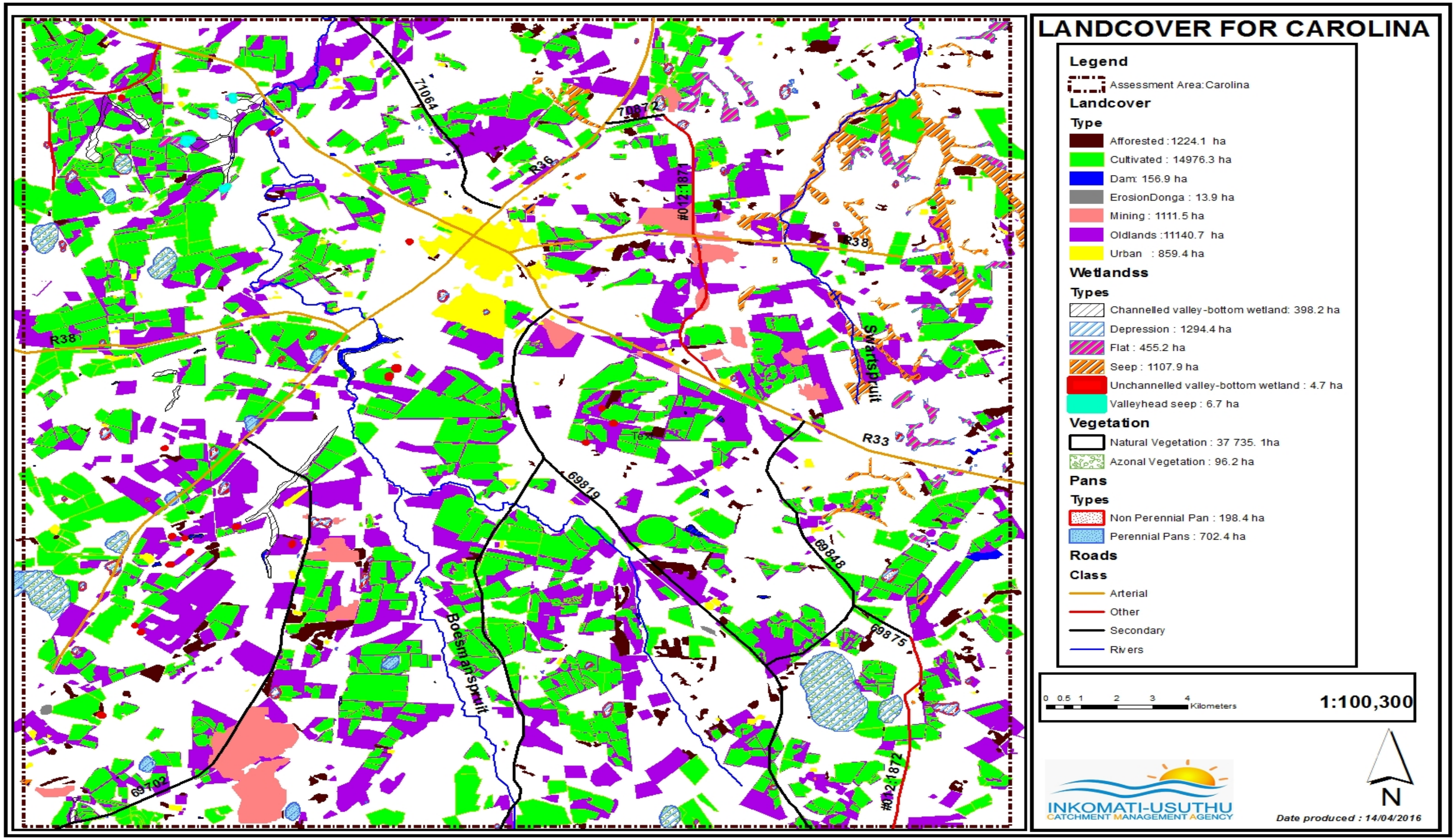

Figure 54: Land cover of the study area in 2006, the agricultural-mining mosaic surrounding the town of Carolina, Mpumalanga. (Courtesy of Nyiko Magoro).

It is critical to note that businesses depend on (i.e. for the use of water in agriculture and mineral mining) and impact on, natural capital stocks and the associated ecosystem services (Houdet et al., 2012). Yet such interactions do not all have the same consequences, as natural capital stocks are divided into renewable and non-renewable assets. While metals and minerals are non-renewable, natural capital assets (e.g. coal), whose exploitation can only lead to their eventual depletion, water resources and populations of mammal species are renewable natural capital assets that can (theoretically) be sustainably managed.

Governments, companies and citizens are often not aware of the benefits they receive from ecosystem services. Sometimes they decide not to recognise, or to discard, these benefits because they cannot capture them for their own purposes or those of target stakeholders. This prevents them from fully integrating the values of natural capital and ecosystem services into policy and decision-making as well as strategic planning and operational routines (Houdet et al., 2012).

Because such ideas and attitudes can lead to wrong, or sub-optimal, decisions from a 'public good' perspective, with negative or catastrophic consequences for those impacted, a good understanding of ecosystem services (including their benefits and trade-offs) in development pathways is a prerequisite if a collective strives for win-win-win outcomes for people, business and nature (TEEB, 2010). This is why there is increasing interest worldwide in the valuation of natural capital and ecosystem services. Such studies generate information regarding the benefits economic agents derive from nature, so as to better inform various decision-making processes and applications for both the public and private sectors (Waage, 2014; Natural Capital Coalition, 2014). As noted above, the availability of better information does not always ensure that it is taken into decision-making.

5.3 Choosing the right valuation approach

Valuation provides insights into what matters to people. This can be useful at various stages of the mining project life-cycle, e.g. investment decision-making, mine design, operations management, risk analysis or closure planning, via qualitative, quantitative, non-monetary and/or monetary valuation methods. Non-monetary valuation methods include quantitative and qualitative research techniques (surveys, interviews) and participatory and deliberative tools (focus groups, citizens' juries, participatory or rapid rural appraisal), as well as methods of expressing preferences in non-monetary but quantifiable terms (preference assessment, time use studies) (Christie et al., 2012; Kelemen et al., 2014).

Some studies also consider the spatial representation of ecosystem services through demand mapping and analytic tools rooted in biophysical approaches. While the choice of the value type largely depends on the type and availability of data, one also needs to critically focus on the guiding research question for framing the study. As argued by Levrel et al. (2012), the most common approach focus (favoured in a typical cost–benefit analysis or in development alternatives) is on opportunity cost assessment. Such an approach is based on the substitutability between forms of capitals (e.g. natural capital can be substituted by financial or human capital). One could, thus, assess the economic value(s) of each positive and/or negative social and environmental impact (externality) of a business or project that is linked, directly and/or indirectly, to stakeholders at the local, regional, national and/or international level. For instance, in coal mining, such externalities would include those arising from environmental pollution (e.g. acid mine drainage, biodiversity loss), the loss/degradation of livelihoods (e.g. loss of grazing land) and broader social costs such as increased health care costs.

Assessing the net impact of a coal mine in monetary terms may, however, not reveal the full picture, as the loss of many natural capital assets and associated ecosystem services may not be presently valued by targeted stakeholders, compared with the immediate benefits of the mining projects (state tax revenues, jobs). A second approach, grounded on the assessment of the cost-effectiveness of reaching specific targets (e.g. no-net-loss or net gains of natural capital), has thus been proposed. This alternative, and potentially complementary, approach is grounded on strong sustainability principles (i.e. no substitution between different forms of capital). In this context, maintenance or restoration costs are critical, as are losses/gains in ecosystem values in space and time.

In other words, while the opportunity cost approach can be useful to identify the most important types of benefits and costs of various ecosystem services to society, the cost-effectiveness approach aims to assess the minimal costs of achieving sustainable use and/or impact mitigation targets (Houdet & Chikozho, 2014).

Given budgetary and time constraints, the study was originally divided into four main work phases, combining the opportunity cost and cost-effectiveness approaches, described in Section 5 above.

The first work phase involved a literature review of environmental challenges facing the study area and various theoretical frameworks (valuation, economic impact modelling, net impact accounting) so as to determine the precise scope and methodology for the study. This was designed to take budgetary limitations into account, which led us to choose qualitative valuation and benefit transfer methods, in the hope that stakeholder-specific information would be available for economic impact modelling.

The second phase involved data collection through stakeholder consultations. The Inkomati Usuthu Catchment Management Agency (IUCMA) provided a map of the study area (Figure 54) and surface areas of different land uses (only 2006 data available though). A site visit in the Carolina area was organised on 5 April 2016 to collect site-specific data. Discussions with a farmer (Mr Derek Combrink) and the Manager of Northern Coal (Mr Greg Middup) were held. Further email discussions with Mboso Coal were also held. Yet, access to mine operation-specific data was not feasible. Targeted coal mining operations did not share data about their revenues/expenses and environmental management processes, costs and liabilities. As a result, it was not possible to assess the positive and negative externalities for their operations.

As a result, the present study was re-framed using exclusively a qualitative valuation approach, based on the maintenance of natural capital in the long term. This approach can be used when there are gaps in quantitative baseline data. The study undertook economic impact modelling of the benefits and costs of the different land uses (one farm and one coal mine) based on data disclosed by targeted business activities; and net impact accounting according to different scenarios.

Despite these limitations, it is hoped that this study will demonstrate some useful that qualitative valuation approaches, so as to open debates on land-use planning in the study area as well as broader water governance challenges facing South Africa.

5.4 Modelling changes in natural capital and ecosystem services in Carolina

5.4.1 Assessing the condition of current natural capital assets

Table 19 summarises the current condition scores for the all the different land-uses in the study area. Scores are based on expert opinion (site visit on April, 5) but low- and high- condition score alternatives are provided to cater for any uncertainty / error at the level of individual parcels (e.g. some grazing lands may be in better condition than others) due to the lack of detailed surveys. In some cases, however (e.g. urban areas), low and high condition would be the same, due to the severity of damages to original ecosystems (i.e. total transformation).

As could be expected, from a total of 71 482 ha (maximum condition score of 7 for original vegetation), with 41 999 ha of relatively natural vegetation remaining (i.e. wetlands, azonal vegetation, and grasslands). Extensive land use changes in the study area have, respectively, led to a loss of 49 271 and 39 365 weighted ha in the low- and high- condition score scenarios. This shows that existing land uses may serve various purposes and provide different types and amounts of ecosystem services to different beneficiaries. In other words, not all changes lead to a complete loss of original habitat condition and some changes can potentially be reversed through habitat restoration measures.

Table 19: The condition of the various land-use categories in the study area.

Land-use category	Surface area (Ha)	Current condition compared to original vegetation score of 7: 1- completely artificial / degraded, 2- very poor, 3- poor, 4- medium, 5- good, 6- very good		Weighted condition score		Loss of hectares (weighted condition score)	
		Low	High	Low	High	Low	High
Afforested	1224	1	2	175	350	1049	874
Cultivated	14976	1	2	2139	4279	12837	10697
Dams	157	1	1	22	22	134	134
Erosion /	14	1	1	2	2	12	12
Mining	1112	1	1	159	159	953	953
Old / disturbed / unused lands	11141	1	2	1592	3183	9549	7958
Urban	859	1	1	123	123	737	737
Channelled valley-bottom	398	3	4	171	228	228	171
Depression	1294	3	4	555	740	740	555
Flat	455	3	4	195	260	260	195
Seep	1108	3	4	475	633	633	475
Unchannelled valley-bottom	5	3	4	2	3	3	2
Valleyhead seep	7	3	4	3	4	4	3
Total wetlands	3267	3	4	1400	1867	1867	1400
Perennial pans	702	3	4	301	401	401	301
Non-perennial pans	198	3	4	85	113	113	85
Natural	37735	3	4	16172	21563	21563	16172
Azonal	96	3	4	41	55	55	41
	71482			**22211**	**32117**	**49271**	**39365**

5.4.2 Assessing the capacity of different land uses to provide different ecosystems services

Table 20 presents the current capacity scores for supplying different types of ecosystem services for the all the different land-uses in the study area. The scores are based on practitioner and expert opinion (site visit on 5 April) and highlight that different land-uses provide different levels of ecosystem services. For instance, wetlands provide water and assimilate and dilute nutrients, while grasslands provide fodder/grazing services and hence are key for livestock production (scores of 2 or 3 out of a maximum of 3).

To simplify the modelling, only one score for each ecosystem service category was given for each land use, thus not reflecting differences in land management practices for the same type of land use. Yet different approaches to ecosystem management for the same land use (e.g. mining or farming) can modify the level of ecosystem services supply.

5.4.3 Assessing the supply of ecosystem services

Table 21 summarises the current potential ecosystem services supply scores (for all the different land-uses in the study area) for different types of ecosystem services. The land uses with the highest levels of ecosystem services supply are natural grasslands (due to the large surface area remaining), wetlands (all types combined), cultivated lands (for provisioning services such as maize) and old/disturbed/unused lands (largely due to relatively large surface areas, because of a relative capacity to supply ecosystem services) (Figure 56).

The ecosystem services supplied the most are fodder/grazing services, animals raised for food (livestock), and soil formation services (Figure 57). Water-related services are less prominent, due to lower surface areas of key underlying habitats (dams, wetlands) while biodiversity conservation services are relatively moderate, due to high levels of ecosystem transformation (Figure 57). coal and other mining resources are currently supplied at relatively low levels, due to the limited surface areas where such activities are allowed to take place.

5.4.4 Assessing the demand for ecosystem services

Based on stakeholder consultations and desktop research, we made a number of assumptions regarding ecosystem services users in the study area (i.e. beneficiaries). The total Carolina population was estimated at around 18 000 people (16 847 in the 2011 census by Statistics South Africa), of which 500 are miners (5 000 with their family members) and 300 farm workers (3 000 with their family members).

Table 22 presents the ecosystem services demand across the study area, with the highest demands being for water-related services (quality, dilution and assimilation, water supply regulation, domestic water supply) and, to a lesser extent, food production services (animals raised for food, cultivated foods, fodder/grazing). While the demand for cultural services appears to be much lower, (to a large extent, reflecting diminished natural capital assets and lack of associated infrastructure, one can also highlight the demand for coal and other minerals, due to the relatively important number of people depending on these activities (Figure 58).

Table 20: The capacity of the various land-use categories to supply different ecosystem services in the study area (0 - nil, 1 - low, 2 - medium, 3 - high).

								Wetlands									
Ecosystem services	Afforested lands	Cultivated lands	Dams	Erosion / dongas	Mining	Old / disturbed / unused lands	Urban	Channelled valley-bottom	Depression	Flat	Seep	Unchannelled valley-bottom	Valleyhead seep	Perennial pans	Non-perennial pans	Natural grasslands	Azonal vegetation
Air pollution regulation (dust)	3	1	1	0	0	1	1	1	1	1	1	1	1	2	1	1	2
Animals raised for food	0	0	0	0	0	1	0	1	1	1	1	1	1	0	2	3	1
Biodiversity conservation	0	0	1	0	0	0	0	2	2	2	2	2	2	3	2	2	2
Carbon storage	3	0	0	0	0	1	0	1	2	2	2	1	2	1	1	1	2
Cultural heritage	0	1	0	0	0	0	2	2	1	1	1	1	1	1	1	1	1
Fire damage control	1	1	3	2	1	1	2	2	2	2	2	2	2	3	2	1	2
Fodder / grazing	0	2	0	0	0	1	0	1	1	1	1	1	1	1	3	3	2
Fuel	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Medicinal products	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	1	1
Wild foods	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
Cultivated crops	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic water supply	1	1	3	0	1	1	0	3	3	3	3	3	3	2	1	1	2
Soil formation / fertility	0	1	0	0	0	1	0	1	1	1	1	1	1	2	2	2	2
Recreation	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1
Water quality (dilution)	1	0	2	0	0	1	0	2	2	2	2	2	2	2	2	1	2
Water quality (assimilation)	1	0	2	0	0	1	0	2	2	2	2	2	2	2	2	1	2
Water supply regulation	2	1	3	0	1	1	1	2	2	2	2	2	2	2	2	1	2
Coal and other mined resources	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0

Table 21: Potential supply of ecosystem services by the various land-use categories in the study area

Ecosystem services	Afforested lands		Cultivated lands		Dams		Erosion / dongas		Mining		Old / disturbed / unused lands		Urban		Wetlands		Perennial pans		Non-perennial pans		Natural grasslands		Azonal vegetation		Total	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Air pollution regulation (dust)	525	1049	2139	4279	22	22	0	0	0	0	1592	3183	123	123	1400	1867	602	803	85	113	16172	21563	110	110	22770	33112
Animals raised for food	0	0	0	0	0	0	0	0	0	0	1592	3183	0	0	1400	1867	0	0	170	227	48517	64689	55	55	51733	70020
Biodiversity conservation	0	0	0	0	22	22	0	0	0	0	0	0	0	0	2800	3734	903	1204	170	227	32344	43126	110	110	36350	48423
Carbon storage	525	1049	0	0	0	0	0	0	0	0	1592	3183	0	0	1400	1867	301	401	85	113	16172	21563	110	110	20185	28287
Cultural heritage	0	0	2139	4279	0	0	0	0	0	0	0	0	246	246	2800	3734	301	401	85	113	16172	21563	55	55	21799	30391
Fire damage control	175	350	2139	4279	67	67	4	4	159	159	1592	3183	246	246	2800	3734	903	1204	170	227	16172	21563	110	110	24537	35125
Fodder / grazing	0	0	4279	8558	0	0	0	0	0	0	1592	3183	0	0	1400	1867	301	401	255	340	48517	64689	110	110	56453	79148
Fuel	525	1049	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	55	55	580	1104
Medicinal products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1400	1867	0	0	0	0	16172	21563	55	55	17627	23485
Wild foods	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	301	401	85	113	16172	21563	55	55	16613	22133
Cultivated crops	0	0	6418	12837	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6418	12837
Domestic water supply	175	350	2139	4279	67	67	0	0	159	159	1592	3183	0	0	4201	5601	602	803	85	113	16172	21563	110	110	25302	36227
Soil formation / fertility	0	0	2139	4279	0	0	0	0	0	0	1592	3183	0	0	1400	1867	602	803	170	227	32344	43126	110	110	38358	53594
Recreation	175	350	2139	4279	22	22	0	0	0	0	0	0	123	123	1400	1867	301	401	85	113	16172	21563	55	55	20473	28773
Water quality (dilution)	175	350	0	0	45	45	0	0	0	0	1592	3183	0	0	2800	3734	602	803	170	227	16172	21563	110	110	21666	30014
Water quality (assimilation)	175	350	0	0	45	45	0	0	0	0	1592	3183	0	0	2800	3734	602	803	170	227	16172	21563	110	110	21666	30014
Water supply regulation	350	699	2139	55	67	67	0	0	159	159	1592	3183	123	123	2800	3734	602	803	170	227	16172	21563	110	110	24284	30722
Coal and other mined resources	0	0	0	0	0	0	0	0	476	476	0	0	0	0	0	0	0	0	0	0	0	0	0	0	476	476
Total per land-use type	**2798**	**5596**	**25674**	**47123**	**359**	**359**	**4**	**4**	**953**	**953**	**15915**	**31831**	**859**	**859**	**30804**	**41072**	**6924**	**9232**	**1956**	**2608**	**339616**	**452821**	**1429**	**1429**		

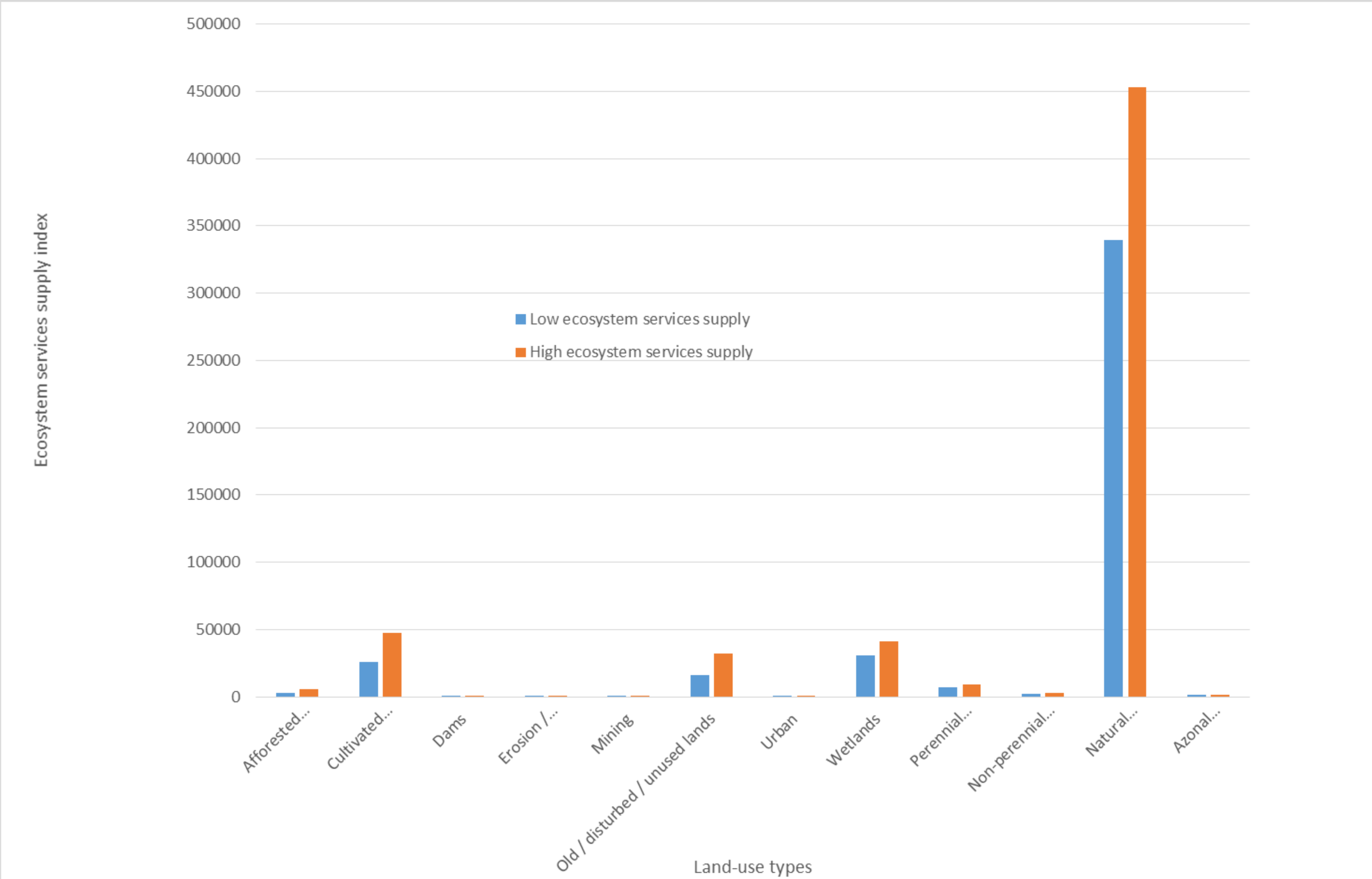

Figure 55: Overall ecosystem services supply scores per land-use

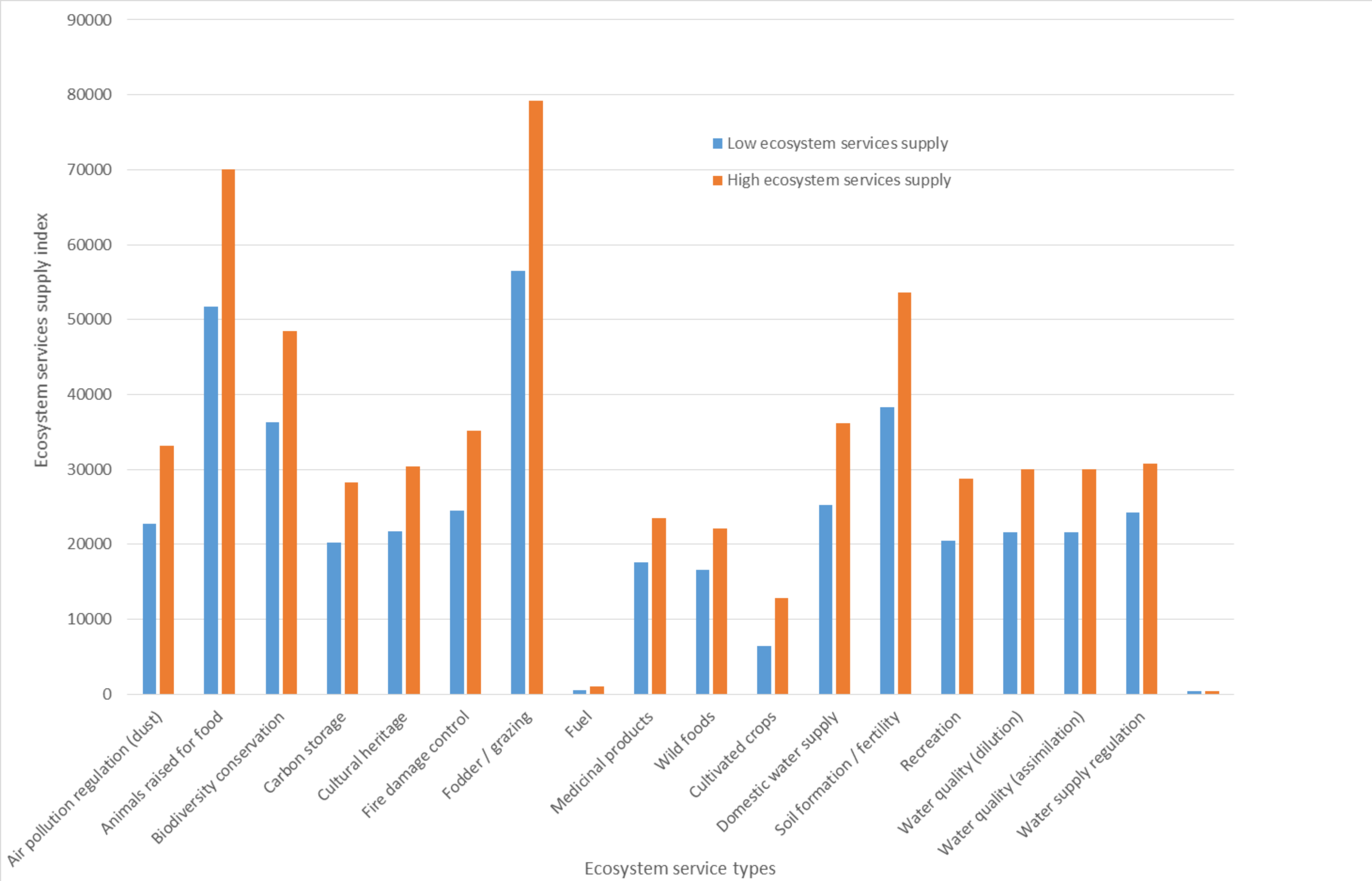

Figure 56: Overall ecosystem services supply scores across the whole study area

Table 22: Ecosystem services demand scores across the whole study area.

	Benificiaries (numbers)					Demand index				
Ecosystem services	1 - low	2 - medium	3 - high	4 - critical	Total	1 - low	2 - medium	3 - high	4 - critical	Total
Air pollution regulation (dust)	4900	4800	7800	500	18000	49	1152	1950	250	3401
Animals raised for food	10000	5000	2700	300	18000	100	1200	675	150	**2125**
Biodiversity conservation	17975	0	25	0	18000	180	0	6	0	186
Carbon storage	17975	0	25	0	18000	180	0	6	0	186
Cultural heritage	17975	0	25	0	18000	180	0	6	0	186
Fire damage control	14800	2900	0	300	18000	148	696	0	150	994
Fodder / grazing	14975	0	25	3000	18000	150	0	6	1500	**1656**
Fuel	15000	0	3000	0	18000	150	0	750	0	900
Medicinal products	10200	7500	150	150	18000	102	1800	38	75	2015
Wild foods	15000	3000	0	0	18000	150	720	0	0	870
Cultivated crops	15000	0	0	3000	18000	150	0	0	1500	**1650**
Domestic water supply	0	0	5000	13000	18000	0	0	1250	6500	**7750**
Soil formation / fertility	15000	0	2700	300	18000	150	0	675	150	975
Recreation	17975	0	25	0	18000	180	0	6	0	186
Water quality (dilution)	0	0	3000	15000	18000	0	0	750	7500	**8250**
Water quality (assimilation)	0	0	3000	15000	18000	0	0	750	7500	**8250**
Water supply regulation	0	0	0	18000	18000	0	0	0	9000	**9000**
Coal and other mined resources	7000	5000	0	5000	17000	70	1200	0	2500	**3770**

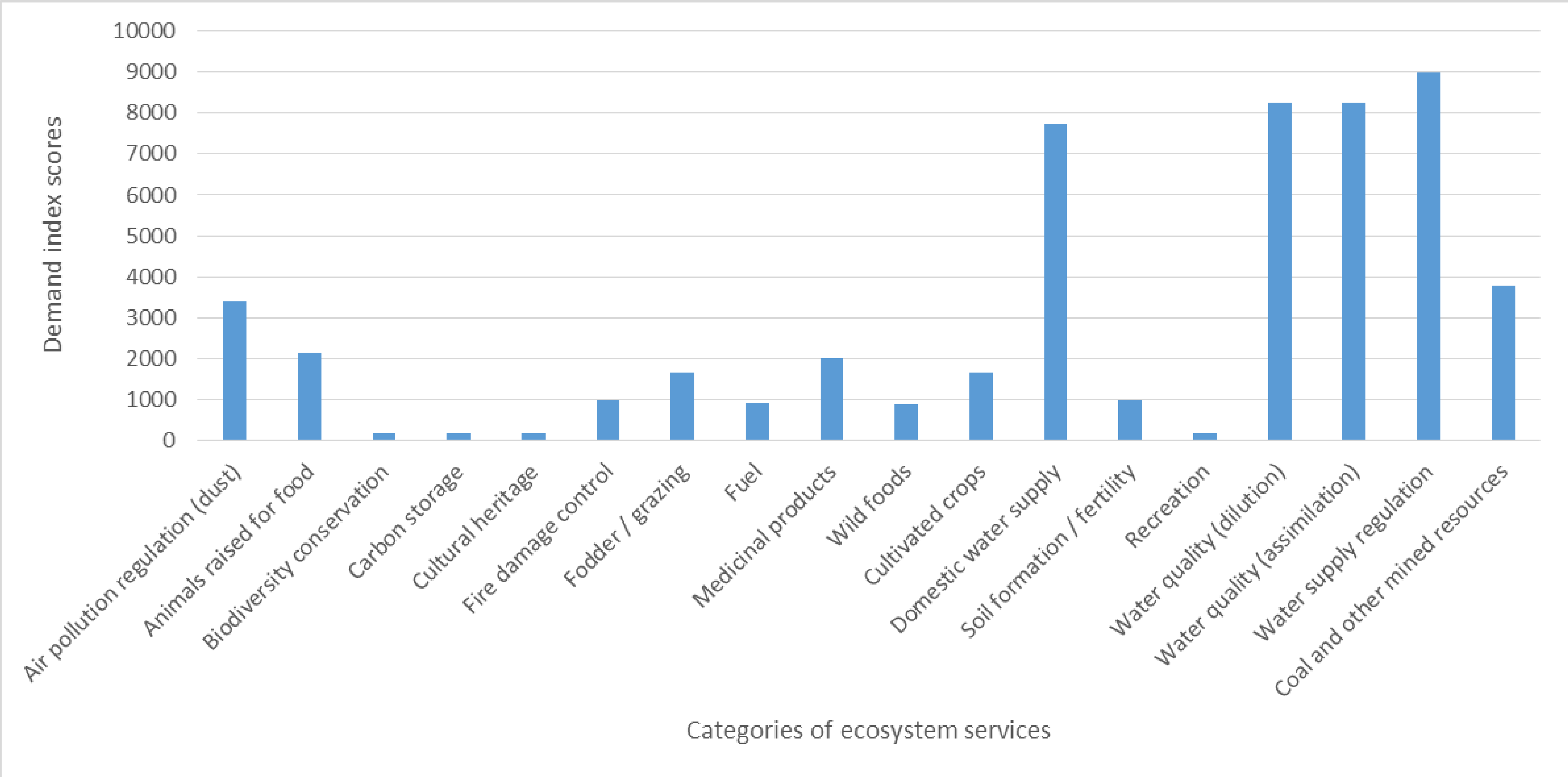

Figure 57: Demand for ecosystem services across the whole study area

Table 23: Ecosystem services stress profile across the whole study area

(supply index to demand index ratio; the higher the ratio, the lesser the stress for the service).

Ratio of ecosystem supply index to demand index		
Supply scenario	**High**	**Low**
Air pollution regulation (dust)	9,7	6,7
Animals raised for food	33,0	24,3
Biodiversity conservation	260,3	195,4
Carbon storage	152,1	108,5
Cultural heritage	163,4	117,2
Fire damage control	35,3	24,7
Fodder / grazing	47,8	34,1
Fuel	1,2	0,6
Medicinal products	11,7	8,8
Wild foods	25,4	19,1
Cultivated crops	7,8	3,9
Domestic water supply	4,7	3,3
Soil formation / fertility	55,0	39,3
Recreation	154,7	110,1
Water quality (dilution)	3,6	2,6
Water quality (assimilation)	3,6	2,6
Water supply regulation	3,4	2,7
Coal and other mined resources	0,1	0,1

5.4.5 Assessing ecosystem services under stress

Given the current structure of ecosystem services supply and demand in the study area, with high demands and relatively low supply of water-related services, it is unsurprising that these services are under stress or pressure (i.e. low ratios of supply index to demand index; Table 24). High pressures also exist for cultivated crops (important activity which supports many livelihoods), fuel resources (low supply levels in landscape originally dominated by grasslands, with users partially dependent on firewood), air pollution regulation (dust control), medicinal plants (high demands but depleted resources) and coal/mined resources (critical economic activity, supporting many livelihoods, but limited supplies under current land-use patterns). Several ecosystem services are, however, relatively oversupplied or have limited current demand (e.g. recreation, biodiversity conservation, carbon storage). This could change in the future, depending on stakeholder concerns and needs.

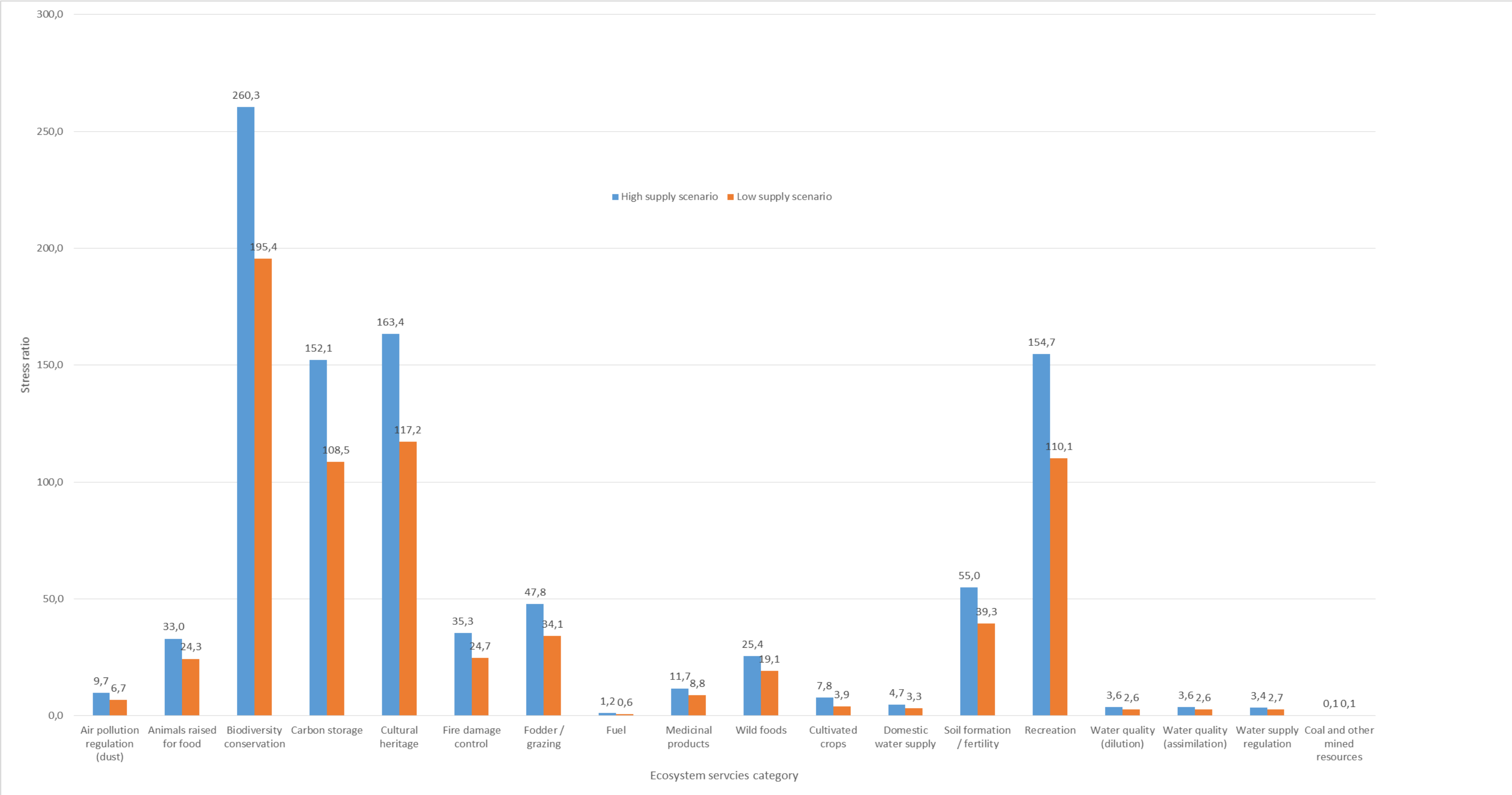

Figure 58: Risk profiles of ecosystem services across the whole study area (supply index to demand index ratio; the higher the ratio, the lesser the level of stress for the service)

5.5 Modelling net changes under increased agricultural and mining development (a 50-year scenario)

There is evidence of mining expansion in the region, while maize and livestock production is becoming more intensive and inter-connected (although not all areas have optimal conditions for such purposes). In this section, we model a 50-years scenario, in which:

- Current mining activities have ceased (closures of mines), resulting in 1 112 ha of new old/disturbed/unused lands (i.e. current mine closure plans may not effectively restore grasslands to their original condition, due to topsoil loss and declining species composition (Schoeman, 2001; Limpitlaw, et al., 2005);
- New mining activities:1 500 ha, including 500 ha from cultivated lands, 50 ha of afforested lands, 800 ha of natural grasslands and 150 ha of old/unused lands;
- No additional loss of wetlands and pans (due to anticipated strict protection measures);
- Productivity loss in cultivated lands (i.e. increased needs for imported fertilisers, due to current agricultural practices); further loss of biodiversity conservation services throughout all land-uses;
- Loss in various water-related ecosystem services in the dams (increased pollution levels, due to the combined effects of agriculture and acid mine drainage) and of domestic water supply in wetland areas;
- Population increase to 25 000, with 6 000 in mining and 5 000 in farming activities (workers and their dependants; with expected increased labour intensities in both sectors and increased subsistence farming through land reform).

Under such a scenario, we find further land use changes in the study area leading to an **accumulated loss of 49 500 and 39 649 weighted ha** in the low- and high-condition score scenarios, respectively. These numbers may seem relatively small but they are associated with **significant losses** in the **supply of biodiversity conservation** (from 48 522 to 25 833 for the high supply scenario), **fodder/grazing** (from 79 148 to 56 660 for the high supply scenario) and **cultivated crops** (from 12 836 to 8 272 for the high supply scenario). On the other hand, as expected, there is a **significant increase** in the **supply of coal and other mined resources** (from 476 to 643 for the high supply scenario).

Combined with **increases** in the overall population (high demands for water-related ecosystem services) and in the **community depending on mining activities**, this generates **increased stress profiles** for most ecosystem services (especially biodiversity conservation and cultivated crops), with domestic water supply, water quality (dilution and assimilation) and water regulation services under severe pressures. Furthermore, looking into the future, the key challenge is that coal mining is not sustainable, as all resources may be exhausted in the medium to long term (100–150 years). Local communities will likely fall into a **locked-in** situation, because a reversal to other land uses from coal mining will most likely not be feasible from a technical, ecological and/or financial perspective under current mine closure and rehabilitation practices (see Schoeman, 2001; Limpitlaw, et al., 2005; van Zyl et al., 2012).

Table 24: Comparing ecosystem services stress profiles (now and in 50 years) across the whole study area (supply index to demand index ratio; the higher the ratio, the lesser the stress for the service).

Ratio of ecosystem supply index to demand index				
	In 50 years		Current	
Supply scenario	High	Low	High	Low
Air pollution regulation (dust)	7,3	5,0	9,7	6,7
Animals raised for food	26,0	19,1	33,0	24,3
Biodiversity conservation	**98,6**	**74,0**	**260,3**	**195,4**
Carbon storage	107,1	76,2	152,1	108,5
Cultural heritage	113,7	81,6	163,4	117,2
Fire damage control	32,1	22,4	35,3	24,7
Fodder / grazing	32,8	22,9	47,8	34,1
Fuel	1,1	0,6	1,2	0,6
Medicinal products	8,3	6,2	11,7	8,8
Wild foods	23,1	17,3	25,4	19,1
Cultivated crops	**4,8**	**2,4**	**7,8**	**3,9**
Domestic water supply	**3,1**	**2,2**	**4,7**	**3,3**
Soil formation / fertility	50,5	36,1	55,0	39,3
Recreation	110,0	78,3	154,7	110,1
Water quality (dilution)	**2,5**	**1,8**	**3,6**	**2,6**
Water quality (assimilation)	**2,5**	**1,8**	**3,6**	**2,6**
Water supply regulation	**2,4**	**1,9**	**3,4**	**2,7**
Coal and other mined resources	**0,1**	**0,1**	**0,1**	**0,1**

5.6 Implications for policy making

5.6.1 Qualitative modelling can inform discussion, planning, and decision-making

The previous section of this study showed what can be achieved through qualitative modelling of natural capital stocks and services. Through practitioner and expert advice, one can model how natural capital stocks and services change over time and space under different scenarios, even with very limited resources. There is no need to value natural capital stocks and services in economic terms to understand how different human activities influence their temporal and spatial distributions.

How can these values and associated models be actively used in stakeholder interactions in the study area?

For ecosystem services values to be used effectively, these need to be expressed, framed, or made available, in an appropriate format which effectively enables their intended use (i.e. concept of fitness for purpose) (e.g. Berghöfer, et al., 2016; Houdet & Chikozho, 2014). In doing so, stakeholders will be able to readily use such values for strategic/land use planning, investment decisions, and internal business management purposes (environmental management, budgeting). In our context, there would be various potential applications, including mining licencing, environmental authorisation processes, an integrated local municipality development plan, as well as management processes related to the various farming and mining businesses.

More specifically, there is a potential opportunity to use such an approach in forthcoming planning activities of the Inkomati Usuthu Catchment Management Agency at the broader catchment level, so as to understand how water-related natural capital stocks and services need to be managed for their conservation and sustainable use. This could be undertaken by involving all key stakeholders in each stage of the qualitative valuation model. For this to be as accurate and successful as possible, additional resources for better biodiversity, land use and beneficiary mapping would need to be sought.

5.6.2 Assessing and disclosing external costs and benefits of different land uses could influence on-the-ground ecosystem management practices

As argued by Yushi et al. (2008), the external costs of all the coal used in China in 2007 came to RMB 1.7 trillion - i.e. 7.1 per cent of China's gross domestic product for the same year. Although the authors proposed many internalisation measures, including imposing energy and environmental taxes, improving coal resource compensation systems – deepening market-oriented reform of coal, and improving liability rules they recognise that this cannot be achieved overnight. In South Africa, similar studies have been undertaken, notably one on the Kusile coal-fired power station (Table 25), where strong arguments were made in favour of renewable energy alternatives.

Table 25: Estimated annual externality cost of Kusile (Blignaut et al., 2011).

	Net output	Externality cost			
	GWh	Low (R million)	R/kWh (Low)	High (R million)	R/kWh (High)
Health	32 301	182.8	0.006	213.3	0.007
Climate change	32 301	3 148	0.097	5 334	0.165
Water	32 301	21 305	0.660	42 357	1.311
Mining	32 301	6 538	0.202	12 690	0.393
Total		**31 174**	**0.97**	**60 594**	**1.88**
Total excluding water for generation purposes*		**9 869**	**0.31**	**18 237**	**0.56**

In our context, assessing the positive and negative economic, social and environmental externalities of coal mining and farming could potentially better inform future environmental authorisation processes and mining practices (i.e. where to mine and how mining should take place). A pre-requisite would be to find a way for target stakeholders (especially mining companies) to disclose quantitative information for the whole lifecycle of their operations (e.g. capital and operational expenditures, local procurement, direct and indirect jobs, greenhouse gas emissions, water use and emissions, waste generation, loss of soil and biodiversity). Indeed, access to reliable data was a real challenge in this study.

Ideally, externality valuation would help assess whether the mining operations in the study area generates net positive or negative impacts on society. This would be a data intensive process, requiring both accurate environmental/biophysical data (e.g. actual water emission for each mining operation, which many businesses may not have) and externality values specific to the study area (for example, carry out new surveys of the local population, or adapt values from other study contexts for application in the Carolina area). Such values could be used to influence the behaviour of various land users (i.e. targeting policy makers), attracting their attention to practices that generate the most negative and/or positive externalities, (although this would unlikely be insufficient, in itself, to generate true behavioural change) (Berghöfer et al., 2016).

5.6.3 Net impact accounting should drive investments in the restoration of natural capital stocks and services

According to Gerhard van der Burgh (2012), *"[at] the current rate of coal mining in Mpumalanga, approximately 12 % of South Africa's total high potential arable land will be transformed, while a further 13.6 % is [sic] under prospecting by the mines in Mpumalanga. The potential loss of maize production from current mining activities is 284 844 tons per annum. A further 162 736 tons of maize could be lost from the prospecting areas that in future could also be transformed. Over the long-run the reduction of 447 581 tons of maize per year, removed from the market, would result in an average annual price increase of R300/ton, over and above a long-run projected average maize price of R2 090/ton. In other words, average maize prices are projected to increase by approximately 14%, which in turn would cause maize meal prices to rise by approximately 5%."*

Mining expansion in the study area without effective ecological restoration of mined lands (soils, vegetation) for other beneficial purposes (will lead to the loss of livelihoods and food security). At the same time, unsustainable farming in the area (with all its negative impacts) will also be detrimental to the resilience of the whole socio-ecosystem. During the site visit, we found no indication that the natural capital stocks, converted to human and financial capital, were re-invested locally. This means that the Carolina area effectively acts as a net exporter of natural capital to other areas of South Africa (and potentially, the world), without gaining compensation for such transfers.

Accordingly, the results of this study strongly suggest that net impact accounting (i.e. net changes in natural capital stocks and services) should be used as a common 'shared tool' to understand, assess and drive environmental management practices by all land-users. This would involve convincing key stakeholders (government agencies, local municipalities, the Inkomati Usuthu Catchment Management Agency (IUCMA), mining companies, farmers (to design and implement policies to reach no-net-loss, or even net gains, in key natural capital stocks (wetlands, natural and improved grasslands) and services: foods, water supply and regulation, waste assimilation and dilution, dust regulation in the short- to long-term, depending on local context and available resources.

Improving land management practices would likely require embedding no-net-loss environmental obligations (i.e. requiring effective restoration and offset measures) in authorisations and environmental management/audit plans for both mining and farming operations, as well as making strong financial assurance safeguards mandatory (i.e. liability costing tied to reaching ecological goals). This would require political commitment and active monitoring by relevant government departments. Given recent talks of the financial difficulties experienced by the coal industry, this may prove difficult. Thus, the alternative of reconsidering which economic activities should be allowed to be carried out in the Mpumalanga Highveld.

5.7 Competition between land uses and guidelines for the use of wetlands

The was a deliverable for the project. A draft development of a guideline for the use of wetlands (a deliverable of the present project) was presented to the working group of the UKCMF, 9 June 2016. The group did not, however, see the guideline as a priority. It is briefly discussed here, as it reappears as a recommendation for further research in Chapter 8.

The research team found that there were a number of existing guidelines for the use of wetlands. These included:

1. The DWS (2014) “Guideline: Assessment of activities/developments affecting wetlands”
2. The Cape Nature factsheet (n.d.) “A landowner's guide to managing wetlands”.
3. The “Mining and Biodiversity Guidelines” (DEA et al., 2013)
4. “Guidelines for Integrating the Protection, Conservation and Management of Wetlands into Catchment Management Planning” (Dickens et al., 2003)
5. “Wetlands and People” (Kotze, 1996)
6. “Guidelines for the Rehabilitation of Mined Land”. (Tanner, 2007).

However, when these are put side by side, a curious anomaly emerges, namely that different land users have very different rules. The following sections are based on a reading of the above six sources.

5.7.1 Agriculture users

During the research project, mine managers criticised farmers for their negative impacts on wetlands. The following rules present a summary of expectation on how farmers should relate to wetlands.

1. Identify and delineate wetlands during summer months, as they may appear to shrink in winter.
2. Keep natural buffer areas of 32 m around wetlands free of invasive alien plants and irrigated crops.
3. If the wetland is a Critical Biodiversity Area (CBA) or Freshwater Ecosystem Priority Area (FEPA), a risk assessment should be conducted prior to activity, or a 100m buffer area should be maintained.
4. Where relevant, activities in wet-lands should be managed within a river management/ maintenance plan.
5. All modifications to water flow, in or through, a wetland require official permission. Disturbed wetlands can often be successfully restored by returning the flow to its original state, through closing of drainage ditches and trenches.
6. Do not restrict, block or alter (including over-abstraction) water supply to a wetland.
7. -Do not over-abstract or divert surface or groundwater feeding into a wetland, which may cause it to dry up. High yielding boreholes should not be sunk in or near wetlands.
8. Dam construction within wetlands transforms the wetland into a permanent water body, resulting in the loss of the important wetland habitat, particularly if it is a seasonally wet system. Dams should thus be constructed outside wetlands and stream channels.
9. Avoid placing pollution sources, such as waste disposal sites, domestic effluent, etc., near wetlands.
10. Regularly clear wetlands of invasive alien plants, taking care not to disturb the soil. i.e. do not use heavy machinery.

11. Certain wetlands (especially grassy floodplains) can be grazed, provided that no overgrazing occurs, and that it is done during the correct season. The intensity of grazing by large livestock within wetlands should be subject to setback lines and other best management principles. If it is a priority, wetland grazing should not be allowed within a 32m buffer area.
12. It is possible to burn wetlands when there are adequate (two-year) intervals and a refuge area (during the burning) is provided for animals. Nevertheless, animals may still be caught in the fire.

5.7.2 Mines

1. Mines should not be constructed in or near wetlands, or in the areas that deliver water that maintain wetlands. The Chamber of Mines' and Department of Environmental Affairs' Mining and Biodiversity Guidelines state: "*Because of the importance of these freshwater ecosystems (river and freshwater ecosystem priority areas, and 1 km buffer of river and wetland Freshwater Ecosystem Priority Areas (FEPAs) … to lives and livelihoods, and the likelihood that their ecological condition would deteriorate if mining activities took place in or close to them (i.e. within a 1 km buffer of river and wetland FEPAS) it is recommended that mining should be avoided in these areas*".
2. Mining planning should follow the above rules in or near wetlands, or in the areas that deliver water that maintains the wetland.

   2.1. **Avoid or prevent impacts** to biodiversity, associated ecosystem services, and people. Where environmental and social factors give rise to unacceptable impacts, mining should not take place.

   2.2. **Minimise the impacts** by changing the project location, siting, scale, layout, technology and phasing.

   2.3. **Rehabilitate** areas where impacts are unavoidable, to return impacted areas to a near-natural state or an agreed land use after mine closure.

   2.4. Pay for **the residual impact** to compensate for the damage, or negotiate for off-set rehabilitation of other wetlands.
3. Mining in wetlands, or within their recharge areas, should be avoided at all costs. It is essential to protect and sustain geohydrological flow to wetlands.
4. Mining effluent of bad quality may not be discharged into the surface waters, including wetlands. Water should be properly retreated before release.
5. Wetland buffers (between mining and wetlands, or rivers and their recharge areas) are required. Buffers reaching an extent of over 500 m may be required for open cast mining. In each case, these should be determined within the contexts of each individual mine and wetland, as well as its recharge area.
6. Restoration and rehabilitation of wetlands affected by mining should aim to:

   6.1. restore the hydrological functioning of the landscape in terms of water quantity and quality;

   6.2. if such restoration is not possible, an alternative rehabilitation should be agreed, to avoid the generation of acid mine drainage and its decant into surface streams;

   6.3. the residual impact (differential cost of full restoration and alternative rehabilitation) should be calculated and funds made available for purposes such as catchment care or restoration of impacted river courses.

5.7.3 Other users

The following guidelines are suggested as a starting point for discussion by local government, CMFs, communities, and other groups:

1. Consider wetlands and their recharge areas in local government planning.
2. Wetlands situated near residential area, or are easily accessible, need to be incorporated into parks with recreation facilities, such as bird hides, information centres or boards, that provide details on ecosystem services provided by wetlands, birds, frogs, and other animal life.
3. Potential pollution sources, such as waste sites or mines, should not be sited close to wetlands and water courses. Housing and other developments should not take place within flood lines and near wetlands.
4. Urban areas and informal settlements need to be provided with regular waste management services as well as sanitation, so as to avoid contamination of water resources, including wetlands.
5. Youth centres may conduct observations or testing exercises at wetland and river sites, for example, the ‘mini-SASS’. Such projects could be made part of public works initiatives, such as the ‘*Adopt a River’* initiative.
6. Local Economic Development projects could draw attention to wise use of wetlands by communal farmers, communities using wetland products, and tourism enterprises.
7. Catchment management agencies need to explicitly include wetlands in their strategies and operational procedures.

5.8 Conclusion

This chapter has further explored the challenges of integrating knowledges of different aspects of wetlands, biodiversity, ecosystem services, and ecological infrastructure. It has pointed to the dangers of subsuming nature into the formal economy, highlighting (in particular) the assumption of substitutability between ecosystems, and problems associated with ‘discounting into the future” (when, in all likelihood, ecological infrastructure will be worth more, not less) as well as raising awareness concerning the long term consequences of certain decisions will affect ecological infrastructure beyond single lifetimes and, therefore, cannot be decided within short-term frameworks.

Despite these challenges, and some difficulties in accessing information from coal mines, this chapter was able to present a case study of such valuation comparing how different land uses and practices and how this may change natural capital (NC) stocks and flows. An example was given on how to engage in a futuristic assessment, based on [imagined] conditions prevailing during a period “up to 50 years from now”. The exercise (in Section 5.5) suggested that, without effective ecological restoration of mined lands (soils, vegetation) for other beneficial purposes (e.g. crop and cattle farming, ecological infrastructure maintenance), mining expansion could lead to the loss of livelihoods and food security (). In this manner, unsustainable farming practices in the area (e.g. further degradation of wetlands, soils and biodiversity) could also be detrimental to the resilience of the whole socio-ecosystem. During the site visit, we found no indication that natural capital stocks, converted to human and financial capital, were re-invested locally. This means that the Carolina area effectively acts as a net exporter of natural capital to other areas of South Africa (and potentially of the world), without gaining compensation for such transfers.

Finally, an analysis of current guidelines on wetlands for three sets of users, pointed out how different they are, and that there is a need to harmonise them. CMFs are ideal places to begin the revitalisation of catchment forums by DWS.

The chapter concludes that the knowledges of different aspects of wetlands, biodiversity, ecosystem services, eco-infrastructure are challenging to integrate in research, but can be integrated by people who live and work in these environments, because they integrate them through dialogue embedded in their own life experiences or life worlds (Visvanathan, 2009). This is further explored in Chapter 6.

6 MULTI-SECTORAL ENGAGEMENT WITH DECISION-MAKING AND MONITORING: A COMMUNITY OF PRACTICE PROCESS IN A CMF WORKING GROUP

6.1 Introduction

6.1.1 Background

This chapter presents the process and results from a three-year dialogue process in which participants in the UKCMF engaged in a 'thought experiment', to envision "*an integrated, participatory process of valuing, making decisions, monitoring and ongoing, inclusive adaptive management that has as its objective to balance the exploitation of coal resources with the sustainability of wetlands and other water-related ecological infrastructure*. "

Following a plea bargain, relating to the Golfview Mining (Leliefontein) court case in Ermelo, the involvement of the UKCMF was requested, to assist in the development of a framework for addressing the inability of the decision-making system, to facilitate reasonable, inclusive discussion concerning historical redress and to promote sustainable choices (with respect to land-use decisions between mining and other land users).

The purpose of the forum was to better align biodiversity and coal mining through an integrated adaptive monitoring plan, as well as a knowledge network centred on the Upper Komati Catchment Management Forum (UKCMF). Because of its previous experience concerning the impact of Acid Mine Drainage on the town's drinking water as well as its participation with institutions such as the IUCMA, DWS, DAFF and local government. It was hoped that the UKCMF would be a suitably qualified to take on this challenge.

This chapter introduces and discusses the development of a "Draft Integrated Monitoring Plan" to align biodiversity and mining development, accompanied by an appropriate DSS" in the UKCMF working group during the February 2014 to September 2016 period.

Monitoring follows from, and should be integrated with, decision-making. It is an adaptive system that can take in new evidence as mining proceeds (Biggs & Rogers, 2003; Rogers & Luton, 2011). The programme is also integrated in the sense of both co-operative governance (i.e. participation in decision-making) and monitoring by relevant departments and institutions to gather further information on the history of this process in the Carolina area.

Based on current research into the revitalisation of catchment management forums (WRC K5/2411), it was established that some participants and their agendas are not currently active in this process. The amalgamation of water services (including sanitation) and water resources will expand the range of issues under discussion in CMFs (Munnik et al., 2015; Munnik & Price, 2015). These changes will be reflected in our approach to social hydro-connectivity in the catchment.

On 19 January 2016, a ten-point framework for a more inclusive, integrative and adaptive decision-making and monitoring process, was proposed to UKCMF participants (via the circulation of invitations). While the proposal aimed at far-reaching changes in a decision-making process, it was made clear that this process needed to be seen on two levels: (1) its intention to catalyse awareness and set directions of, and mechanisms to, support change, and (2) to develop the capacity for the UKCMF to meaningfully participate in decision-making relating to coal mining, wetlands, water resources, and ecological infrastructure in the area. The development of the monitoring and decision support systems (contemplated in this project) therefore needed to be seen as the initial steps in a long-term process (see Swilling et al., 2016).

6.1.2 Mandate for new decision-making process

The original mandate derives from the destruction of a wetland on the Ermelo coalfield. It resulted in a court case, driven by local (Ermelo area) stakeholders (the Escarpment Protection Group).

The Ermelo mine was ultimately made to pay penalties that, at the time, were described as *"the largest criminal penalty ever imposed for environmental offences in South Africa*" (Mondaq, 2012), for diversion of water resources, inadequate pollution control, and transformation of three hectares of indigenous vegetation. The mine was also required to rehabilitate the damaged wetland at an expected cost of between R50 million and R100 million. The finding and the fine were widely regarded as evidence of a reversal in official attitudes towards wetlands. However, it should be noted that the prosecution in this case was driven by civil society intervention, namely by the Federation for Sustainable Environments (FSE) which included local farmers in the area.

6.1.3 Carolina as an action research site

Carolina and the UKCMF, which serves the area of the town and environs of Carolina, were chosen by the research team because of an acid mine drainage (AMD) event that, January of 2012, polluted the town's drinking water supply dam, resulting in the deprivation of the town's water supply for seven months, which imposed several externalities (household, health and economic costs) and led to social unrest (see Chapter 1).

Some stakeholders in the UKCMF have a sophisticated, technical understanding of coal mining and its impacts (Carolina *Omgewingstudiegroep* meeting, 23 November 2015). There is also a growing concern about the impacts of coal mining on other land-use options, particularly agriculture. In the township of Silobela, recent demonstrations were launched against coal mining dust and, on the basis of the argument that coal mining jobs are not available to locals, raised questions about whether benefits from coal mining flow into the local Carolina economy (Action Voices, 2015).

From local observations (confirmed during UKCMF workshop discussions) it is clear that competition between coal mining and other land uses leads to increasing tension. Effective planning is difficult, so an integrated planning system is needed.

An important consideration concerning the choice of a study site, was that it is located within the Inkomati-Usuthu CMA, where water quality regulation is arguably more advanced than in many other areas. The IUCMA, which actively supports the UKCMF, thus allows for a glimpse into the future, when other Water Management Areas will also be regulated by Catchment Management Agencies. The UKCMF thus represented a group of civil societies participating within the CMA structure.

This chapter provides a brief account of the process undertaken with the UKCMF working group, to develop an integrated, participatory process of valuing, making decisions, monitoring, involvement in inclusive adaptive management that has, as its objective, to balance the exploitation of coal resources with the sustainability of wetlands and other water-related ecological infrastructure. The process was based on a combination of local knowledge, inputs from experts and dialogue.

6.2 Process undertaken with the UKCMF working group: limitations and its achievements

6.2.1 Research team engagement with the UKF

This section presents a summary chronology of the research team's interaction with UKCMF and its participants. The project outputs require the development of a multi-stakeholder network around the proposed future integrated monitoring plan and DSS (Burns, 2014; Engeström, 2000). For details on how to encourage participation in a Catchment Management Forum, see Appendix E)

1. The project began with background research into the histories of the Golfview (Leliefontein) case. All materials developed in the research were shared with the working group.

2. The project was introduced to the UKCMF in February 2014. In subsequent meetings, regular report backs on project progress were given. Invitations to working group meetings were consistently sent out to UKCMF stakeholders, which included officials from DMR, DWS, DAFF, local government, mining companies, and mining consultants.

3. In early 2014, field research (into decision-making processes and coal mining) was undertaken, using the Cultural Historical Activity Theory (CHAT) methods, into attitudes of mining managers, regulators, farmers and citizens. Results were subsequently made available to the UKCMF (see Chapter 2).

4. In August 2015, fieldwork took place, for a winter assessment of six channelled valley-bottom wetlands (see chapter 4).

5. In September 2015, a first round of interviews with land owners (whose properties contain wetlands) took place.

6. The UKCMF was included in discussions on the forum revitalisation project (K5/2411: see Munnik et al., 2015) and DWS representative Mr Matome Mahasha. This was an important revitalisation initiative from DWS, which foresees an active role for CMFs and the K5/2411, facilitating a comparison of UKCMF's initiatives with those of other water-related forums.

7. UKCMF participants took part in a focused 90-minute session, as part of a 21 Oct 2015 forum meeting, serving as report-back and an introduction to the series of workshops that would follow.

8. The team joined in an exploratory evening meeting with the local Carolina *Omgewingsgroep* (Environmental Study Group supported by the Dutch Reformed Church, open to other participants) on 23 November 2015.

9. On 24 November 2015 and 19 January 2016, the WRC research project hosted a series of workshops at the Featherbed Lodge, Carolina. Inputs were gathered for developing the integrated monitoring plan and DSS (during the 2015 meeting). In the 2016 meeting a dedicated 4-hour workshop was held, to mirror back the proposed integrated monitoring plan and DSS developed in September 2015 (see '5' above).

9. In addition to the above, informal communication with a number of community members took place. On 9 June 2016, the project team (Prof Palmer and Dr Munnik) conducted a session with the UKCMF working group in which the 10 principles were reworked into a practical assessment of the knowledge requirements that they implied.

10. The project team, assisted by Ben Cobbing of CCSGIS, further developed these knowledge requirements into the two outputs presented in this report. Later, in September 2016), Mr Cobbing

returned to Carolina to share and review the results. Participants expect that the knowledge system will be a dynamic and open to updating as circumstances change.

Throughout this open process, invitations were sent to a large group of participants (more than 70) including representatives of the Department of Mineral Resources (DMR). To date, this process has had no DMR representation. For further details on UKCMF dialogues, See Appendix E, for a full record of minutes taken during UKCMF meetings.

6.2.2 Comments on the existing decision-making and monitoring system

In the two meetings as detailed above (21 October, and 24 November 2015; see Appendix E), some concerns were raised about the current coal decision-making process, which were subsequently addressed in the proposed decision-making system. Namely:

- That decision-making is not inclusive enough at present, particularly from government departments other than DMR;
- That decision-making is not transparent, and is unnecessarily complicated and demanding (e.g. in terms of paper work, including very thick reports);
- Information is difficult to access and understand;
- That decision-making does not take into account, and protect, wetlands and water resources, and that this may limit future economic and land use options in the area;
- That mining impacts are singled out, while agriculture and local government are not so strongly regulated;
- That current decision-making does not protect people from water quality threats;
- That there is no follow-up on decisions, no compliance monitoring;
- That various facets are not integrated, e.g. social, environmental aspects;
- That DWS inputs are ignored and that DWS is not able to refuse water licences;
- There is a lack of communication between DMR and other departments;
- There is widespread suspicion of political inference in granting mining permissions (where they should not be granted);
- That benefits and costs of coal mines are not clearly explained to the public during consultation processes.

These criticisms show an in-depth appreciation of the political dynamics of the situation, centred on the powerful position of the DMR in decision-making. It is a general consensus in the UKCMF that the DMR practice is to ignore other departments, including DWS, other land users, and the catchment management system. This is contrary to the principles of co-operative governance. Participants are aware of power dynamics. including politicians overriding normal decision-making, and “corrupt” decision-making (unreasonable decisions).

The comments demonstrate a desire for fairness, transparency, information, understandable explanations of coal mine benefits and impacts, protection of wetlands and water resources, and attention to other land uses.

Participants also made a number of proposals relating to decision-making and monitoring:

- A booklet be developed, in accessible language and different languages, explaining how coal occurs in Carolina, with some geological explanation, of why and how it happens that pollution from coal mines impact on rivers, wetlands and underground water resources, which would enable UKCMF participants to take part in debates and processes concerning coal mining;
- That specific attention should be given to illegal and non-compliant mines;
- That, because mining impacts are cumulative, they should be assessed on a long- term basis;
- That there needs to be public assessment of whether mines are doing well (or not), like the Green and Blue Drop schemes:

- Integrated legislation is needed to regulate coal mining and its impacts;
- Regional (local) people should be involved in decision-making about coal mining and water resources;
- Greater awareness of wetlands and their value should be promoted;
- Local people should be empowered to influence decisions about coal mining;
- The media should be used to create awareness and influence decisions.

These proposals reflect a need for better targeted compliance monitoring, integrated decision-making, participation, access to information, awareness of the value of wetlands (as part of decision-making) plus intentions to use media and political channels. These reflect a sophisticated understanding of citizenship. These issues informed the decision-making system proposed for discussion (see Appendix E).

6.3 Development of an integrated monitoring plan able to align biodiversity and mining development

6.3.1 Current decision-making around coal

Current decision-making around coal reflects a system in transition. In dealing with this from a legal point of view (a fundamental determinant of the system), Chapter 3 (1) outlined the importance of law as a framework for decision-making; (2) described how ecosystem and resilience-based perspectives and adaptive management approaches have shifted understandings of environmental and natural resources law; (3) defined the mining life-cycle and South African laws that frame this cycle; and (4) explained recent shifts in the South African legal framework governing the mining life-cycle, in particular, movement away from a fragmented model of regulation to a single environmental system, and how this frames the issues described in the previous paragraph.

Two general insights emerged from the exercise described in Section 6.2.2.

- First, it is clear that the structure and approach of the law relating to mining is still very much in the mould of the traditional approach to environmental law and natural resource governance, and not explicitly aimed at valuing and protecting ecological infrastructure. There have also been a number of amendments aimed at strengthening this framework of law over the past few years, which largely entrench this approach. While changing the course of this trajectory to accommodate a more adaptive approach, ongoing monitoring, support and strengthening of a broader epistemic community will be difficult, but not impossible. There are windows of opportunity provided, for instance, by the content of the NEMA principles or the new regulations that are crystallising around the single environmental system.

- Second, this review showed that understanding how and why the Carolina crisis unfolded as it did involves having regard to the instruments framing mining companies' environmental obligations approved by the regulators, principally the DMR (even prior to the commencement of their operations). Accessing these instruments is however difficult, due to a critical lack of transparency. The rights, duties, powers and exemptions around mine closure and their major flaws (as highlighted in the afore-going discussion) are also essential for understanding the 'how and why' cumulative impact of the mines operations, which severely impacted the drinking water supply to Carolina.

In other respects, however, the legal framing does not allow for vigorous or effective resistance and contestation. This was particularly evident prior to the decision to prospect, or mine, being taken. Section 10 objections, resistance associated with access to land, and reliance on the Maccsand principle to align prospecting and mining authorisations with land-use planning requirements, have so far proved to be ineffective in terms of balancing prospecting and mining with the imperatives of protecting wetlands, biodiversity and ecological infrastructure. Resistance and contestation at this point is more imperative than at the stage when extraction has already been authorised, as it affords a different form of protection of the natural landscape.

While the use of the rights articulated in the Bill of Rights and the constitutional principle of legality could be used to challenge parts of the legal frame that are weak, this is a drawn-out and risky process, unfairly placing the burden of reform on civil society.

The overall conclusion is that the current mining licensing process is too narrowly conceived to provide opportunities for contestations on the grounds laid out above. It is too specific and small in scope to be useful on its own when attempting to address contestation related to the socio-ecological object, ecosystem services etc. These decisions should be made – and then monitored, and adapted according to monitoring – on a regional basis. Thus, a catchment management strategy – based on long term planning, proper consultation and participation, taking into account ecosystem services etc (but also their political or power) – could be the ideal vehicle.

6.3.2 A theoretical framework for coal mining decisions within a sustainability perspective

What are the requirements for, or characteristics of, the proposed plan and DSS?

The answers to these questions are drawn from the theoretical framework developed in Chapter 1: namely, an approach that draws on the core concepts of adaptive management, ecosystem services and the ecological infrastructure that produces them, within an understanding of social-ecological systems, to propose a process of valuing, making decisions, monitoring and ongoing, inclusive adaptive management. It is a theoretical framework that could balance water resource and biodiversity protection with water use for mining. The framework provides for the identification and development of regulatory instruments for coal mining through its entire life cycle that can adequately take into account the protection of ecological infrastructure with an emphasis on water resources. It lays the foundation for a model of legislative requirements and the institutional arrangements that should be in place, from the point of view of relevant management institutions. It also proposes to use participatory, stakeholder-based methods of valuation, which can be included in participatory processes of decision-making, ongoing monitoring and work well within an adaptive management framework, in which decisions can be reviewed in the light of emerging information and dynamic changes.

In the valuation of natural capital or ecological infrastructure, issues of sustainability and the time horizon of decisions loom large. Norton (2003) explores an adaptive management and social learning process as a form of multi-criteria, participative decision-making that includes, but goes beyond, economic valuation. He also argues for a process of co-creation of values, which is local, includes criteria of ecological economics on the basis of a valuation of ecosystem services and natural capital, while acknowledging the principles outlined below.

- Generally, economic rationality and consumer–preference (with the available methodologies to give them content) are adequate to decisions in a single lifetime, at most, and are most effective on short term. Most decisions affecting natural capital are not on that scale.
- Certain decisions are characterised by risk, irreversibility, large scale uncertainty; and issues that concern values (such as sense of place, cultural continuity).
- Decisions need to be made that keep options open for future generations, that is, not diminishing their options, including natural capital – which may well be embedded in, and entwined with, cultural capital;
- These decisions are beyond monetised evaluation, and therefore should be made with reference to the correct decision-making spaces and methodologies.

6.3.3 Required characteristics of integrated water quality management plan and DSS

The proposed system needs to:

1. Be embedded in the catchment management system;
2. Involve national and provincial departments, such as the Department of Water and Sanitation, (DWS), DMR, Department of Environmental Affairs, Depart of Agriculture, Forestry and Fisheries, Department of Health, and various bodies involved in land use planning;
3. Must protect sensitive, important, and irreplaceable, water eco-infrastructure. Some areas are off-limit for coal prospecting (and mining);
4. Legacy issues are taken into account, to restore and protect water eco-infrastructure, as part of a comprehensive view;
5. Be integrated into land use planning (meaning all plans for use of eco-infrastructure);
6. Be supported by a dynamic knowledge network (existing plans, maps of wetlands, information about river classification, monitoring points, access to legal interpretation and support, resources within departments, organisations within the network with easy access and capacity building);
7. Aim at long term sustainability, keep options open, be accessible, participatory, inclusive, transparent, adaptive, and fair, and address issues of transformation and historical redress.

These considerations were consolidated into a 10-point integrated monitoring plan and DSS, and presented to the UKCMF on 19 January 2016.

6.3.4 Revised integrated monitoring plan able to align biodiversity and mining development, accompanied by an appropriate Decision Support System

A core outcome of this project was to "*develop and test a multi-sectoral integrative monitoring framework linked to a decision support system that will cater for bio-physical, economic and societal needs*".

The workshop of 19 January 2016 engaged with the concept of social hydro connectivity, which builds on the concept of hydro-connectivity (Jordan 2015; US EPA, 2015). It then considered the integrative monitoring framework and decision support system developed through a series of workshops, critiqued and improved it (see Appendix E for more detail on this workshop).

The following ten steps can be described as both a framework and a plan. In the steps outlined below, a number of values about how to balance decision-making between coal mining and the protection of biodiversity and water resources are expressed. In that sense, it is a framework. At the same time, the 10 steps reflect a practical approach to this balancing act. In another sense, it is a thought experiment, in which an inclusive process considers land use choices now and into the future, and a sustainable use of what may be described as ecological infrastructure. It presents an implicit critique of the existing system.

At the outset of this project, the research team acknowledged (as part of the proposal now annexed to the contract) that a three-year project would not achieve substantive change in such a short span of time, but that it could catalyse awareness and set directions of, and mechanism to support, change.

While the steps below are formulated for the Carolina catchment, the intention is to expand them to other catchments.

Early in its deliberations, the UKF working group ascertained that it was not "mandated" within the current framework to make decisions about coal mining (after this aspect was questioned by a mine manager participating in the process). The catchment management system is an emerging one, from both the principled framework of IWRM (that gives a strong role to catchment citizens, echoing the constitution in its support for active citizens' participation), as well as from institutional decisions about managing water resources on a catchment basis.

The ten-step process in developing a multi-sectoral **integrative licensing and monitoring framework to integrate biodiversity and environmental water quality in the coal mining life-cycle**

1. *A regional-scale overview of existing ecological infrastructure (water resources, biodiversity, climate and soils for agriculture) is compiled – and forms part of the Decision Support System. List authorities and their roles.*

This means that these plans must be brought to the attention of stakeholders and participants in the UKF, work through during capacity building exercises, and made accessible, both in terms of detail (a URL or on a website) as well as executive summary for immediate use. They need to be analysed in terms of ecological infrastructure as they may not be expressed in that form.

2. *An overview of land use options and the drivers behind them - cultural resources, needs for historical redress including land claims, options for land use, IDPS is compiled*.

These would be the topics of overall discussion, in the manner of ongoing systemic action research, so that a mutual understanding if not a consensus is reached at least to the point where the basic, and more complex, situation is clear to all participants, and trade-offs are possible or can at least be put into words. There needs to be a dialogue in which all voices are heard, and options considered over a long term. [this may take the form of an AWARD WatRES discussion, or a separate chapter to the CMS on coal mining...]

3. *Long term development trajectories are developed in terms of the National Development Plan, including options for (and resources needed for) a transition to the Green (low carbon) Economy.*

Envisaging a Green Economy for Carolina, within the boundaries of the quaternary catchment, but also embedded within a Mpumalanga and broader national economy. It would entail assessing current economic activities and their impacts, and envisaging a transition from what is practised now to what the future may be.

4. *Coal mining options are assessed in terms of (4.1) benefits to the national and local economies (4.2) impacts on hydro-eco-infrastructure (4.3) sterilisation of competing land uses and development options (4.4) future costs of rehabilitation and restoration of land (eco-infrastructure).*

On this basis, the current and proposed future uses of ecological infrastructure are assessed in terms of how they relate, to current economic activities, but also how they support, or sterilise, future uses of ecological infrastructure in a green economy. Such discussions need to happen on a level playing field resulting from empowerment and dialogue type facilitation.

5. *Options are weighed in terms of their sustainable use and impact on eco-infrastructure, future land use and development options, benefits and costs, and need (socio-economic need).*

Stakeholders discuss and negotiate, in the UKF and other forums such as the local government's Integrated Development Plan, departmental processes and, in terms of SPLUMA, how these options contribute to public welfare and public interest. Stakeholders in the UKF, with the support of the IUCMA, act as custodians of hydro-ecological-infrastructure. These discussions must happen on a level playing field with empowerment and facilitation for dialogue.

6. *This forms the basis of a monitoring system that is enabled by legal instruments, for example water use licences, mining authorisations, Social and Labour Plans, etc.*

For the monitoring system to be enabled, it is a necessary precondition for stakeholders within the Upper Komati forum to have sight of, and comment on, these legal instruments, and to be supported in understanding and using them. Stakeholders should automatically have access to this information, and actively participate in their processing. It should not be necessary to incur legal costs to access the information, and, as a result, to create adversarial conditions within the decision-making process. Mines' compliance is made public in a system similar to the Green and Blue Drop incentive schemes.

7. *The decision-making and monitoring system is streamlined in terms of a principle pragmatism approach to IWRM. Documents are concise, accessible and honest.*

Decision-making and information are written in accessible language, within reasonable length, with pertinent conclusions presented in an understandable way, removing the need for inference: for example, of who polluters are, or what the potential for pollution is. Technical data and analysis are available in appendices; stakeholders/ interest groups have access to publicly-funded technical support to cross-check conclusions presented and data and analysis on which these are based. Annual reports communicate monitoring results.

8. *Relevant departments participate in and enable this process through offering specialist knowledge, share and consider inputs and support participation of especially historically disadvantaged groups through capacity building*.

All departments understand their duty to invite and support public participation, including through regular capacity building. They have dedicated officials, such as those in CMAs, for this task. These tasks can also be undertaken by civil society organisations or Chapter 9 institutions, with regular monitoring and evaluation by the participants who are supported in this way. These functions are Key Performance Indicators for these departments, according to the principles of Batho Pele. The system is underpinned by easy access to information. Media is used extensively and public awareness is built and maintained.

9. *The Catchment Management Agency acts as co-ordinator of this process in terms of water issues. National departments, for example through task teams (such as the current Acid Mine Drainage task team), with focus on job creation, transition to green economy etc., assure alignment and integration with national priorities*.

With water at the centre of most of these land use options, the emerging Catchment Management system is strengthened by the opportunities for co-operative governance, clear role descriptions and integration of land use plans. Processes to develop, update and extend Catchment Management Strategies are ideal opportunities for this function (see Rogers & Luton, 2011).

10. *A Decision Support System is developed through a knowledge networking process within the Upper Komati Catchment Forum, as a linked constellation of knowledge resources, including precedents of decision-making. Knowledge sources are developed, archived and made accessible, for example through websites linked to the IUCMA, national, provincial and local governments, as well as civil interest groups.*

The next section describes the decision support system, which was developed in the form of a dynamic decision support system.

6.4 Decision support system

The training materials developed in this project, are the outcomes of a social learning process in which a knowledge system to support decision-making about and monitoring of coal mining decisions with the aim of balancing these with the protection of wetlands, water resources and ecological infrastructure, was co-created with participants. During the process, there was a growth of capacity to use this knowledge system or network, which is supported by these training materials.

For further information on how to involve a wide range of participants an active consultation process, see Appendix D, "How to engage with coal mines through a Catchment Management Forum".

This popular guide was produced as part of the knowledge system (Decision Support System) for an integrated, participatory process of valuing, making decisions, monitoring and ongoing, inclusive adaptive management that has as its objective to balance the exploitation of coal resources with the sustainability of wetlands and other water-related ecological infrastructure.

It is meant for citizens who want to protect water and biodiversity; for people who are involved in making decisions about coal mining, and people who are concerned about the kinds of decisions being made about coal mining. It is also for people who want to know more about the effects of coal mining on the environment and ecological infrastructure, biodiversity and on people. This booklet emerged as a request out of the dialogue with the UKCMF.

See Appendix E: "Record of Upper Komati Catchment Management Forum Dialogues", which provides records of the UKCMF meetings through which the inclusive decision-making and monitoring process was developed.

The materials/ methods, described above, form part of a strategic path to change the status quo in the direction of a new inclusive, sustainable, adaptive management system. This process is embedded in the UKF, which is in turn supported by the IUCMA as part of the emerging national catchment management system.

The DSSs: Instructions for users who wish to accessing the data in the knowledge system

Data and maps assist with queries relating to any development in the X11B quaternary catchment around Carolina, Mpumalanga. Since we do not know the nature of a specific query, this knowledge pack provides general data and maps, as well as specific datasets that we consider useful in terms of the Centre for Environmental Rights (CER) mine application process. Data and maps are provided in three main formats: GIS data (and various sub-types), Google Earth (KMZ) data and digital maps (JPEG and PDF). To start using the knowledge pack data, users need to check what resources they have.

Option 1: Full GIS capacity and capability

If the user has full GIS capacity and capability, then data is provided in the following 2 formats:

- File Geodatabase (ESRI)
- Shapefile (QGIS, other)

The data table shown in the knowledge pack is in Geodatabase (. GDB) format. There are various feature datasets shown for polygon, polyline and point features as well as various Raster (image, grid) files. Geodatabase files or folders are ESRI's proprietary data format and may not read into all GIS packages. Shapefiles have been provided for all the polygon, polyline and point feature classes. If the user does not have full GIS capacity and capability, either install GIS copy or move to options 2 or 3

Option 2: Google Earth and an internet connection

If the user has a Google Earth and an internet connection, then data is provided in KMZ format. To read a Google Earth KMZ file, it is necessary the user will need to install Google Earth on his/her PC / device and will also need an internet connection. Maps are provided in two digital formats: JPEG and PDFNote that Google Earth is a data-intensive application and unless you have free WIFI or data, please use with caution. All you will need to do, is navigate to KMZ file you want to open, and double click on the KMZ file and it will open in Google Earth.

If the user has no Google Earth, either install Google Earth or if no internet connection, move to Option 3.

Option 3: A computer than can open a JPEG or PDF

It the user has a computer that can open a JPEG or PDF, then data is provided in these two formats, in the form of static maps.

The maps are provided in two digital formats: JPEG and PDF. A JPEG file will open with any standard Windows or Mac photo viewer, while a PDF will open with Adobe Reader. If you do not have Adobe Reader, download a free copy from the Adobe Acrobat website.

Option 4: Hard copy maps from IUCMA or local Environmental Study Group (Omgewingsgroep)

If not, use the hard copy maps provided by the IUCMA or get access to a PC. Hard copy maps were also provided to the Omgewingsgroep in Carolina which meets in a local church, and can make the maps available to the IUCMA as needed. The knowledge system will also be made available to the IUCMA.

In response to requests from participants in the UKCMF working group, the project resolved to also develop training material in a form that could be printed and used as a reference and training guide for participants of Catchment Management Forums. The guide was designed to be informative and empowering, and written in an intelligent, accessible style. Please note that this material is also intended to be used in the Toward Practicing a New Paradigm (TPNP) WRC project K5/2248, part of the Institute for Water Research at Rhodes University family of projects. It is attached here as Appendix D. The central focus of the 30-page booklet is "How to engage with coal mines through a Catchment Management Forum".

The handbook is intended for citizens who are concerned about, or involved in, decisions about coal mining and the protection of water and biodiversity resources. It is written for a specific CMF working group in the Upper Komati Forum, but the intention was to create a pilot format that could serve as a useful example for all CMF working groups dealing with protection of water resources against coal mining in their catchments. The specific information in this booklet is based on the Upper Komati Forum (the Carolina or X11B catchment), but the principles can be applied more widely. This booklet should be used with "How to establish and run a CMF" (in the WRC TPNP K5/2248 How to Series).

6.5 Conclusion

The project succeeded in creating a discursive space in which participants from all sides in the UKCMF were able to share their experiences and understandings of the current system in which decisions about coal mining – and its impacts on water resources, wetlands, biodiversity and other land uses – could be explored. Through the process, participants were able to listen to each other, debate with each other and arrive at a common vision of a decision-making and monitoring process which has the potential to provide an integrated, participatory process of valuing, making decisions, monitoring and ongoing, inclusive adaptive management that has as its objective to balance the exploitation of coal resources with the sustainability of wetlands and other water-related ecological infrastructure.

The process built on local knowledge, particularly of the local geology which was confirmed by the hydropedology study (see chapter 4 and Appendix C). Local farmers felt vindicated in seeing the diagrams and explanations provided by Prof McCarthy from the University of the Witwatersrand. Participants were keen to be involved in the ecosystems services study conducted by Joel Houdet. One farmer offered his business information in order to enable a comparative study with the benefits of coal mining in the area, but coal mines were loath to provide information. Farmers and community members were involved in the wetland assessments, in order to understand the social context in which the wetlands function.

The group was broadly representative. Community members from both township and town, (*Omgewingsgroep* and the Highveld Environmental Justice Network (HEJN), which was supported by NGO groundWork), mining managers, as well as consultants to the mining industry, as well as regulators in the IUCMA, DWS (Acid Mine Drainage Task team on coal participated, and UKCMF participated in the work of this task team).

Participants remarked on the absence of the Department of Mineral Resources from the process, and generally from UKCMF meetings. It reflected a general lack of consultation, they felt, with representatives and regulators of other land uses, including agriculture and water and sanitation. In that sense, this project provided an opportunity for these groups who feel themselves excluded from current decision-making, to envision an alternative.

The principles underlying their thinking about an alternative process are important. It starts with the need for a clear view of existing ecological infrastructure in the care of various departments and users. It aims to understand the needs, including for land reform, that people have. It takes a long-term view within the bounds of the National Development Plan, and keeps ecological sustainability in mind. Coal mining proposals need to be assessed in open process, and weighed in terms of social, economic and ecological benefits. Monitoring, and adapting the system of permissions, is a crucial part of the system, in which people's participation is made easy through support by officials. This approach depends upon and in turn strengthens an efficient catchment management system.

It can be foreseen that, as the Catchment management system grows, more CMFs are brought into being (there are at least 81 country-wide, existing in different shapes and forms – Munnik et al., 2015), decisions around the licensing of mining that could threaten water resources, and the monitoring of those decisions, will increasingly happen with the crucial participation of CMFs. This research was thus an attempt here not only to envision how such a process would work, but also whether such a process would be feasible and possible – in the revitalisation of CMFs going forward.

The team is grateful to the participants in the UKCMF who gave so much time and attention to these issues.

7 POLICY IMPLICATIONS

7.1 Introduction

This project was occasioned by the dramatic failures of the current regulatory system to protect the Holbankspruit in the Upper Vaal from destructive coal mining impacts, and chose as a study site the Carolina quaternary catchment where drinking water provision was interrupted for seven months as a result of an Acid Mine Drainage incident. Its aim is to prevent similar events from occurring and impacting on water resources, wetlands and biodiversity.

Although the Anker Coal Leliefontein case has not been studied in detail, it is understood that the mine had been licenced by DMR (CER, 2011) and that Anker Coal had previously admitted in court that it had presented misleading information to DMR about its Steenkoolspruit operations near Witbank in 2009 to acquire a prospecting permit (CER, 2011). However, it was not DMR but the civil society organisation FSE which had brought the Leliefontein case to court, stepping into the vacuum created by DMR inaction. The destructive impacts resulted from activities that were authorised, but not monitored for compliance. The aim of the research was to explore ways of preventing similar events from occurring and impacting on water resources, wetlands and biodiversity.

Therefore, at the core of this research project was an opportunity to envision a new, inclusive, participatory process for considering planning, decision-making and monitoring that concerns coal mines and their impacts on wetlands, biodiversity, wetlands and ecological infrastructure. The policy recommendations below draw from it.

7.2 Policy recommendations: General

1. Use the results to request a review of the decision-making and monitoring processes associated with coal mining and its impacts on water resources and biodiversity.

2. Call for the participation of government departments **including** the DMR, and that important that inter-governmental inputs are taken seriously and influence decision-making. It is particularly important that mining should not commence without water-use licences.

3. Improve regulations: regular inspections on environmental impacts take place; that regulation is transparent, being reported regularly and fully to the CMFs.

4. Consolidate, align and enable easy public access to local government, provincial and national plans for land use, within an appreciation of the ecological infrastructure as a basis for decisions making.

5. Encourage dialogue on future land use options — including (but not limited to) coal mining and the drivers of economic transformation, land reform and historical redress. Encourage this in an effort to reach consensus, or at least a situation where basic and more complex situations are clear to all participants, and trade-offs are possible or can at least be put into words. This needs to be a dialogue in which all voices are heard and long-term options are considered.

6. Formulate long term development trajectories in terms of the National Development Plan, including options (and resources needed) for a transition to a low carbon, Green Economy.

7. Assess coal mining options in terms of benefits to national and local economies, in relation to impacts on hydro-eco-infrastructure. Take account of land becoming functionally damaged, and preventing competing uses and development options, as a result of coal mining. Internalise costs of functionally effective rehabilitation and restoration of land (eco-infrastructure).

8. Make decisions about whether, and where, to mine coal on the basis of long-term sustainable use of landscapes, in terms of their sustainable use and impacts on eco-infrastructure, future land use and development options, benefits and costs, and socio-economic needs.

9. Catchment management forums, with the support of Catchment Management Agencies and other government departments, empowered to monitor the use of mining and related rights enabled by free access to legal instruments: for example, water use licences, mining authorisations, Social and Labour Plans, etc.

10. Streamline the decision-making and monitoring system in terms of a principled pragmatic approach to IWRM, the aim being to produce documents that are concise, accessible and honest.

11. The need for relevant government departments to participate in citizen monitoring processes through offering specialist knowledge, sharing and considering inputs, and supporting participation through capacity building, particularly for historically-disadvantaged groups.

12. With water being the central consideration of most of the land use options, the emerging Catchment Management system needs to be strengthened by providing opportunities for co-operative governance, and clear role descriptions and integration of land use plans. Processes to develop, update and extend Catchment Management Strategies are ideal opportunities for fulfilling this function (Rogers & Luton, 2011).

7.3 Policy recommendations: approach to wetlands

1. The water resource management recommendation is to make use of hydropedology mapping to identify wetlands in the Highveld grassland ecosystem **that are still hydrologically connected.** Thereafter, a moratorium should be put in place on implementation of any aspect of the coal mining life cycle (Chapters 2 and 3 and Appendices A, B and F)) within the perimeter of the still-connected wetland systems.

2. Key biophysical data and the hydropedology study indicated that the conventional wetland delineation of the first two wetland assessments would not reveal wetland impacts until it was too late for remediation action. Hydropedological and hydrological connectivity studies are thus essential for identifying areas where puncturing of the sandstone layers (due to mining activities) may cause wetlands to "leak away". Similarly, there is a need to map unpunctured landscape units and proclaim such areas as "no mining zones". Without such planning, the Highveld wetlands will continue to be at risk.

3. Publish the limitations of the delineation approach in the widely-used WET Health and WET ecosystem services assessments, in enabling an early warning of wetland impact from coal mining. Therefore, make use of hydropedology to delineate Highveld wetlands for the purpose of identifying intact wetland connectivity and lobbying for effective wetland protection.

4. The Departments of Water and Sanitation, Environmental Affairs and Mineral Resources need to engage at the highest political and administrative levels to address impunity problems in coal mining regulation and co-operative government and governance. Until such action is taken, water activism will continue to be the most effective avenue for wetland protection.

7.4 Policy recommendations: legal aspects

1. There is a need to place certain wetlands, high-value biodiversity areas and important ecological infrastructures beyond the realm of contestation. Such actions will place a greater emphasis on regional and spatial planning tools and how these can contribute to placing certain geographical regions, or particular localities, off limits to mining. Rather than restricting the focus to the licensing process, the nation's conservation, biodiversity, water, spatial planning and agricultural laws must be investigated to ensure that they afford authorities the appropriate forms of power to enable authoritative delineation of land uses that respect ecological limits at the appropriate scale. Whilst conservation plans, biodiversity plans, environmental management frameworks and land use planning schemes abound, the legal status of many such plans is still problematic. The potential for the Spatial Planning and Land Use

Management Act (SPLUMA) to protect wetlands, biodiversity and ecological infrastructure is worth further investigation.

2. In addition to determining appropriate uses, authorities must have the power to define thresholds for uses within particular geographical areas. Decisions in this regard must bind mining authorities. The prohibition of environmental or waste management authorisations in particular geographical areas will facilitate such actions, but there may be a need to qualify and refine such powers and to extend it to other authorities (for example to water and agriculture ministries).

3. Revisit criteria for granting prospecting and mining rights, environmental authorisations, water use licences, and waste management licences. Also, to give content to certain criteria applied by the Minister of Mineral Resources when granting prospecting or mining rights (for example, requiring that the grant will not result in 'unacceptable' pollution or ecological degradation). Unacceptability in this case should be unambiguously linked to compliance with the nation's conservation, biodiversity; and probably also food security goals.

4. Revisit timing, assessment protocols and discourses of justification frequently used when conducting site-level EIAs for prospecting and mining projects, recognising that site-level EIAs frequently perform risk management functions other than those associated with management of environmental risks. For example, such EIAs may be important to facilitate the assessment of risk exposure, in which case they will be formulated at a pre-design stage of the project. When finances are granted, any project design changes should initiate the need for an amendment. The justification discourses employed in an application for an environmental authorisation revolve around the activity and its impacts, rather than focusing on ecological infrastructure at risk. Adopting an alternative focus on licensing will enable the use of the ecological infrastructure, rather than licensing the activity, thus requiring applicants to adjust the manner in which they present ecological infrastructure valuation. Valuation should include how the difficult issues are addressed, justifying harm, dealing with substitutability and irreversible impacts, deferring decision-making, and the manner in which they present techniques of observation and care.

5. Strengthening the process for raising the ten objections identified. Where prospecting and mining are allowed to occur, the licensing of such should allow for meaningful contestation in a forum that is transparent and is not biased towards mining interests.

7.5 Policy recommendations: resource economics and green economy perspectives

1. The application of concepts and methods from ecological economics, resource economics, and externality studies is at an early stage. Presenting biodiversity and water resources concerns in the language of ecological infrastructure is finding an audience, but comes with the risks associated with conceptualising nature as 'ecological infrastructure'; and thus, commodifying ecosystems. Nevertheless, these considerations remain important for decision-making. Thus, we recommend setting up a WRC Indaba to compare and evaluate different ecosystem evaluation approaches.

2. Developing a perspective of greening the South African economy (Swilling et al., 2016) needs to be taken into account, especially concerning relationships between coal mining and competing land uses.

3. Net impact accounting (i.e. net changes in natural capital stocks and services) to be used as a common shared tool to understand, assess and drive environmental management practices by

all land-users. The purpose being to convince key stakeholders to implement policies so as to reach no-net-loss, or even net gains, in key natural capital stocks (wetlands, natural and improved grasslands) and services (foods, water supply and regulation, waste assimilation and dilution, dust regulation), depending on local context and available resources.

8 CONCLUSION AND RESEARCH RECOMMENDATIONS

This project centred on a dialogue process supported by a number of studies from different disciplines. These studies responded to aspects of the dialogue, and were instrumental in creating knowledge resources required for inclusive decision-making and monitoring within a catchment management framework.

An important part of the research was an attempt at understanding the reality of different stakeholders in coal mining in the quaternary catchment – and enabling stakeholders to understand each other. This was achieved via the Cultural Historical Activity Theory (CHAT) methodology – a transparent framework of interviewing stakeholders, mirroring back the results and supporting stakeholders to engage with points of tension within it. This fed directly into the dialogue process, run along “cognitive justice” lines. The project confirmed the use of the CHAT in multidisciplinary studies.

The focus on wetlands and protection of water resources was strengthened by research into the wetlands and the ecosystems they provide, which were scientifically tested as well as in qualitative interviews with land owners. The hydropedology approach – tracing the flow of water in the soil - confirmed two important aspects of local knowledge: the vulnerability of the hydrological regime to puncturing of the sandstone and plinthic layers during coal mining, and the impossibility of restoring these geologically determined drivers, as well as the physical reality of hydro connectivity in this area. These insights were well received in the dialogue process and strengthened the confidence of local stakeholders.

An economic study – although frustrated by non-co-operation from a mine – clearly showed that land use options other than coal mining were important for longer term sustainability, both in the environmental and the economic sense, and should form part of decision-making and subsequent monitoring.

A fundamental supporting research area was to develop an in depth understanding of the administrative and legal processes regulating coal mining. The legal analysis sought to bring clarity about the implications of SES, as well as explore to what extent current legal thinking in this area supports the protection of ecological infrastructure.

The dialogue process was also supported by developing, through political ecology, an understanding of contestation around coal mining and the protection of biodiversity, ecological infrastructure and water resources. The project also undertook a historical-conceptual exploration of activism within biodiversity and conservation sector, to account for the current interest in resource economics and ecological infrastructure approaches.

The project was challenged by the reference group, in its first meeting, to deal with hydro connectivity in the landscape, and to explore the concept of ecological infrastructure. These concepts were used in the dialogue process.

Finally, this process led to the formulation of a new framework for decision-making and monitoring. It provides a view of the emergence of a citizen driven care of water, soil and mineral resources, the result of the unfolding of a democratic dispensation following on colonialism and apartheid, in which mining was privileged by authorities over other land uses. The emerging system of catchment management, and the participation of citizens in it, provides a new conceptual and practical framework to think about decision-making and monitoring around coal mining and competing land use, as this project has shown.

This is emerging work that needs to be followed up.

This project is part of a growing stream of multi- and transdisciplinary research to address complex problems in the water sector. The WRC should look systemically into the implications of transdisciplinarity for research into the complex social ecological systems of water use, including industrial and mining research. An enabling environment needs to be created for such projects

8.1 Research recommendations

1. Policy framing of the delineation approach to wetlands protection, thus seriously adding to the current delineation approach, which does not pay sufficient attention to the interconnectedness of water in the landscape, thus underplaying the importance of the drivers of wetland systems. Further research into the Leliefontein (Golfview Mining) case study is recommended as the project highlighted serious shortcomings in current rehabilitation approaches.

2. Research and follow-up action on the implementation of proposals of the Golder report on the AMD event in Carolina; co-operation with the UKCMF, the IUCMA, relevant government departments and mining companies, is recommended.

3. As coal mining comes under increasing pressure from climate change regulations and competition from renewable energy, a series of research projects into: (i) closure policy and rehabilitation standards (covering legal, institutional (regulation); (ii) participation and technical aspects of rehabilitation) should be undertaken to ensure that landscapes and water resources are not damaged by current formal and informal coal mining to the extent that their value cannot be recovered.

4. Participatory research, supported by technical research into an array of options that should focus on the healthy use of water and soil in a healthy environment.

5. Participation of CMFs in decision–making systems should continue with respect to coal and other land uses that impact negatively on water resources.

6. Research into appropriate accessible decision-making systems as well as monitoring coal mining and its impacts on water resources, should continue to engage the support and participation of citizens.

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APPENDIX A:

REGULATION THROUGHOUT THE COAL MINING LIFE CYCLE

TABLE OF CONTENTS

1 INTRODUCTION

This appendix consists of an annotated list of 50 instruments relevant to regulating the relationship between mining (including coal mining) and the environment, with comments on their usefulness, and relationship to ecological infrastructure thinking.

The instruments listed below have been divided into those relevant to:

A. Resource directed measures
B. Source directed controls (standards, statements of liability, regulatory controls)
C. Monitoring, inspections and powers of state intervention
D. Criminal offences and powers of court in criminal matters

The instruments listed in these categories differ from high level statements of rights and principles,[1] and mid-level planning instruments.[2] Rather, the instruments tend to be quite concrete and specific in their application, both to the individual private enterpriser the relevant state department.

The annotation to each instrument has the following scope:

The legal authority for the instrument[3]
The powers conferred, duties imposed, or rights established by the instrument[4]
Three analytical questions:
How does the instrument link to the discourse of ecological infrastructure?
The use of this instrument in the Carolina acid mine drainage event of January 2012 (and its aftermath)
General comments on the use of this instrument.

Very few of the instruments are consistent with the discourse on ecological infrastructure. The predominant conceptual framework and discourse is that of sustainable development, where nature in its diverse forms, is predominantly conceived of in terms of types of "impact" that require mitigatory or remedial action, and with the policy goal of integrating economic and social development with environmental protection. The paucity of instruments giving effect to the notion of ecological infrastructure is understandable given that the sustainable development narrative is "hard-wired" into the substance of the regulatory framework through the constitutional environmental right, and the statement of environmental management principles in the National Environmental Management Act (NEMA).

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[1] Examples include the constitutional right to environment (s 24) and the right of access to sufficient water (s 27); the principles of environmental management in s 2(4) of the NEMA; the notion of state custodianship of water resources and minerals, and state "trusteeship" of biodiversity.
[2] Such as the Catchment Management Strategy (NWA); the Integrated Development Plan (MSA); Water Services Development Plans (WSA); and Bioregional Plans (NEMBA).
[3] This refers to the relevant statutory source of the instrument, identified by the section number, Act number and year (see also abbreviations).
[4] Powers, rights and duties should all be read with their legal character in mind; i.e. the potential to ultimately be backed by State force. Powers are ordinarily exercised by state officials; duties may be imposed on state officials or on mining proposals; and rights may vest in mining proponents or third parties. It is not necessary that legislative provisions always convey all three categories of legal action.

2 RESOURCE DIRECTED MEASURES

Resource-directed measures are rights, powers and duties directed toward the resource, rather then the source of pollution or ecological degradation.

2.1 Classification of water resources and specification of resource quality objectives

Legal authority: Sections 12 – 15, National Water Act (NWA)

Powers: 1) The Minister of Water Affairs must prescribe a system for classifying water resources. The classification system is intended to ensure the ecological sustainability of all significant water resources by taking into consideration the social and economic needs of the competing interests in relation to the water resource. Regulations on the classification system were published in 2010 as GN810 in *GG* 33541 of 17 September 2010. 2) Minister of Water Affairs must for every significant water resource, determine the class and the resource quality objectives (RQOs) that apply. RQOs may relate to a variety of the water resources' dimensions. The Minister may also make a preliminary determination.

Duties: The Minister of Water Affairs, the Director-General, an organ of state, and a water management institution must give effect to the water resource class and the RQOs when exercising any power or performing any duty under the NWA.

Link to ecological infrastructure concept: Recognition of ecosystem goods, services and attributes in the classification regulations, also recognise that some water resources will be worked harder than others, but subject to the "ecologically sustainable base configuration scenario".

Questions: Do either of the Boesmanspruit or Nkomati rivers have a classification and specified RQOs? When were they established? Do they have a preliminary classification? Which parties (if any) are aware of the resource classification and RQOs?

Comments: What is interesting about the duties is that it also binds "an organ of state"; i.e. any national, provincial or local authority (not only water affairs) that exercises rights or powers in relation to that water resource.

2.2 Determination of the Reserve

Legal authority: Sections 16 – 18, National Water Act

Powers: The Minister of Water Affairs must as soon as reasonably practicable after the class of a water resource has been determined, determine the Reserve for all or a part of that resource. The Minister may make a preliminary determination of the Reserve.

Duties: The Minister of Water Affairs, the Director-General, an organ of state, and a water management institution must give effect to the Reserve when exercising any power or performing any duty under the NWA.

Link to ecological infrastructure concept: The Reserve is the quantity and quality of water required (a) to satisfy basic human needs for water; and (b) to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the water resource.

Questions: Has the Reserve for either the Boesmanspruit or the Ncomati been determined? Is there a preliminary classification? Which parties (if any) are aware of the Reserve for these sources?

Comments: Like the duty to give effect to the resource classification and RQOs, the duty to give effect to the Reserve binds a broad range of parties – in fact, any organ of state. The Reserve is a broad enough concept to carry the interests of the people of Carolina in a safe drinking water supply.

2.3 Protection of threatened or protected ecosystems (National Environmental Management: Biodiversity Act 10 of 2004 (NEMBA))

Legal authority: Sections 51 – 55, National Biodiversity Act

Powers: 1) The Minister of Environmental Affairs may publish a national list of ecosystems that are threatened and in need of protection. A national list of ecosystems that are threatened and in need of protection was published as GN1002 in GG 34326 of 27 May 2011. 2) The MEC responsible for the environment may publish a provincial list of ecosystems in a province that are threatened and in need of protection. In respect of these powers, four categories of ecosystem may be listed. The first would seem to apply to Carolina; i.e. critically endangered ecosystems that have undergone severe degradation of ecological structure, function or composition as a result of human intervention and are subject to an extremely high risk of irreversible transformation. 3) The Minister of Environmental Affairs may identify any process or activity in a listed ecosystem as a threatening process.

Duties: 1) Any published national or provincial list must be reviewed every five years. 2) If the Minister has identified a threatening process in a protected ecosystem, the proponent of the process must obtain an environmental authorisation under the NEMA. 3) An organ of state obliged to prepare an environmental implementation plan or environmental management plan under the NEMA, and a municipality in the preparation of an IDP must take into account the need for the protection of listed ecosystems.

Link to ecological infrastructure concept: These laws allow for the bounding and recognition of “ecosystems” in particular areas and for their protection.

Questions: Is there any scope for recognising the Boesmanspruit catchment as an ecosystem requiring recognition and protection at either the national or a provincial level?

Comments: This protection looks fairly impressive but it is not linked to any duties that have a substantial impact. The regulations spell out the implications of listing an ecosystem as threatened and protected however and these must be followed up. The need for protection of an ecosystem is not linked to any quality of the system itself (i.e. it need not be a “pristine” or a conservation area, for example), but rather to the state of degradation of that system.

3 SOURCE DIRECTED CONTROLS (STANDARDS, STATEMENTS OF LIABILITY, REGULATORY TOOLS)

3.1 Rehabilitation standard

Legal authority: Section 38(1)(d), Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA), s 24N(7)(e).

Duties: The holder of a prospecting or mining right must, as far as it is reasonably practicable, rehabilitate the environment affected by the prospecting or mining operations to its natural or predetermined state or to a land use which conforms to the generally accepted principle of sustainable development.

Link to ecological infrastructure concept: Not explicit.

Questions: What kind of end land use did the EMPs for the mines in the Carolina case specify?

Comments: This is the "rehabilitation standard" in the MPRDA. It is key because it determines the extent of financial provision and the scope of efforts to close the mine and manage residual and latent environmental impacts. The standard is stated very broadly and it is highly unlikely that any EMP would state a return to a "natural state". Apparently the use most commonly identified is a return of the land to a "wilderness area".

3.2 Statement of liability for environmental damage

Legal authority: Section 38(1)(e), MPRDA; section 24N(7)(f), NEMA.

Duties: 1) The holder of a prospecting or mining right is responsible for any environmental damage, pollution or ecological degradation as a result of his or her prospecting or mining operations and which may occur inside and outside the boundaries of the area to which the right relates (MPRDA formulation). 2) To the responsibility for environmental damage, pollution and ecological degradation, the NEMA adds "the pumping and treatment of extraneous water".

Link to ecological infrastructure concept: Not explicit.

Questions: In which of the mines' mining area was the drinking water supply of the town of Carolina related? Is there a map showing the extent of the different mining areas?

Comments: This standard is not expressly linked to any criminal liability (as for example, the failure to manage impacts in accordance with the Environmental Management Programme (EMP)). However is it valuable to counter arguments that mining companies are not responsible because the pollution etc is not taking place *within* the mining area.

3.3 Environmental management plan/programme

Legal authority: Sections 38 – 40, item 10, Schedule 2 MPRDA

Duties: 1) An applicant for a prospecting right must prepare an environmental management plan in accordance with the MPRDA regulations. 2) An applicant for a mining right must prepare an environmental management programme in accordance with the MPRDA regulations. 3) The holder of a prospecting or mining right must manage all impacts in accordance with the approved EMP, where appropriate, and as an integral part of operations. 4) The Minister of mineral resources must consult with any state department administering a law relating to the environment and request the HoD to submit comments within 60 days.

Powers: 1) The Minister of mineral resources must approve an EMP within 120 days if (a) the applicant has established baseline data on the affected environment; investigated, assessed and evaluated the impact of the prospecting or mining operations on the environment, socio-economic conditions and national heritage; developed an environmental awareness plan for employees; and described the manner in which pollution or ecological degradation would be modified, remedied, controlled, etc; (b) provided the relevant financial provision; and (c) has the capacity or has provided for the capacity to rehabilitate and manage negative impacts on the environment. 2) At any time after approving an EMP, the Minister of minerals may approve an amended EMP.

Link to ecological infrastructure concept: The MPRDA's provisions on the EMP do not give effect to the notion of "ecological infrastructure". They are situated within a sustainable development discourse and the management of environmental "impacts". The regulations do not allow for or guide a valuation of environmental assets in the public interest.

Questions: 1) Did all the mines operating in the catchment area have approved EMPs? Which of the mines in the catchment held old order rights that required the amendment of the EMP upon the Minister's direction, and which were the holders of new order rights? 2) If the rights were old order rights, did the Minister direct any amendments of the EMP? 3) According to the approved EMPs what impacts did the prospecting and mining operations have on the water resources? Was any provision made for cumulative impacts? What mitigation measures were indicated in the EMP? What did each EMP say about how those impacts would be managed upon closure? 4) Did the Minister of minerals approve an amended EMP at any time (old or new order rights)? 5) When approving the EMP or an amended EMP for any of the mines did the Minister of minerals consult with other State departments administering laws relating to the environment? If so, which departments were consulted? What was their input to the process?

Comments: The EMP is the central regulatory tool in managing the environmental impacts of mining. It requires applicants to undertake a detailed EIA of the operations before starting and forms the basis for the continued operational management of environmental impacts. At the time the crisis took place the relevant rules were contained in s 38 of the MPRDA (and are in fact still relevant because the new system under NEMA which requires applicants getting an environmental authorisation, only kicks off in December 2014). It would therefore be critical to obtain copies of the approved EMPs for all the mines operating in the catchment area. Determining how the different EMPs described the impacts on the water resources in the catchment would constitute a mini-project on its own. The EMP is closure oriented and must include information on the closure objectives and a closure plan. It was the only one of the 5 environmental duties articulated in s 38 to be linked to a criminal offence. The power of the Minister of minerals to amend an EMP is couched very broadly and there is no public participation requirement linked to this amendment.

3.4 Objection to the granting of a prospecting or mining right

Legal authority: Section 10 MPRDA.

Rights: 1) Interested and affected persons may submit an objection to the granting of a prospecting or mining right to the Regional Manager (RM).

Duties: 1) If an objection is submitted the RM must refer the objection to the Regional Mining Development and Environmental Committee (RMDEC). 2) The RMDEC must consider the objection and advise the Minister of minerals thereon. 3) The Minister of minerals may not approve an EMP without considering the advice of the RMDEC, where this is relevant.

Link to ecological infrastructure concept: None.

Questions: When any of the new mines in the catchment were being approved, were objections submitted and referred to the RMDEC? What was the view of the RMDEC in each case?

Comments: The power to object provides interested and affected parties with one avenue to oppose the granting of prospecting and mining rights on environmental grounds. The relief however is weak – simply a referral to the RMDECs. At the time the crisis occurred, the RMDECs were being criticised as loaded with Department of Mineral Resources (DMR) officials that crowded out the views of other departments. The RMDEC also has advisory powers. It is seen as a weak institution that generally pre-emptively rubberstamps a positive decision. The RMDECs also lack transparency. Discussions are not open to the public and deliberations and decisions are not publicly accessible.

3.5 Financial provision for rehabilitation

Legal authority: Section 41 MPRDA (to be replaced by section 24P NEMA in December 2014).

Duties: 1) An applicant for a prospecting or mining right must make the prescribed financial provision for the rehabilitation of “negative environmental impacts” before the Minister of minerals approves the EMP. 2) The holder of a prospecting or mining right must annually assess his or her environmental liability and increase the financial provision to the satisfaction of the Minister. 3) The holder must maintain and retain the financial provision until the Minister of minerals issues a closure certificate.

Powers: 1) If the Minister of minerals is not satisfied with the amount of financial provision he or she may appoint an independent assessor to conduct the assessment. 2) If the holder fails to rehabilitate or to manage environmental impacts the Minister may, upon written notice to the holder, use all or part of the financial provision for this end. 3) After a closure certificate is issued the Minister of minerals may still retain any portion of the financial provision for rehabilitation or to manage latent and residual impacts.

Link to ecological infrastructure concept: None. The DMR has a guideline on the calculation of financial provision but these are squarely based on “impact management” not on replacing the value of lost natural capital.

Questions: 1) Did the mines operating in the Carolina catchment area make financial provision for rehabilitation? What amounts were proposed? What form did the financial provision take (usually a trust)? Did the mines maintain the financial provision, annually reassessing their environmental liability? 3) Did the Minister of minerals express dissatisfaction over the levels of financial provision and appoint an independent auditor? Did the Minister use the financial provision to rehabilitate or manage negative impacts?

Comments: The duty to make financial provision for rehabilitation is a key element of the closure model for mines. The DMR guideline on this has been strongly criticised for failing to properly quantify the full costs of rehabilitation and the management of residual and latent environmental impacts. The holders of old order rights were not specifically required to make provision for financial provision for closure, although as part of amended EMPs they would generally propose a higher level of financial provision.

3.6 Closure certificate

Legal authority: Section 43 MPRDA (amended on 7 June 2013 by Act 49 of 2008).

Duties: 1) The holder of a prospecting or mining right must apply to the RM for a closure certificate upon lapsing, abandonment or cessation of the right in question; cessation of the prospecting or mining operation; and completion of the prescribed closure plan within 180 days of any of these events occurring. Post 7 June 2013: This duty also applies the holder of an old order right, or to a previous owner of works that has ceased to exist; until the closure certificate is issued the holder remains responsible for the pumping and treatment of “extraneous water”. 2) The application for a closure certificate must be accompanied by the prescribed environmental risk report. 3) The application for a closure certificate may be accompanied by an application for the transfer of environmental liabilities. 4) The Minister of minerals may not grant a closure certificate until the Chief Inspector and the department responsible for water affairs, have confirmed in writing that the provisions pertaining to health and safety and management of potential pollution to water resources have been addressed. Post 7 June 2013: The duty to obtain certification extends to each government department charged with the administration of any law relating to any matter affecting the environment, and they must also certify that the pumping and treatment of extraneous water has been addressed.

Powers: 1) The Minister of minerals may issue a closure certificate (subject to the certification of the Chief Inspector and the department of water affairs). 2) The Minister may retain any portion of the financial provision for managing latent and residual impacts becoming known in the future. Post 7 June 2013: 3) The Minister of minerals, in consultation with the Minister of environment, may initiate steps to ensure the regional closure of mine.

Link to ecological infrastructure concept: None, the closure certificate is based on the "impact model".

Questions: 1) Which of the mining companies in the Caroline catchment meet the conditions for applying for a closure certificate? 2) Which companies have applied for a closure certificate? 3) Have any closure certificates been granted? 4) If closure certificate were granted what other state departments were consulted? 5) Does the Minister of minerals have any plans for regional closure of mines in the Caroline catchment?

Comments: The closure certificate is a key element in the model for regulated closure. At the time the crisis occurred it still functioned to end the liability of the mine for managing environmental impacts. From December 2014, liability will continue notwithstanding the issue of a closure certificate.

3.7 Transfer of environmental liabilities

Legal authority: Section 43(2) MPRDA; regulations 58–59, MPRDA regulations

Powers: 1) Together with an application for a closure certificate, the holder of a prospecting or mining right may apply for the transfer of environmental liabilities and responsibilities. 2) The Minister may transfer environmental liabilities and responsibilities specified in the EMP to a competent person (outlined in reg 59). 3) When deciding to transfer environmental liabilities and responsibilities, the Minister of minerals may consult with "relevant government departments" or organs of state that administer a law relating to the environment.

Link to ecological infrastructure concept: Not explicit.

Questions: 1) If any of the mines in the Carolina catchment applied for a closure certificate, did they also apply for the transfer of environmental liabilities and responsibilities? 2) If transfer were granted, do the persons taking them on meet the competence specifications in reg 59? 3) If the Minister of minerals granted the transfer, with what other State departments did he consult? 4) Did the transfer of environmental liabilities and responsibilities go together with a reduction of the financial provision for rehabilitation?

Comments: There are many cases in which the transfer of environmental liabilities and responsibilities has gone hand in hand with revising the scope of these liabilities down.

3.8 Notification obligations to DWAF relating to mines and mining-related activities

Legal authority: Regulation 2, GN704

Duties: 1) Any person intending to start a new mine or mining-related activity (including loading and off-loading zones) must notify the Dept of Water Affairs of this intention 14 days prior to starting. 2) In person in control of an existing mine or mining-related activity must submit a copy of any amendments to the Dept; notify the Dept of any intention to cease the operation of a mine or a particular mining-related activity; and notify the Dept by the fastest means possible of any emergency incident or potential emergency incident involving a water resource.

Link to ecological infrastructure concept: Not explicit.

Questions: 1) Were these notification obligations complied with prior to the crisis? 2) Was notice in accordance with these obligations given when the crisis struck? 3) Post the crisis, have mines in the area been more diligent in meeting their notice obligations? 3) Have criminal charges been laid where there has been non-compliance?

Comments: These rules are essentially about ensuring that the Dept of Water Affairs, as the principle regulator, is informed of mining-related activities. A possible weakness is that the rules do not require mining proponents to notify the catchment management agency, where one has been specified. Non-compliance with this regulation is a criminal offence.

3.9 Locality restrictions relating to water resources

Legal Authority: Regulation 4, GN704

Duties: 1) No person in control of a mine or mining-related activity may build certain structures (e.g. residue deposits, dams) within the 1:100 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, borehole or well, or on ground likely to become water-logged, undermined, unstable or cracked. 2) No person in control of a mine or mining-related activity may carry on any underground or opencast mining, prospecting or any other operation or activity under or within the 1:50 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, whichever is the greatest. 3) No person in control of a mine or mining-related activity may place or dispose of any residue or substance which causes or is likely to cause pollution of a water resource, in the workings of any underground or opencast mine excavation, prospecting diggings, pit or any other excavation. 4) No person in control of a mine or mining-related activity may use any area or locate any sanitary convenience, fuel depots, reservoir or depots for any substance which causes or is likely to cause pollution of a water resource within the 1:50 year flood-line of any watercourse or estuary.

Powers: 1) The Minister of water may in writing authorise an exemption from any of these substantive rules.

Link to ecological infrastructure concept: These provisions are simply about protecting water resources based on assumptions about when flood events occur. Doesn't specifically advance ecological infrastructure concept.

Questions: 1) Were these substantive rules observed by all the mines operating within the Carolina catchment area? 2) Did the Minister of water affairs authorise an exemption from any of these rules in writing? 3) Have criminal charges been laid where there has been non-compliance?

Comments: These rules are good to have but they are also in danger of constituting the lowest common denominator for pollution prevention efforts. Climate change is also driving the frequency of flood events. The good thing about all the substantive rules in the GN704 regs is that they apply to any person "in control", hence they would also apply to contract miners. Non-compliance with this regulation is a criminal offence. All of the rules in GN704 discussed below are "stand-alone"; i.e. they apply over and above any measures that may have been specified in an EMP, environmental authorisation or water use license.

3.10 Restrictions on use of material

Legal authority: Regulation 5, GN 704 Regulations

Duties: 1) No person in control of a mine or activity may use any residue or substance which causes or is likely to cause pollution of a water resource for the construction of any dam or other impoundment or any embankment, road or railway, or for any other purpose which is likely to cause pollution of a water resource.

Powers: 1) The Minister of Water Affairsmay in writing authorise an exemption from this rule.
Link to ecological infrastructure concept: This provision seems to be about preventing the use of materials that can cause pollution when they are brought into contact with water. Doesn't specifically advance ecological infrastructure concept.

Questions: 1) Was these substantive rule observed by all the mines operating within the Carolina catchment area? 2) Did the Minister of water affairs authorise an exemption from this rule in writing? 3) Have criminal charges been laid where there has been non-compliance?
Comments: A good to have rule, it would be better if the regs were more specific about the most damaging materials. Non-compliance with this regulation is a criminal offence.

3.11 Duty to maintain separate clean and dirty water systems

Legal authority: Regulation 6, GN 704 Regulations

Duties: 1) Every person in control of a mine or mining-related activity must establish separate clean and dirty water systems around the mine or activity that meet the technical specifications set out in the regulations.

Powers: 1) The Minister of water may in writing authorise an exemption from this rule.
Link to ecological infrastructure concept: This provision is about trying to prevent dirty water coming into contact with clean water. Doesn't specifically advance ecological infrastructure concept.

Questions: 1) Was these substantive rule observed by all the mines operating within the Carolina catchment area? 2) Did the Minister of water affairs authorise an exemption from this rule in writing? 3) Have criminal charges been laid where there has been non-compliance?

Comments: A good to have rule. Non-compliance with this regulation is a criminal offence.

3.12 Reasonable measures to protect water resources

Legal authority: Regulation 7, GN 704 Regulations

Duties: 1) Every person in control of a mine or mining-related activity must prevent waste water or pollution causing substances from entering a water resource either by natural flow or by seepage and must retain and collect the waste water or substance. 2) Every person in control of a mine or mining-related activity must design, modify, locate, construct and maintain all water systems, including residue deposits, in any area so as to prevent the pollution of any water resource through the operation or use thereof and to restrict the possibility of damage to the riparian or in-stream habitat through erosion or sedimentation, or the disturbance of vegetation, or the alteration of flow characteristics. 3) Every person in control of a mine or mining-related activity must effectively minimise the flow of any surface water or floodwater into mine workings, opencast workings, etc. through cracked or fissured formations, subsided ground, sinkholes, outcrop excavations, adits, entrances or any other openings. 4) Every person in control of a mine or mining-related activity must manage residue stockpiles and deposits, tailings etc. in a manner that they will not fail or become unstable. 5) Every person in control of a mine or mining-related activity must prevent the erosion or leaching of materials from any residue deposit or stockpile from any area and contain material or substances so eroded or leached in such area by providing suitable barrier dams, evaporation dams or any other effective measures to prevent this material or substance from entering and polluting any water resources.

Powers: 1) The Minister of water may in writing authorise an exemption from any of these substantive rules.

Link to ecological infrastructure concept: These provisions are simply about protecting water resources. Doesn't specifically advance ecological infrastructure concept.

Questions: 1) Were these substantive rules observed by all the mines operating within the Carolina catchment area? 2) Did the Minister of water affairs authorise an exemption from any of these rules in writing? 3) Have criminal charges been laid where there has been non-compliance?

Comments: These rules provide an additional indication of what "reasonable measures" might be in terms of ss 19 of the NWA and 28 of the NEMA. Non-compliance with this regulation is a criminal offence.

3.13 Security measures around water resources

Legal authority: Regulation 8, GN 704 Regulations

Duties: 1) Every person in control of a mine or mining-related activity must effectively fence-off any impoundment or dam containing poisonous, toxic or injurious substances and erect warning signs at prominent locations. 2) Every person in control of a mine or mining-related activity must ensure access control in any area used for stockpiling or disposal of residue or harmful substances to protect measures taken for pollution control in terms of these regulations. 3) Not allow the use of this area for any other purpose if it is likely to cause the pollution of a water resource. 4) Every person in control of a mine or mining-related activity must protect any existing pollution control measures or replace any existing pollution control measures deleteriously affected, damaged or destroyed by the removing or reclaiming of materials from any residue deposit or stockpile, and establish additional measures for the prevention of pollution of a water resource which might occur, is occurring or has occurred as a result of such operations.

Powers: 1) The Minister of water may in writing authorise an exemption from any of these substantive rules.

Link to ecological infrastructure concept: These provisions are about protecting the other measures put in place to prevent pollution. Doesn't specifically advance ecological infrastructure concept.

Questions: 1) Were these substantive rules observed by all the mines operating within the Carolina catchment area? 2) Did the Minister of water affairs authorise an exemption from any of these rules in writing? 3) Have criminal charges been laid where there has been non-compliance?

Comments: These rules provide an additional indication of what "reasonable measures" might be in terms of ss 19 of the NWA and 28 of the NEMA. Non-compliance with this regulation is a criminal offence.

3.14 Temporary or permanent cessation of mine or activity

Legal authority: Regulation 9, GN 704 Regulations

Duties: 1) When there is a temporary or permanent cessation of a mining operation or mining-related activities, the person in control must ensure that all pollution control measures have been designed, modified, constructed and maintained so as to comply with the GN704 regulations. 2) Any person in control of a mine or activity must ensure that the in-stream and riparian habitat of any water resource, which may have been affected or altered by a mine or activity, is remedied so as to comply with these regulations.

Powers: 1) The Minister of water may in writing authorise an exemption from any of these substantive rules. 2) The minister of water affairs may request a copy of any surface or underground plans upon the permanent or temporary cessation of mining activities.

Link to ecological infrastructure concept: These provisions are about ensuring the integrity of pollution control measures even when there has been a permanent or temporary cessation of such and about remedying the instream and riparian habitat of a water resource. Doesn't specifically advance ecological infrastructure concept.

Questions: 1) Were these substantive rules observed by all the mines operating within the Carolina catchment area? 2) Did the Minister of water affairs authorise an exemption from any of these rules in writing? 3) Have criminal charges been laid where there has been non-compliance?
Comments: There is no reference in these regulations to the financial provision for rehabilitation, which could be a weakness. Non-compliance with this regulation is a criminal offence.

3.15 Duty to rehabilitate coal residue deposits

Legal authority: Regulation 11, GN 704 Regulations

Duties: 1) Any person mining or establishing coal residue deposits must rehabilitate such residue deposits so that all residue deposits are compacted to prevent spontaneous combustion and minimise the infiltration of water; and the rehabilitation of the residue deposits is implemented concurrently with the mining operation.

Powers: 1) The Minister of water may in writing authorise an exemption from this substantive rules.

Link to ecological infrastructure concept: These provision establishes a specific rule relevant to the rehabilitation of coal residue deposits. Doesn't specifically advance ecological infrastructure concept.

Questions: 1) Was this substantive rule observed by all the mines operating within the Carolina catchment area? 2) Did the Minister of water affairs authorise an exemption from this rule in writing? 3) Have criminal charges been laid where there has been non-compliance?

Comments: Non-compliance with this regulation is a criminal offence.

3.16 Environmental authorisation

Legal authority: Section 24–s24S, NEMA.

Duties: 1) Any person who carries on a listed or specified activity must apply for an environmental authorisation, generally from the relevant provincial environmental authorities (this duty did not apply to prospecting or mining as such, but rather to ancillary activities such as constructing roads, building certain structures relating to water, removing indigenous vegetation; etc). 2) For purposes of obtaining the environmental authorisation, the person would have to appoint an independent environmental assessment practitioner to conduct a thorough environmental impact assessment of the activity. This would involve public participation as well. 3) Upon obtaining an environmental authorisation the holder would have to comply with any specified conditions.

Powers: 1) The Minister of environment and the provincial environmental MECs are empowered to specify the activities requiring an environmental authorisation. 2) The competent authority for the approval of environmental authorisations for listed activities is generally the provincial department responsible for the environment. 3) The competent authority can also approve the "rectification" of failure to obtain an environmental authorisation, upon payment of an administrative fine not exceeding R1 million (at that time).

Link to ecological infrastructure concept: Environmental impact assessment was not generally developed around the concept of ecological infrastructure. So the conceptual tools of this form of regulation rather centre on "impacts" than on valuation of the environment either for public or private purposes.

Questions: 1) Were any of the mines operating in the Carolina catchment area required to obtain an environmental authorisation? Did any of the activities necessitating an environmental authorisation relate to water resources? Were these authorisations in fact obtained? 2) Did any of the mines apply for a rectification of a failure to obtain an environmental authorisation? 3) If the mines did not obtain an environmental authorisation, were criminal charges instituted in line with s 24F (as was then the rule)?
Comments: After the EMP, the environmental authorisation (under NEMA) and the water use license (under the NWA) are the other major regulatory tools for regulating the environmental impacts of mining. The environmental management inspectorate enforces the rules around environmental authorisations (see section E below).

3.17 Statutory duty of care relating to the environment

Legal authority: Section 28, NEMA.

Duties: 1) Every person who causes, has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot reasonably be avoided or stopped, to minimise and rectify such pollution or degradation of the environment. Without limiting the generality of the meaning of "every person" it includes (a) an owner of the land or premises; (b) a person in control of land or premises; (c) a person who has a right to use the land or premises on which or in which any activity or process is or was performed or undertaken; or any other situation exists, which causes, has caused or is likely to cause significant pollution or degradation of the environment. This duty is retrospective; i.e. it applies to a significant pollution or degradation that occurred before the commencement of NEMA, arises or is likely to arise at a different time from the actual activity that caused the contamination; or arises through an act or activity of a person that results in a change to pre-existing contamination. The "reasonable measures" a person may be required to undertake include investigating, assessing and evaluating the impact on the environment; ceasing, modifying or controlling any act, activity or process causing the pollution or degradation; containing or preventing the movement of pollutants or the causant of degradation; eliminating any source of the pollution or degradation; or remedying the effects of the pollution or degradation.

Powers: This statutory duty of care is subject to the power of the D-G of the Dept of environmental affairs, or a provincial HoD to direct that the person take reasonable measures (see further section C below).

Link to ecological infrastructure concept: To the extent that this section also allows the authorities to recover costs for remedial measures where the person does not act (see further section E below), one could say it is recognising the value of the environment in some sense. Questions: 1) In the case of each mine operational in the Caroline catchment, what was their relationship to the land? Who other than the mines was an owner, user or controller of the land? 2) What "reasonable measures" did the mines put in place to deal with the pollution and ecological degradation of the water resources?

Comments: This section (which has its parallel in s 19 of the NWA) is an extremely important tool in the arsenal of environmental regulation. Significant about it is that it is not specifically linked to the mining rights holder (so mining companies cannot circumvent this duty by contracting mining out to another company) and it has retrospective application.

3.18 Notification obligations relating to emergency incidents

Legal authority: Section 30, NEMA.

Duties: 1) There is a duty vesting in a "responsible person" (a person who causes the incident, or who owns or was in control of the hazardous material at the time the incident occurred) or his or her employer (if the incident occurred during the course of the person's employment to notify the D-G of environment, SAPS, the provincial head of environment or the municipal head of environment; and any persons who whose health may have been affected of an "incident". An "incident is defined as an "unexpected, sudden and uncontrolled release of a hazardous substance, including from a major emission, fire or explosion, that causes, has caused or may cause significant harm to the environment, human life or property." 2) The responsible person must take all reasonable measures to contain and minimise the effects of the incident, institute clean-up procedures, remedy the effects and undertake an immediate and long-term assessment of the incident.

Link to ecological infrastructure concept: Not explicit.

Questions: 1) Have any of the mines operational in the Carolina catchment notified the authorities of an incident? 2) If so, what happened thereafter?

Comments: I have head of this provision being used at least once in the Ermelo area by the Anker coal.

3.19 Existing lawful water use

Legal authority: Sections 32–35, National Water Act

Rights: An existing lawful water use gives a person who uses water in any of the ways specified in s 21 of the NWA a right to continue with the water use. An existing lawful water use took place two years prior to the entry into force of the NWA and would have been authorised by the law immediately in force prior to the NWA.

Duties: The holder of an existing lawful water use must follow any existing conditions or obligations attaching to that use.

Powers: 1) The responsible authority can request that the existing lawful water use be converted to a license. 2) The responsible authority may verify the lawfulness and extent of the existing lawful water use.

Link to ecological infrastructure concept:

Questions: 1) Have any of the mines in the Carolina catchment claimed that the existing lawful use if the basis of their entitlement to use water? 2) If so, did the responsible authority (Dept of Water Affairs?) verify the extent and lawfulness of the right? 3) What conditions were attached to the existing lawful water use?

Comments: It has been said that a number of mines have justified their water use on the basis of taking over the water uses of the farms on which they operate, so this could potentially also serve as an water resource management tool.

3.20 Water use license

Legal authority: Sections 27–29, National Water Act

Rights: A water use license gives the holder a right to use water in any of the ways specified in s 21 of the NWA, though the license is no guarantee of the statistical probability of water, the availability of water, or the quality of water.

Duties: The holder must comply with the conditions attached to the license.

Powers: The responsible authority may attach a broad range of conditions to the license, including conditions relating to water conservation measures, monitoring and analysis of water use, requiring the preparation of and adherence to a water management plan.

Link to ecological infrastructure concept: The NWA appears to be better than the other Acts in putting environmental resources "to work" whilst also seeking to protect their ecological integrity.

Questions: 1) Do the mines in the Carolina catchment area have water use licenses? 2) If so, what conditions are specified regarding the management of the water resources that contributed to the Carolina crisis?

Comments: The water use license is directly relevant to the crisis that unfolded in Carolina as it is the most specific environmental management tool applicable to water resources in this context. It is a criminal offence to fail to obtain a water use license, where this is required; or to fail to comply with any condition attached to a license.

3.21 Security for the protection of the water resource or property

Legal authority: Section 30, National Water Act

Powers: 1) The responsible authority may require the applicant to give security for any obligation or potential obligation arising from a water use license and which is necessary to protect the water resource and property. 2) The responsible authority may determine the type, extent and duration of any security required. Security can take the form of a letter of credit from the bank, a surety or bank guarantee, a bond, insurance policy, or any other appropriate form of security. The duration of the security may extend beyond the date of the license.

Rights: A person may apply in writing at any time to have the security given amended or discharged.

Link to ecological infrastructure concept:

Questions: 1) Were any of the mines in the Carolina catchment required to provide the security contemplated in this section? 2) If so, did they provide it?

Comments: This appears to be the NWA's equivalent of "financial provision" for rehabilitation under the MPRDA.

3.22 Statutory duty of care relating to water resources

Legal authority: Section 30, National Water Act

Powers: 1) The responsible authority may require the applicant to give security for any obligation or potential obligation arising from a water use license and which is necessary to protect the water resource and property. 2) The responsible authority may determine the type, extent and duration of any security required. Security can take the form of a letter of credit from the bank, a surety or bank guarantee, a bond, insurance policy, or any other appropriate form of security. The duration of the security may extend beyond the date of the license.

Rights: A person may apply in writing at any time to have the security given amended or discharged.

Link to ecological infrastructure concept:

Questions: 1) Were any of the mines in the Carolina catchment required to provide the security contemplated in this section? 2) If so, did they provide it?

Comments: This appears to be the NWA's equivalent of "financial provision" for rehabilitation under the MPRDA.

3.23 Control of emergency incidents

Legal authority: Section 30, National Water Act

Duties: 1) There is a duty vesting in a "responsible person" (a person who causes an incident, or who owns or was in control of the substance at the time the incident occurred) or his or her employer (if the incident occurred during the course of the person's employment) to notify the Department of Water Affairs, SAPS or the relevant fire department, or the relevant catchment agency. An "incident" is defined as "any incident or accident in which a substance pollutes or has the potential to pollute a water resource or has or is likely to have a detrimental effect on a water resource."2) The responsible person must take all reasonable measures to contain and minimise the effects of the incident, undertake clean-up procedures, remedy the effects, and undertake such measures as the catchment management agency may verbally or in writing specify.

Link to ecological infrastructure concept: Not explicit.

Questions: 1) Have any of the mines operational in the Carolina catchment notified the authorities of an incident? 2) If so, what happened thereafter?

Comments: This provision is very similar in form to s 30 of the NEMA, so it could be used in the alternative or in conjunction with that provision. There are subtle differences between the two; e.g. in the definition of "incident" and in the range of parties that should be notified.

3.24 Duties of water services authorities

Legal authority: Sections 11–21, WSA

Duties: 1) Water services authorities (essentially municipalities) are responsible for ensuring access to water services. Access should be progressively more efficient, affordable, economical and sustainable. Water services include water supply and sanitation services. 2)

In emergency situations a water services authority must take reasonable steps to provide basic water supply and basic sanitation services to any person within its area of jurisdiction, at the cost of that authority. 3) A water services authority must prepare a water services development plan that includes, *inter alia*, details on existing industrial water use within the area of the jurisdiction of the water services authority, of existing industrial effluent disposed of within the authority's area of jurisdiction, and the future provision of water services including water for industrial use and the disposal of industrial effluent. The development and adoption of a water services development plan involves public participation. 4) A water services authority must make bylaws that specify the standard of the services, including standards relating to water for industrial use.

Link to ecological infrastructure concept: None.

Questions: 1) Who was the water services authority responsible for providing water to the Carolina residents? 2) What did the water services development plan of this authority say about the sources of mine water pollution in the catchment? 3) What were the water services authority's bylaws on the sources of 'industrial water' in the catchment? Is the mine water regarded as industrial water? 4) Did the water services authority take reasonable steps to provide basic water supply when the disaster struck?

Comments: The WSA is clear that 'industrial use' includes water used for mining.

4 MONITORING, INSPECTIONS AND POWERS OF STATE INTERVENTION

4.1 Performance assessment reports of EMP (including final performance assessment report preceding closure)

Legal authority: Regulation 55, MPRDA regulations

Duties: 1) A permit or rights holder under the MPRDA must (a) conduct monitoring on a continuous basis; (b) conduct performance assessments of the EMP, as required; and (c) compile and submit a performance assessment report to the minister of mineral resources. 2) The frequency of performance assessment reporting is every two years, or as specified in the EMP, or as agreed with the minister. A performance assessment report must be in the format specified by published guidelines and contain at least the information specified in reg. 55(3). 3) The permit or rights holder must comply with any of the minister's directions after he considers the performance assessment report. 4) When the holder intends closing an operation a final performance assessment report must be compiled and submitted to the minister. This report must specify that the requirements of relevant legislation have been complied with, that the closure objectives specified in the EMP have been met; that residual impacts have been identified; and that the risk of latent impacts have been identified and quantified and arrangements for the management thereof assessed. The final performance assessment report may be submitted at the same time as the application for a closure certificate.

Powers: 1) The permit or rights holder may appoint an independent competent person to conduct the assessment. 2) The minister of mineral resources considers the assessment and may direct the holder of the permit or right to repeat the exercise, to provide supplementary information, or to appoint an independent competent person to conduct the assessment. 3) The minister of mineral resources may disclose a performance assessment report submitted by the holder to any person upon request.

Link to ecological infrastructure concept: Not explicit, situated within the EIA model of environmental management.

Questions: 1) Did the mines in the Carolina catchment area submit performance assessment reports to the minister on a regular basis? 2) What did those performance assessment reports say? 3) For the mines that are non-operational in the Caroline catchment area, were final performance assessment reports submitted to the minister? 4) what did such reports specify about residual and latent environmental impacts?

Comments: This is a key monitoring tool to ensure proper compliance with the EMP. It may be linked to the minister of minerals' other powers, such as powers of intervention in terms of s 45 or 46 of the MPRDA or the power to direct an amendment of the EMP.

4.2 Inspections (with and without a warrant)

Legal authority: Sections 91–92, MPRDA

Powers: 1) The minister of mineral resources may designate a variety of officials as "officers" for purposes of carrying out routine inspections. 2) Authorised officers may without a warrant and during office hours conduct routine inspections; i.e. enter the prospecting or mining area for purposes of inspecting any activity, process or operation; and ask to examine books, records or statements. 3) Authorised officers may under the authority of a warrant enter a prospecting or mining area if they believe any provision of the Act is being contravened; direct the person in control or employed in the prospecting or mining area to furnish information or assist with the investigation; inspect books, records, statements and documents and make copies; examine any appliance or material substance found in the area; take samples; seize any material, substance, book, record, statement or other document.

Link to ecological infrastructure concept: None

Questions: 1) Were routine inspections of the mining operations in the Caroline catchment area conducted? 2) Were any inspections ever conducted that required the issue of a warrant? If so, what happened subsequent to the inspection?

Comments: These provisions would have applied at the time the crisis in Carolina occurred and they are still in force. However from 18 December 2014, inspections relating to the environmental authorisation will be conducted by the environmental mineral resource inspectorate (under s 31 of the NEMA).

4.3 Orders of mineral inspection officers

Legal authority: Section 93, MPRDA

Powers: 1) If an authorised officer believes or suspects there has been a contravention of the MPRDA or any other law (e.g. mine health and safety), or an condition of an environmental authorisation, he or she may direct the rights holder (a) to take immediate rectifying steps; and (b) order that the operations be suspended or terminated or give such other instructions connected therewith as may be necessary. 2) The D-G of mineral resources must confirm or set aside any order given by an authorised officer within 60 days of it being issued. If there is no confirmation of the order, it lapses.

Link to ecological infrastructure concept: None.

Questions: 1) Were any orders under s 93 issued to mines operating in the Carolina catchment? 2) If so, what was the content of those orders? 3) Were any mines in the Carolina catchment ever orders to suspend or terminate their operations?

Comments: This measure was available to the DMR at the time the Carolina crisis occurred. The power is broad-ranging in its application; e.g. applicable to mine health and safety and also environmental infractions. From 18 December 2014, the chief instrument of the new environmental mineral resource inspectorate will be the compliance notice under the NEMA.

4.4 Minister of minerals' power to institute urgent remedial measures

Legal authority: Section 45, MPRDA

Powers: 1) The minister of mineral resources may direct a rights holder under the MPRDA to investigate, evaluate, assess and report on the impact of any pollution or ecological degradation; take the measures specified in a directive; and complete such measures before a given date. The trigger for the minister's power is prospecting or mining operations causing or resulting in ecological degradation, pollution or environmental damage that may be harmful to the health or well-being of anyone and that requires urgent remedial measures. 2) If the holder fails to comply with the directive, the minister may take the measures necessary to protect the health and well-being of any affected person or to remedy ecological degradation or stop pollution of the environment. 3) The minister may apply to the High Court (*ex parte* application) for an order to seize and sell such property of the holder as may be necessary to cover the costs of implementing urgent remedial measures. Otherwise, the minister may use funds appropriated by Parliament to implement the measures. 4) The minister may recover an amount equal to the funds necessary to fully implement the measures from the holder concerned.

Duties: 1) Before implementing any measures the minister must afford the rights holder an opportunity to make representations.

Link to ecological infrastructure concept: None

Questions: 1) Did the minister of mineral resources ever issue a directive to the mines operating in the Carolina catchment area to undertake the urgent remedial measures contemplated in s 45? 2) Did the minister of mineral resources ever initiate urgent remedial measures, particularly after the occurrence of the Carolina crisis? 3) If so, was the minister able to recover the costs from the rights holders?

Comments: This is the MPRDA counterpart to s 19 of the NWA and s 28 of the NEMA. The unusual aspect of this provision is that it is specifically triggered by impacts that are harmful to health or well-being (this would clearly have been the case when Carolina residents' drinking water was polluted), and that the minister can seize and sell property of the rights holder in order to undertake urgent remedial measures on behalf of the state. I have never heard of this provision being used.

4.5 Minister of minerals' power to remedy environmental damage

Legal authority: Section 46, MPRDA

Powers: 1) If the minister of mineral resources establishes that urgent remedial measures need to be taken to prevent pollution or ecological degradation of the environment, but the holder of the right is deceased or cannot be traced, or if a juristic person has ceased to exist, the minister may instruct the regional manager to take the necessary measures. The measures, if taken, must be funded from the financial provision for rehabilitation or where there is a shortfall, from monies appropriated by Parliament.

Duties: 1) Upon completion of the urgent remedial measures, the regional manager must apply to the registrar in the mine titles deeds registry to have the title deed of the land endorsed to that effect that the land has been remedied.

Link to ecological infrastructure concept: None

Questions: Has the minister of mineral resources instructed the regional manager to take urgent remedial measures in respect of the ownerless and abandoned mines in the Carolina catchment?

Comments: This provision empowers the minister of mineral resources to act where a rights holder cannot be traced (for her powers in terms of s 45 are otherwise dependent on the rights holder first failing to act).

4.6 Minister of minerals' power to suspend or cancel rights

Legal authority: Section 47, MPRDA

Powers: 1) The minister of mineral resources may cancel or suspend any right or permit under the MPRDA if the holder is conducting operations in contravention of the MPRDA; breaches any material term or condition of the right; is contravening the approved EMP/environmental authorisation; has submitted inaccurate, incorrect or misleading information in connection with any matter required to be submitted under the Act. 2) The minister must direct the holder to take specified measures to remedy any contravention, breach or failure.

Duties: 1) Before cancelling or suspending a right the minister must follow certain rules relating to procedural fairness (written notice to the holder, reasons for the decision, allowing the holder a reasonable opportunity to show why the right should not be cancelled or suspended).
Link to ecological infrastructure concept: None

Questions: 1) Did the minister of mineral resources ever issue a written notice to the mines operating in the Caroline catchment advising them of a contravention of the MPRDA and threatening to cancel or suspend their rights? 2) If so, what happened afterwards?

Comments: A rule giving the MPRDA some administrative teeth. Not clear on how extensively it has been used however.

4.7 Technical investigation and monitoring (GN704)

Legal authority: Regulation 12, GN704

Powers: 1) The minister of water may, after consulting the ministers responsible for mineral resources and the environment respectively, require any person in control of a mine or activity to arrange for a technical investigation or inspection on any aspect aimed at preventing pollution of a water resource or damage to the in-stream or riparian habitat connected with or incidental to the operation of a mine or activity. This may include an independent review. 2) The water minister may further require any person in control of a mine or activity to submit a programme of implementation to prevent or rectify any pollution of a water resources; etc. 3) The minister of water affairs may direct any person in control of a mine or activity to implement a compliance monitoring network to monitor the programme of implementation by establishing, operating and maintaining monitoring installations of specified types and at specified locations.
Duties: Any person in control of a mine or activity must submit plans, specifications and design reports approved by a professional engineer to the minister of water affairs, not later than 60 days prior to commencement of activities relating to (a) the construction of any surface dam for the purpose of impounding waste, or water containing waste or slurry; (b) the implementation of any pollution control measures at any residue deposit or stockpile; and (c) the implementation of any water control measures at any residue deposit or stockpile.

Link to ecological infrastructure concept: None

Questions: 1) Did the minister of water ever order any of the mines operating in the Carolina catchment to conduct a technical investigation and develop a programme of implementation and compliance and monitoring network? 2) Did the persons in control of the mines in the Carolina catchment submit the plans, specifications and design reports relating to the various structures and pollution and water control measures?

Comments: The minister of water is probably more likely to use s 19 of the NWA than this provision for technical monitoring in the GN704 regulations. These regulations are also under review and are likely to be replaced. However they were in force when the Carolina crisis struck.

4.8 Monitoring and performance assessment of environmental authorisation

Legal authority: Section 24Q, NEMA

Duties: An environmental authorisation must include general terms and conditions that require the holder to conduct such monitoring and performance assessment of the approved EMP as may be prescribed.

Link to ecological infrastructure concept: None

Questions: None

Comments: This provision of the NEMA only enters into force from 18 December 2014. On its own it is also without substance or teeth as the monitoring and performance assessment rules will be set out in the regulations or the EMP.

4.9 Statutory duty of care directives (NEMA)

Legal authority: Section 28, NEMA

Duties: “Everyone” has a statutory duty of care in relation to the environment (see Section D, item 18 above).

Powers: 1) If a person who is causing, has caused or may cause significant pollution or degradation of the environment fails to take reasonable measures to stop such pollution or degradation from occurring, D-G or a provincial HoD may direct the person to cease any activity, operation or undertaking; undertake an impact assessment of specific activities; commence, diligently continue or complete certain measures within a specified date. 2) If a person fails to undertake or inadequately undertakes the measures specified in the directive, the D-G or a provincial HoD may take reasonable measures to remedy the situation or apply to a competent court for appropriate relief. 3) The D-G or the provincial HoD may recover costs for the measures, before they are implemented, from a range of persons including any person that negligently failed to prevent from activity or process from being undertaken or the polluting situation to come about. The costs claimed must be reasonable.

Rights: A person may apply to a court for an order directing the D-G or a provincial HoD to issue a directive to a person causing pollution or ecological degradation, essentially where the administrative heads have failed to act.

Link to ecological infrastructure concept: None

Questions: 1) Has the D-G for environment nationally or the provincial HoD issued a s 28 directive to any of the mines operating in the Carolina catchment? 2) Has the D-G or a provincial HoD initiated the taking of reasonable measures where the person to whom the directive has been issued has failed to respond appropriately?

Comments: This is one of the key enforcement tools in the NEMA. It is helpful in that it is NOT linked to a person being a rights holder (so difficult for companies to avoid, for instance, by contracting the mining operation out to third parties). It applies by virtue of the person's relationship to a particular piece of land.

4.10 Statutory duty of care directives (NWA)

Legal authority: Section 19, NWA

Duties: "Everyone" has a statutory duty of care in relation to water resources (see Section D, item 23 above).

Powers: 1) If a person who is causing, has caused or may cause significant pollution or degradation of a water resource fails to take reasonable measures to stop such pollution or degradation from occurring, the catchment management agency may direct the person to diligently continue or complete certain measures within a specified date. 2) If a person fails to undertake or inadequately undertakes the measures specified in the directive, the catchment management agency may take the measures it considers necessary to remedy the situation. 3) The catchment management agency may recover all costs incurred as a result of it taking remedial measures jointly and severally from a range of persons. The costs claimed must be reasonable. 3) The catchment management agency may also claim from any person who has benefitted from the implementation of the remedial measures. 4) The catchment management agency may apportion the liability for the cost of remedial measures.

Link to ecological infrastructure concept: None

Questions: 1) Has a catchment management agency (or the Dept of Water Affairs if no agency has been established) issued a s 19 directive to any of the mines operating in the Carolina catchment? 2) Has catchment management agency initiated remedial measures where the person to whom the directive has been issued has failed to respond appropriately?

Comments: One of the most important enforcement tools in the NWA. Section 19 directives were successfully applied to continue pumping operations in the KOSH basin (*Harmony Gold* series of cases).

4.11 Powers of environmental management inspectors

Legal authority: Sections 31A – 31Q (NEMA)

Powers: 1) Environmental management inspectors (EMIs) have range of general powers that relate to questioning persons, inspecting documents and records, taking samples, digging or boring into the soil, taking photographs; etc. As part of these general powers they were empowered to issue written notices that compel persons to answer questions. 2) EMIs may seize items in line with the provisions of the Criminal Procedure Act, with some interesting additional powers, such as the power to seize a vehicle by removing a part and thus immobilising it. 3) EMIs may stop, enter and search vehicles, vessels and aircraft without a warrant. 4) EMIs may without a warrant conduct routine inspections of land, buildings and premises. With a warrant, they may also enter and inspect residential premises. 5) EMIs may issue compliance notices that set out details of the conduct constituting non-compliance, any steps a person must take and the period within which those steps must be taken, and things that a person may not do for a particular period. 6) If a person fails to comply with a compliance notice the EMI must report this fact to the minister of environment or the MEC for environment. The minister or MEC may then vary or revoke the environmental authorisation.

Duties: A person who receives a compliance notice issued by an EMI must comply with its provisions within the specified time period.

Rights: A person to whom a compliance notice has been issued may object to the notice.
Link to ecological infrastructure concept: None

Questions: 1) Were the EMIs involved in inspecting the areas affected by the water crisis in Carolina at any time prior to, during or after the crisis hit? 2) Were compliance notices issued to any of the mines operative in the Carolina catchment? If so, what were the conditions of the compliance notice?

Comments: The EMIs are the “green scorpions”, i.e. the key enforcement agents for the provisions of the NEMA. At the time of the Carolina crisis, they would have had powers to enforce the provisions of the environmental authorisation required for activities ancillary to prospecting and mining. From December 2014, the minister of minerals will be empowered to appoint environmental mineral resources inspectors, which will have the same powers of EMIs within the scope of their specified mandate.

4.12 Interventions relating to water services institutions

Legal authority: Sections 62–63, WSA

Powers: 1) The minister of water and sanitation and any relevant province must monitor the performance of every water services institution, including compliance with all applicable national standards. 2) If a water services authority has not effectively performed any function imposed on it by the WSA, the minister may, in consultation with the minister responsible for co-operative government and traditional affairs, request the province to intervene in accordance with s 139 of the Constitution. 3) If within a reasonable time after the request being made the Province has unjustifiably failed to intervene or has intervened ineffectively, the minister of water affairs may assume control of the function subject to the extensive procedural safeguards outlined in the WSA (which derive, in turn, from the Constitution).

Duties: 1) Every water services institution must co-operate with the minister in the monitoring of its performance by, for instance, furnishing information and allowing access to books, records and physical assets.

Link to ecological infrastructure concept: None

Questions: 1) What evidence exists to affirm that the minister of water affairs and the relevant provincial functionaries were monitoring the relevant water services institutions implicated in the Carolina crisis? 2) Did the minister of water and sanitation issue the province with a formal request to intervene in the situation? 3) Did the minister take over the function of providing water to the Carolina community?
Comments: These powers of intervention have been criticised as particularly cumbersome and unwieldy, preventing effective action from the national and provincial government where there are failures at the local level (a debate on this topic was hosted by the Water Research Commission earlier in 2014).

4.13 Inspection of water services works

Legal authority: Section 80, WSA

Powers: 1) Any person authorised in writing by the minister of water and sanitation, the province or a water services institution may at any reasonable time and *without prior notice* enter any property and inspect any water services work in order to ascertain whether the WSA, its regulations or a directive made under it is being complied with. Restrictions apply however to the entry of dwellings. 2) After reasonable notice to the owner or occupier of the property an authorised person may undertake various actions aimed at repairing, maintaining, removing or demolishing a water services work.

Link to ecological infrastructure concept: This provision gives the authorities powers to enter properties so as to maintain the ‘gray’ infrastructure associated with water services. The definition of ‘water services work’ refers to gray, not green infrastructure.

Questions: 1) What water services works (dams, reservoirs, pumphouses, boreholes, pumping installations; etc) were implicated in the Carolina crisis? 2) Were any inspections of these works carried out? If so, by whom, and how was their failure implicated in the generation of the crisis?

Comments: This provision can potentially be criticised on the basis that it only confers powers to inspect and not an actual duty to maintain water services works.

5 CRIMINAL OFFENCES AND POWERS OF COURT IN CRIMINAL MATTERS

5.1 Right of appeal under NEMA

Legal authority: Section 43, NEMA

Rights: 1) Any person has a right to appeal to the minister of environment against a decision taken by any person acting under a power delegated by the minister under NEMA or a SEMA. 2) Any person has a right to appeal to the MEC against a decision taken by any person acting under a power delegated by that MEC under NEMA or a SEMA.

Link to ecological infrastructure: Not explicit.

Questions: 1) When the environmental authorisations were granted for the listed activities associated with the mines in the Carolina catchment, was the granting of the environmental authorisation appeals? 2) If so, what were the grounds of appeal?

Comments: These provisions establish an administrative appeal and would have allowed for civil society intervention in the granting of environmental authorisations to the mines operating in the Carolina catchment.

5.2 Right of appeal to the Water Tribunal

Legal authority: Section 141(1)(f), NWA

Rights: Any person who has timeously lodged an appeal may appeal to the Water Tribunal against the granting of a water use licence.
Link to ecological infrastructure: None
Questions: 1) Were any appeals to the Water Tribunal lodged against the decision to grant mines operating in the Carolina catchment with a water use licence? 2) If so, what was the outcome of the appeal?

Comments: Section 141 allows for appeals on a variety of grounds. The Water Tribunal has interpreted s 141(1)(f) strictly to apply only to license applications where there has been a public participation process, but this approach was overruled in the *Escarpment Environment Protection* case.

5.3 Right of appeal under the MPRDA

Legal authority: Section 96, MPRDA

Rights: Any person whose rights or legitimate expectations have been materially and adversely affected or who is aggrieved by an administrative decision under the MPRDA may appeal in the prescribed manner to either the D-G of the DMR or the minister of mineral resources.

Link to ecological infrastructure: None

Questions: 1) Were appeals under the MPRDA lodged against the decision to grant mining rights to any of the mines operative in the Carolina catchment? 2) If so, what was the outcome of the appeal?

Comments: The *Bengwenyama* case (CC) clarified that a right of appeal under the MPRDA does exist, though the lodging of an appeal does not suspend the right.

5.4 Criminal offences for non-compliance with GN704 obligations

Legal authority: Regulation 14, GN704

Rights: The National Prosecuting Authority (NPA) may prosecute a person for any of the offences listed in regulation 14. These include the failure to notify the department of water affairs regarding certain activities on a mine, failure to manage clean and dirty water systems, failure to observe the locality and material restrictions; etc.

Link to ecological infrastructure: None

Questions: 1) Were any charges based on the offences listed in regulation 14 of the GN704 regulations laid against any of the mines, their directors, shareholders, or employees following the Carolina crisis? 2) If so, were the charges prosecuted and what was the outcome?

Comments: The penalty for offences under GN704 is an unspecified fine or imprisonment of up to five years. Regulation 14(2) enables an offence of an employee or manager to be imputed to the person in control of the mine and *vice versa*.

5.5 Criminal offences for non-compliance with NEMA obligations

Legal authority: s 24F, s 28(14) and (15), s 34 NEMA

Rights: 1) The NPA may prosecute a person for the failure to obtain an environmental authorisation in respect of a listed activity, to comply with any of the conditions attached to an environmental authorisation, or to fail to comply with or contravene an environmental management programme. 2) The NPA is also empowered to prosecute someone who wrongfully and intentionally or negligently (i.e. with fault) causes environmental pollution or ecological degradation.

Link to ecological infrastructure: None

Questions: 1) Were any charges based on the offences listed in the NEMA laid against any of the mines, their directors, shareholders, or employees following the Carolina crisis? 2) If so, were the charges prosecuted and what was the outcome?

Comments: This represents the law at the time the Carolina crisis occurred. These provisions have since been repealed and replaced by s 49A and 49B of the NEMA. The penalty for an offence under s 24F was a fine of R5 million or imprisonment of 10 years or both. The penalty for an offence under s 28(14) and (15) was a fine not exceeding R1 million or imprisonment of 1 year or both. In criminal proceedings under the NEMA, if it appears that the offence caused loss or damage to any organ of state or other person (including the cost incurred or likely to be incurred by the organ of state in rehabilitating the environment), the course may summarily enquire into the extent of the damage and make an order for civil damages (without there needing to be a separate civil trial for this. There are provisions in s 34 for the offences of managers, agents and employees to be imputed to the employer and *vice versa*. It also allows for the offences of firms to be imputed to directors.

5.6 Legal standing to enforce laws

Legal authority: Section 32, NEMA

Rights: Any person or group of persons may seek appropriate relief in respect of any breach of threatened breach of any provision in the NEMA, including a principle in chapter 1, or any provision of a SEMA, or any other statutory provision concerned with the protection of the environment. The interests that may be protected by such relief are very broad, extending to anyone acting in the public interest.

Link to ecological infrastructure: Not explicit.

Questions: 1) Did any person or group seek appropriate relief in respect of any breach or threatened breach of the NEMA, etc. in relation to the Carolina crisis? If so, what was the outcome of the case?

Comments: The LHR did become involved in the Carolina matter but it is not clear whether they relied on this provision.

5.7 Private prosecutions

Legal authority: Section 33, NEMA

Rights: Any person may, in the public interest, or in the interest of the protection of the environment institute a conduct a private prosecution in respect of any breach of threatened breach of any duty, other than a public duty resting on an organ of state. The duty may be specified in any national or provincial legislation or bylaw, or any regulation, license, permission or authorisation issued in terms thereof.

Link to ecological infrastructure: Not explicit

Questions: Did any private prosecutions or attempted private prosecutions arise out of the Carolina crisis?

Comments: I have yet to hear of this provision ever being used.

5.8 Criminal offences for non-compliance with NWA obligations

Legal authority: Section 151–154, NWA

Rights: The NPA may prosecute any person for any of the offences listed in s 151 of the NWA. Offences include using water contrary to the provisions of the Act; failure to comply with any condition of a water use license; failing to comply with a directive issued under the Act; unlawfully and intentionally or negligently committing any act or omission that pollutes a water resource or that detrimentally affects a water resource. There are additionally a number of ‘procedural’ offences (e.g. failing to provide access to books and records; etc).

Link to ecological infrastructure: Not explicit.

Questions: 1) Were any charges based on the offences listed in the NWA laid against any of the mines, their directors, shareholders, or employees following the Carolina crisis? 2) If so, were the charges prosecuted and what was the outcome?

Comments: The penalty for a first conviction for any of these offences is a fine (unspecified) or up to 5 years imprisonment; for a second conviction a fine and/or imprisonment of up to 10 years. Similarly to the NEMA, there are provisions allowing the court to summarily inquire into civil damages (s 152) and to make an order for such damages (s 153); and for the actions of employees and managers to be imputed to employers and *vice versa* (s 154).

5.9 High court interdicts for discontinuation of activities and remediation

Legal authority: Section 155, NWA

Powers: A High Court may, on application by the Minister or the water management institution, grant an interdict or any other appropriate order against any person who has contravened any provision of the NWA, including an order to discontinue any activity constituting the contravention and to remedy the adverse effects of the contravention.

Link to ecological infrastructure: Not explicit

Questions: Did the minister or a water management institution apply for any such interdict in respect of the Carolina crisis?

Comments: A similar provision is not found in the other legislation, but this is essentially just a restatement of the common law.

5.10 Criminal offences for non-compliance with MPRDA obligations

Legal authority: Sections 98 and 99, MPRDA

Rights: The NPA may prosecute any person for any of the offences listed in s 98 of the MPRDA. Offences include failing to obtain an approved EMP or consulting with the lawful owner or occupiers, and failing to conduct operations in accordance with the EMP.

Link to ecological infrastructure: Not explicit.

Questions: 1) Were any charges based on the offences listed in the MPRDA laid against any of the mines, their directors, shareholders, or employees following the Carolina crisis? 2) If so, were the charges prosecuted and what was the outcome?

Comments: These provisions are going to be amended by the MPRDA Amendment Act that is currently pending. However, they were in force at the time that the Carolina crisis occurred. The penalty for failing to obtain an approved EMP or failing to consult was a fine not exceeding R100 000 and/or imprisonment not exceeding two years. The penalty for failing to conduct operations in accordance with the approved EMP was a fine not exceeding R500 000 and/or imprisonment not exceeding 10 years.

APPENDIX B:

PERSPECTIVE ON THE LEGAL LIFE CYCLE OF COAL MINING IN RELATION TO RESOURCE PROTECTION, FROM A MINING MANAGER'S PERSPECTIVE

The following appendix was developed to understand which requirements would come into view to an environmental manager of a coal mine setting out to understand what is required of him or her.

A mining manager needs to follow many different pieces of legislation to legally prospect, mine/produce and close a mining site. These include: The National Water Act, 1998; The National Environmental Management Act, 1998; The Mineral and Petroleum Resources Development Act, 2002; Mine Health and Safety Act, 1996; National Heritage Resources Act, 1999. These are available to all mining companies who wish to apply or renew their various licenses involved in the mining life cycle, as well as a range of guidelines to help them check whether or not they adhere to them, and how to apply. The Department of Mineral Resources has a web page dedicated to applying and renewing the various mining rights called Samrad (http://portal.samradonline.co.za/, you need to register to access the page, but this is easily done, and can be done by anyone), and this is easily accessible to all environmental officers and mining managers. It contains the various forms that need to be filled out, and the required documents at each phase. The Endangered Wildlife Trust (www.ewt.org.za) has all of the necessary legislation that is required to be adhered to, in downloadable format online. This is free to anyone who accesses it. It contains all of the legislations, all the guidelines that an environmental officer or mining manager will need to complete each phase of applying for legislation, as well as templates to follow for each part of the application process.

The instruments needed in applying for mining rights, how to apply, and what legislation that needs to be followed is clearly found online, with various ways of accessing this information.

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There are 3 phases to a mining lifecycle:

Reconnaissance and Prospecting; Mining/Production and Decommissioning and closure.

Each of these phases need their own distinct licenses from various government authorities.

1 RECONNAISSANCE AND PROSPECTING

The reconnaissance phase of a mining lifecycle is the survey phase of the region that is being investigated for the potential of mineral or petroleum resources. This is a quick and low cost operation, done in order to find an area that is viable to do more extensive research, known as the prospecting phase.

According to Kang (2004), coal exploration is done in order to determine the location, nature and extent of the resources available in the area being researched, and to delineate any features that could potentially affect the economy of the extraction. Exploration generally has two objectives; 1) to find a location in which a certain amount of coal of a required quality may be recovered successfully, and 2) to determine the amount of a required quality of coal can be extracted economically from a certain location.

To evaluate the coal deposits, the following operations are needed according to Kang (2004):

1. Obtain a prospecting right from the South African Government,
2. Evaluate the available geological information
3. Do a surface exploration
4. Do a subsurface exploration
5. Analyse collected samples
6. Estimate the coal resources available and any geological factors in their potential extraction

At this stage, the Mining and Petroleum Resources Development Act (MPRDA) requires the mine to get permission for the reconnaissance and prospecting (Mining and Biodiversity Guideline, 2013). This is known as a Prospecting right.

1.1 Mining Prospecting Right

An application for a mining prospecting right will need to include the following:

1. Details of the land or area. Submission of the prescribed plan in the prospecting work programme will be deemed compliance herewith.
2. A prospecting work programme: The Full particulars of the prospecting work programme (regulation 7).

This prospecting work programme needs to include:

- The full particulars of the applicant (The contact person and correspondence address are an authorised representative of the company)
- A visualisation of the land which the application relates
- A registered description of the land, specifying the farm name and subdivision.
- What mineral or minerals to be prospected for.
- A geological description of the land, including a geological map at a scale that can substantiate the prospecting methods, a detailed geological description that can substantiate the prospecting methods, and a geological description of known mineral/rock/commodity deposits of economic interest within the regional geology
- A description of how the mineral resource and its distribution will be determined. An action plan is required with timeframes showing what information, maps, reports and studies will be produced. This needs to include: Borehole results, Sampling analyses, Maps showing location depth of prospecting work with sampling points and the lithology, mineral content and mineral distribution, the geophysical survey data, geochemical results, results from any other investigations, geological modelling, feasibility reports
- A description of the prospecting method or methods to be implemented. Including: - A description of the extent, depth, locality of any excavations, trenching, pitting, and drilling; - a description of the extent, depth and locality of bulk sampling and testing; -

a surface plan of the prospecting area, showing intended location, extent and depth of all boreholes, trenches or excavations; – a list of literature surveys, desk top studies, geophysical, research and target identification, prospecting phases relating to initial invasive and infill work, analytical and modelling work, environmental studies, pre-feasibility studies, and phases related to investment decision making; – drilling technique (e.g diamond core drilling, auger drilling)

- A schedule of prospecting activities, such that prospecting activities must be done in phases and within specific timeframes
- Technical data detailing the prospecting method or methods to be implemented and the time required for each phase. An explanation of the technical work and expertise is required
- A cost estimate of the expenditure to be incurred for each phase of the prospecting operation. This includes a realistic estimate of the environmental management and rehabilitation cost to be identified in the environmental management plan
- Documentary proof of the applicants' technical ability or access thereto to conduct the proposed prospecting operation
- Documentary proof of a budget and of the applicants financial ability or access thereto. This includes loan agreements, resolution by a company to provide finances, any other mechanism
- An undertaking to adhere to the proposals as set out by the prospecting work programme, signed by the applicant

3. Financial and technical competence: Details and documentary proof of the applicant's technical ability and financial resources that are compatible with the prospecting work programme, that are readily available or how they will be provided that will allow the applicant to carry out the prospecting activities in terms of the prospecting work programme, as well as to mitigate and rehabilitate relevant environmental impacts satisfactorily. Submission of the prescribed information in the prospecting work programme will be deemed compliance herewith.
4. Title deeds or deeds in respect of land: These need to be certified copies of the title deed or deeds in respect of the land or area to which the application applies. Accurate title deed reference number(s) will be deemed compliant.
5. Existing rights and past provisions of the Act: A list of the existing rights and permits held by the applicant, tabled with indication of the region, location with regard to the land name and the existing right or permit number for each mineral or minerals.
6. R500 ZAR prescribed fee
7. A certified copy of the identity document of the applicant
8. A certified copy of the certificate of Incorporation, if applicable
9. A certified copy of the certificate to commence business, if applicable
10. A copy of resolution, if acting in a representative capacity
11. Other documents include: Consultation (within 30 days), Environmental Management Plan Template (within 60 days) and the BEE Template (within 30 days).

1.2 Consultation:

The methodology applied to consultation, wherein the applicant must:

1.1 Name the community as defined in the guideline, or explain why no such community was identified
1.2 Specifically state whether or not the Community is also the landowner.
1.3 State whether or not the Department of Land Affairs been identified as an interested and affected party
1.4 State specifically whether or not a land claim is involved
1.5 Name the Traditional Authority identified by the applicant.

1.6 List the landowners identified by the applicant. (Traditional and Title Deed owners)
1.7 List the lawful occupiers of the land concerned
1.8 Explain whether or not other persons' (including on adjacent and non-adjacent properties) socio-economic conditions will be directly affected by the proposed prospecting or mining operation and if not, explain why not.
1.9 Name the Local Municipality identified by the applicant
1.10 Name the relevant Government Departments, agencies and institutions responsible for the various aspects of the environment and for infrastructure which may be affected by the proposed project.
1.11 Submit evidence that the landowner or lawful occupier of the land in question, and any other interested and affected parties including all those listed above, were notified.

2. A description of the existing status of the cultural, socio-economic or biophysical environment, as the case may be, prior to the proposed prospecting or mining operation;

3. An identification of the anticipated environmental, social or cultural impacts,

4. A description of any proposed land use or development alternatives, proposed, alternative means of carrying out the proposed operation, and the consequences of not proceeding with the proposed operation.

5. A description of the process of engagement with identified communities, landowners and interested and affected parties: The applicant must;

5.1 Provide a description of the information provided to the community, landowners, and interested and affected parties to inform them in sufficient detail of what the prospecting or mining operation will entail on the land, in order for them to assess what impact the prospecting will have on them or on the use of their land;
5.2 Provide a list of which of the identified communities, landowners, lawful occupiers, and other interested and affected parties were in fact consulted.
5.3 Provide a list of their views in regard to the existing cultural, socioeconomic or biophysical environment, as the case may be,
5.4 Provide a list of their views raised on how their existing cultural, socio-economic or biophysical environment potentially will be impacted on by the proposed prospecting or mining operation;
5.5 Provide list of any other concerns raised by the aforesaid parties.
5.6 Provide the applicable minutes and records of the consultations.

6. A description of the most appropriate means to carry out the proposed operation with due accommodation of the issues raised in the consultation process.

According to Endangered Wildlife Trust (2012), the application for a prospecting right has three separate and distinct public consultation processes that must be conducted; 1) The Department of Mineral Resources (DMR) Regional Manager Notification and objection process, 2) The Applicant notification and consultation process, and 3) Preperation and submission of an Environmental Management Programme (EMP).

1. An application for a prospecting right must be lodged at the office of the DMR Regional Manager, where the Regional Manager will either accept or reject it depending on whether or not it fulfils the requirements. If accepted, it needs to appear in one of the following places within 30 days of acceptance, as well as on a notice board in the office of the Regional Manager: Provincial gazette, posted in the

Magistrate's Court or in a local or national newspaper (Endangered Wildlife Trust, 2012).

2. Once the application has been accepted, the interested and affected persons (according to the MPRDA, these include companies, trusts and associations with an interest in the prospecting application or who may be affected by the prospecting activities) need to be called upon with regards to the land in question, where they must submit their comments within 30 days from the date of notice.
   The applicant must notify the landowner/lawful occupier as well as any other affected party of its application for a prospecting right.
3. An Environmental Management Plan (EMP) must be submitted when applying for a prospecting right. The EMP must contain the stipulated contents required by Regulation 52 of the MPRDA Regulations.
   The applicant must be granted a prospecting right as well as the approval of an EMP by the DMR.

Prospecting activities should adhere to the prospecting work program and the EMP, with performance assessment reports on both of these aspects submitted to the Regional Manager at prearranged intervals (usually every two years).

Interested and affected parties include, but are not limited to:

- Host Communities
- Landowners (Traditional and Title Deed Owners)
- Traditional Authority
- Land Claimants
- Lawful land occupier
- The Department of Land Affairs
- Any other person (including on adjacent and non-adjacent properties) whose socio-economic conditions may be directly affected by the proposed prospecting or mining operation
- The local municipality
- The relevant Government Departments, Agencies and institutions responsible for the various aspects of the environment and for infrastructure which may be affected by the proposed project

1.3 Environmental Management Plan (EMP)

An applicant needs to submit an environmental management plan when applying for a prospecting right. The EMP needs to include:

- A description of the environment likely to be affected by prospecting or mining operation. – Describe environment on site relative to the surrounding area; - Describe specific environmental features that may require protection, remediation, management or avoidance; - a map showing the spatial locality of environmental, cultural/heritage and current land use features identified on site; -Confirm description of the environment has compiled with the participation of the community, and interested and affected parties; -If no community participation was done, a detailed explanation must be provided.
- Assessment of the potential impacts of the prospecting or mining operation on the environment, socio-economic conditions and cultural heritage.

  1) Describe the proposed prospecting or mining operation, which must include: 1.1. A list of all the main prospecting activities, such as access roads, topsoil storage sites; 1.2. A plan showing the spatial location and extent of the main activities with dimensions; 1.3. An estimated timeline of the phases in relation to the implementation of these activities and infrastructure; 1.4. Any listed activities in terms of the NEMA EIA regulations that will be occurring.

2) Identify the potential impacts which identification must: 2.1. A list of the potential impacts of each of the aforesaid activities; 2.2. Describe all cumulative impacts; 2.3. A specialist report on cultural and heritage resources; 2.4. A list of potential impacts on communities, individuals or competing land uses that are in a close proximity to activity; 2.5. Confirm whether or not the list of potential impacts involved participation of the interested and affected parties; 2.6. A detailed explanation as to why the landowner was not involved with the list of potential impacts if that is the case; 2.7. A specialist report relating to the investigation, in line with baseline information and proposed activities

- A summary of the assessment of the significance of the potential impacts and the proposed mitigation measures to minimise adverse impacts. This includes: 1. The criteria of assigning significance to potential impacts; 2. A list of potential impacts identified in respect of each of the main prospecting activities throughout the phases, with the corresponding significance assessment; 3. A summary of the assessment of potential cumulative impacts. The proposed mitigation measures must provide: 1. A list of actions, activities or processes that have sufficiently significant impacts to require mitigation; 2. A list of technical or management options chosen and a concomitant list of options chosen to modify, remedy, control or stop any action, activity, or process that will cause a significant impact; 3. A review of the significance of the identified impacts in relation to mitigation measures proposed
- Financial Provision must be made for an identified disturbance. A plan is needed showing the location and aerial extent of the main mining actions, activities, or processes anticipated. A rehabilitation plan needs to be aligned with closure objectives. A calculation of the quantum of the financial provision required to manage and rehabilitate the environment. An indication of the required amount of financial provision that will be available if the right is granted.
- Planned monitoring and performance assessment of the environmental management plan. The applicant is required to: 1. Provide a list of identified impacts which will require monitoring programmes; 2. Describe the functional requirements of the monitoring programmes; 3. Define the roles and responsibilities for the execution of the monitoring programmes; 4. Commit to time frames for monitoring and reporting.
- Closure and environmental objectives. The applicant is required to: 1. Include a rehabilitation plan showing the areas and extent of the prospecting activities, with an anticipated prospected area at the time of closure; 2. Include closure objectives and extent to which they have been aligned to the baseline environment; 3. Confirm the environmental objectives in relation to closure have been consulted with interested and affected parties.
- The public participation records and results are required, with the identification of interested and affected parties include: 1. The name of the community or communities; 2. State whether or not the community is the landowner; 3. State whether or not the Department of Land Affairs is an interested and affected party or not; 4. State if a land claim is involved; 5. Name the Traditional Authority identified; 6. List the landowners identified; 7. List the lawful occupiers of the land; 8. Explain whether or not other persons' socio-economic conditions will be directly affected by the prospecting or mining activity; 9. Name the local Municipality; 10. Name the Government Departments, agencies and institutions responsible for the various aspects of the environment and for the infrastructure which could potentially be affected by the project; 11. Submit evidence that the landowner or lawful occupier and any other interested and affected parties were notified.
- In terms of the engagement process, these need to be provided: 1. A description of the information provided to the interested and affected parties (including community and landowners), that details what the prospecting or mining activity will entail on the land; 2. A list of which of the identified interested and affected parties were in fact consulted; 3. A list of their views on existing cultural, socio-economic or biophysical

environment; 4. A list on how they believe their existing views on cultural, socio-economic or biophysical environment will be impacted on by the prospecting or mining operation; 5. A list of any other concerns raised by the interested and affected parties; 6. The applicable minutes and records of the consultations; 7. Information on any objections received.
The details regarding the manner in which the issues were addressed should also be included.

- The environmental awareness plan must describe how the applicant intends to inform his/her employees of environmental risk which may result from their work, the manner in which the risk must be dealt with to avoid pollution or degradation to the environment, and the general environmental awareness training and dealing with emergency situations and remediation measures for such emergencies.
- The applicant must have the capacity or have provided for the capacity to rehabilitate and manage negative impacts on the environment. The applicant is required to state the amount it requires to both mange and rehabilitate the environment, and details as to how the amount was derived. They also have to specifically confirm the stated amount has been adequately provided for in corresponding budget reflected in the Prospecting Work Programme. This requirement is not the same as the financial provision which concerns the financial risk to the State, and may not necessarily be accessible to fund rehabilitation or mange the environment.
- The environmental management plan, if approved, will become an obligation in terms of the right issued

1.4 Granting and duration of a prospecting right

1. The Minister must within 30 days of receipt of the application from the Regional Manager, grant a prospecting right if -

a) the applicant has access to financial resources and has the technical ability to conduct the proposed prospecting operation optimally in accordance with the prospecting work programme;
b) the estimated expenditure is compatible with the proposed prospecting operation and duration of the prospecting work programme;
c) the prospecting will not result in unacceptable pollution, ecological degradation or damage to the environment and an environmental authorization is issued;
d) the applicant has the ability to comply with the relevant provisions of the Mine Health and Safety Act, 1996 (Act No. 29 of 1996);
e) the applicant is not in contravention of any relevant provision of this Act; and
f) in respect of prescribed minerals, the applicant has given effect to the objects referred to in section 2(d).

2. The Minister must, within 30 days of receipt of the application from the Regional Manager, refuse to grant a prospecting right if:

a) the application does not meet all the requirements referred to in subsection (1);
b) the granting of such right will result in the concentration of the mineral resources in question under the control of the applicant and their associated companies with the possible limitation of equitable access to mineral resources.

3. If the Minister refuses to grant a prospecting right the Minister must, within 30 days of the decision, in writing notify the applicant of the decision with reasons.

4. The Minister may, having regard to the type of mineral concerned and the extent of the proposed prospecting project, request the applicant to give effect to the object referred to in section 2(d).

5. If the application relates to land occupied by a community, the Minister may impose such conditions as are necessary to promote the rights and interests of the community, including conditions requiring the participation of the community.

6. A prospecting right granted in terms of subsection (1) comes into effect on the effective date.

7. A prospecting right is subject to this Act, any other relevant law and the terms and conditions stipulated in the right and is valid for the period specified in the right, which period may not exceed five years.

2 MINING / PRODUCTION

This phase of the mining lifecycle is where the greatest environmental impacts are likely to occur. In this phase, the adequacy of the mitigation measures as described in the EMP, which have been approved by DMR and/or DEA, are tested. The EMP will direct the management of impacts on biodiversity and ecosystem services. (Mining and Biodiversity Guideline, 2013).

2.1 An application for a Mining Right will need to include the following:

1. Details of the land or area.
   (Note: Submission of the prescribed plan in the Mining work programme will be deemed compliance herewith)
2. Mining work programme

The mining work programme needs to include:

1(1) (a) Full particulars of the applicant
1(1) (b) Showing of the land and mining area to which the application relates.
1(1) (c) A registered description of the land or area to which the application relates.
1(1) (d) Details of the identified mineral deposit concerned with regard to the type of mineral or minerals to be mined, its locality, extent, depth, geological structure, mineral content and mineral distribution.

The applicant is required to provide a detailed description of the identified mineral deposit concerned with regard to the type of mineral to be mined, its locality, extent, depth, geological structure, mineral content and mineral distribution, supported by a tabulated categorization of proven and probable reserves, cross referenced to supporting reserve plans over the area applied for.

The aforesaid information must include and be cross referenced to a mineral resource map and include, but not be limited to:

i. The mineral to be mined;
ii. The locality of the mineral deposit in relation to the nearest town/city;
iii. The locality of the mineral deposit relative to the mining area,
iv. The information required in terms of regulation 8 in cases where the application was preceded by a prospecting right,
v. existing exploration results and supporting geological reports,
vi. A brief description of the geological structure of the mineral deposit;
vii. The size of the deposit,
viii. The depth of the mineral deposit below surface;
ix. Details of proven and probable reserves, taking into consideration previous mining and extraction rates,
x. Estimated grades, and a reserve statement that can be understood relative to the mineral resource map

1(1) (e) Details of the market for, the market's requirements and pricing in respect of, the mineral concerned.

This regulation requires the determination of the price assumptions to be used in the prescribed cash flow forecast required in terms of regulation 1(1) (g) (vi), supported by the relevant market conditions affecting the pricing of the minerals concerned. The aforesaid information should typically include, but should not be limited to:

i. A list of products and their proportionate quantities
ii. A list of product consumers,
iii. For each specific product, give an indication of whether the market is :-
    a. Local
    b. Regional
    c. International
iv. Details of infrastructure requirements such as roads, rail, electricity and water,
v. Contract details such as:
    a. Duration
    b. Annual consumption
    c. Quality specifications
    d. Uses
    e. Prevailing market prices
    f. Selling arrangements.
vi. A detailed explanation of the price assumptions together with supporting specialist analyses and forecasts where applicable.

The price determined must be transferred into line item 2 of the cash flow forecast required in terms of regulation 1(g) (vi).

1(1) (f) Details with regard to the applicable timeframes and scheduling of the various implementation phases of the proposed mining operation, and a technically justified estimate of the period required for the mining of the mineral deposit concerned.

The applicant is required to provide detail with regard to the applicable timeframes and scheduling of the various implementation phases of the intended mining operation, and a technically justified estimate of the period required for the mining of the mineral deposit concerned. The information required to meet the requirements of the regulations must include, but should not be limited to:

i. The various construction and implementation phases from the planning stage up to the commencement of full production,
ii. A production forecast based on the reserve statement and the expected extraction, recovery and residue rates, which explains the sources of production over the period reflected in the cash flow forecast.
iii. A justification, based on proven and probable reserves and on production rates of the period over which the mine is expected to remain in production.

This information, must serve to provide the necessary verification of the production rates reflected in the cash flow forecast required in terms of regulation 1(g) (vi).

1(1) (g) (i) Details and costing of the mining technique, mining technology and production rates applicable to the proposed mining operation.

Compliance with the aforesaid regulation requires the applicant to provide the basic design and costing of the mining operation, which information must include, but should not be limited to:

i. A map indicating the basic mine design together with a description of how, and in what sequence, the mineral reserve will be extracted, including the specific mining techniques to be used such as:

a. Opencast mining, underground mining, excavating and loading, drilling and blasting, monitoring, conventional mining, trackless mining, block caving, shrinkage, pumping, dredging, or any other technique to be used.

b. Equipment and machinery, stores and materials, electricity, water, maintenance, consumables and any other costs.

c. The position of access roads, shafts or declines, workshops, offices and stores, pumping facilities, primary development or pit design, processing plant locality, residue deposition sites, topsoil storage sites, stockpiles, waste dumps, and any other basic mine design features.

ii. A description of any specific engineering constraints that may be anticipated in accessing and extracting the mineral resource, such as groundwater management, flooding, surface protection, fly rock risks, seismicity, or any other identified constraints.

iii. A description of planned engineering solutions to any constraints identified.

iv. A forecast of annual production rates;

v. Information as to whether the mining operation or part thereof is to be contracted out, and

vi. The annual operating costs of mining (excluding capital, labour and processing plant costs) in a cash flow format together with a detailed explanation of the relationship of these costs to the mining method to be used to extract the mineral deposit.

The costs thus derived must be clearly explained and used to justify the numbers that are reflected in line item 4 of the cash flow forecast required in terms of regulation 1(1) (g) (vi).

1(g) (ii) Details and costing of the technological process applicable to the extraction and preparation of the mineral or minerals to comply with market requirements.

Compliance with Regulation 1(1) (g) (ii), requires the applicant to describe:

i. The full range of mineral commodities or products that are to be produced by the mine,

ii. The basic design, supported by a process flow diagram, of any

a. metallurgical extraction process,

b. washing plant,

c. mechanical sorting, crushing or screening plant, or

d. any other plant or process, that may be required to extract the products or commodities that are to be produced to meet market requirements,

iii. An explanation of the efficiency of the process, together with an estimate of the mineral recovery rate, and the expected mass or volume of mine waste or residues,

iv. The annual operating costs, in a cash flow format, of the aforesaid mineral processing plant, together with a detailed explanation of the relationship of these costs to the specific methods to be used to extract the mineral commodity or mine product from the mineral deposit, and to dispose of mine waste or residues.

The costs thus derived must be clearly explained and used to justify the numbers that are reflected in line item 5 of the cash flow forecast required in terms of regulation 1(1) (g) (vi).

1(1) (g) (iii) Details and costing of the technical skills and expertise and associated labour implications required to conduct the proposed mining operation.

Compliance requires that this section is compatible with the information contained in the Social and Labour Plan, and must show:

i. The entire organizational structure required to operate the mine, including services, whether parts thereof will be outsourced or not,

ii. The respective skills requirements to conduct the proposed mining operations,
iii. The number of people that will be employed in each skill category required to operate the mine.
iv. The associated annual cost in respect of wages and salaries, and
v. Information as to whether any part of the mining operation is to be contracted out, including:
a. the necessary organizational structure for such a contract,
b. the respective skills requirements for such a contract, and
c. persons in each skills category for such a contract,
d. the annual cost of wages, salaries, and directors fees of such a contract
e. the annual cost of such a contract, and
f. how it will be ensured that compliance with applicable mining legislation will be maintained in such circumstances.

The costs thus derived must be clearly explained and used to justify the numbers that are reflected in line item 6 of the cash flow forecast required in terms of regulation 1(1) (g) (vi).

1(1) (g) (iv) Details and costing of regulatory requirements in terms of the act and other applicable law, relevant to the proposed mining operation.

Compliance requires that the applicant provides information regarding the cost of Government regulation that will become a cost to the mining operation, including, but not limited to the following:
i. Environmental management and rehabilitation costs, which costs must be presented in an annual cash flow format, and must be a realistic estimate of both the ongoing environmental management cost, and the environmental rehabilitation cost, which estimate must later be substantiated by the Environmental Management Programme, In this regard please provide the following information: complete the standard guideline document developed for financial provision. Complete 10 forecasts (one for each year of operation) and to then determine the progressive total in year 10 (excluding concurrent rehabilitation). The progressive total determined for Year 10 must be transferred to Table I as a cost in the first year. Attach 10 forecast plans. (one for each year of operation)
ii. Royalty payments, which must be substantiated by the annual rate of production which has been planned,
iii. Mine Health and Safety Regulations, which include, among others, the drawing up of prescribed mine plans,
iv. Occupational health,
v. Rates and taxes, and
vi. National Skills Fund,

The costs thus derived must be clearly explained and used to justify the numbers that are reflected in line item 7 of the cash flow forecast required in terms of regulation 1(1) (g) (vi).

1(1) (g) (v) Provisions for the execution of the social and labour plan

Compliance with this sub-regulation requires the applicant to provide financially for the implementation of the Social and Labour Plan in terms of the implementation of:
i. Human resource development programme,
ii. Local economic development programme, and
iii. The processes to manage downscaling and retrenchments.

The abovementioned costs must be reflected as per the Social and Labour Plan. The costs quantified in the aforesaid categories must be presented in an annual cash flow format that justifies the numbers that are reflected in line item 8 of the cash flow forecast required in terms of regulation 1(1) (g) (vi).

> 1(g) (vi) Details regarding other relevant costing, capital expenditure requirements, and expected revenue applicable to the proposed mining operation.

Compliance requires that the applicant provides:

i. A list of all other annual costs which may not be provided for elsewhere in the standard format of the cash flow forecast.
ii. A complete cost list of all capital items, which list must be compatible with the capital items identified to implement the mine design and processing plant design referred to in terms of regulations 1(1) (g) (i) and (ii) above, respectively.
iii. The total capital cost which must be stated in the year in which it is to be incurred,
iv. The expected expenditure on any ongoing capital investment to be made in the year in which it is expected to be incurred, and
v. Costing details of any contingencies not specifically catered for in these regulations. The costs thus derived must be clearly explained and used to justify the numbers that are reflected in line item 9 of the required cash flow forecast in terms of regulation 1(1) (g) (vi).

> 1(g) (vi) A detailed cash flow forecast and valuation, excluding financing of the proposed mining operation, which forecast must also clearly indicate how the applicable regulatory costs will be accommodated therein.

In order to comply, the Mining Work Programme must present a detailed cash flow forecast and valuation, excluding financing, of the mining operation required by Regulation 1(1) (g) (vi) in accordance with the following format and line items:

The content of each line item contained in the aforementioned format must be explained in detail in order to comply with the relevant provisions of the Regulation. The requirements of the Regulation will not be met by simply referring to the cash flow forecast when explaining the said line items, in that their purpose is precisely to justify and explain the numbers used in the said forecast. The numerical content of the specified line items must, therefore, be fully justified and informed by a detailed derivation as described above for the purpose of meeting the requirements of Regulations 1(1) (d), (e), (f), and (g) (i), (ii), (iii), (iv), (v) and (viii).

> 1(g) (vii) Details regarding the applicant's resources or proposed mechanisms to finance the proposed mining operation, and details regarding the impact of such financing arrangements on the cash flow forecast.

Compliance requires that the applicant shows how the foregoing cash flow forecast required in terms of regulation 1(1) (g) (vi) will be financed. The applicant is therefore required to:

i. Identify the applicable start-up cost requirements as identified in comparison with said cash flow forecast,
ii. Identify any negative amounts in the cash flow which would require financing. The purpose of this section, therefore, is to
iii. Explain how the identified funding requirement will be provided for, and
iv. Provide the necessary evidence that the required funding has been secured. Funding a project could be available in a large variety of ways, such as current assets, retained earnings, loan finance, mezzanine finance, or equity. The applicant is required to:
    i. Show, in cash flow format, how such financing will impact on the foregoing cash flow forecast and valuation.

ii. Provide conclusive evidence that the applicant has the identified amount available, or
iii. Any other particular party has resolved or undertaken to provide the identified amount, or
iv. Any other particular party has underwritten the identified amount, and
v. Provide the necessary documentary evidence that the applicant or the other particular party referred to above has the means to provide or underwrite the identified amount.

1(h) An undertaking, signed by the applicant, to adhere to the proposals as set out in the mining work programme.

The mining work programme becomes an obligation of the holder of a mining right, in terms of the Regulation and the applicant is required to sign an undertaking to adhere to the proposals as set out therein.

3. Financial and technical competence.
   Provide details and documentary proof of the applicant's technical ability and financial resources compatible with the Mining Work Programme that are readily available or how they will be provided for, to enable the applicant to carry out the Mining activities in terms of the Mining Work Programme and to mitigate and rehabilitate relevant environmental impacts satisfactorily. (Note: Submission of the prescribed information in the Mining Work Programme is deemed to be compliance herewith)
4. Detailed financing plan.
   (Note: Submission of the prescribed information in the Mining Work Programme is deemed to be compliance herewith).
5. Title deed or deeds in respect of land.
   Provide a certified copy or copies of the title deed or deeds in respect of the land or area to which this application relates. (Note: Submission of the accurate title deed reference number(s) is deemed to be compliance herewith)
6. Existing rights.
   Provide a list of existing rights and permits held by the applicant to be compiled in tabular form which indicate the region, the location with regard to the land name and the existing right or permit number for each mineral or minerals.
7. Social and labour plan.

The Social and Labour plan needs to include:
Preamble

1.1 Name of the company/applicant Organization’s registered name
1.2 Name of mine/ production Operation
1.3 Physical Address Mine address and not corporate address
1.4 Postal Address
1.5 Telephone Number
1.6 Fax Number
1.7 Location of mine or production Operation Route or locality map with clear direction to the operation
1.8 Commodity Commodities to be mined
1.9 Life of the mine- projected period that the mine will remain operational before closure as justified by Mining Work Programme.
1.10 Financial Year Date of financial year for the company
1.11 Reporting Year by 31st March of each year.
1.12. Responsible person Mine Manager
1.13 Geographic origin of employees (mine community and labour sending areas).

Human resource development programme
Compliance with Skills development Legislation

Applicants who by law have to register with SETAs must provide the following:

Name of SETA.

Registration number with the SETA.

Confirmation of having appointed a Skills Development Facilitator.

Proof of submission of workplace skills plan and date of submission.

Skills development plan

Provide a detailed skills development plan that outlines how the Mine or Production Operation intends to offer employees development of requisite skills in respect of learnerships, bursaries (of core and critical skills), artisans, ABET training (level I, II, III, IV and NQF 1), other training initiatives reflective of demographics as defined in the amended Mining Charter. The following should be provided:

Form Q Number and education levels of the workforce:

Determine current illiteracy level and ABET needs;

Provide the targets to be trained and the timeframes; and

Provide how ABET would be implemented.

Form R Hard-to-fill vacancies

Provide the vacancies that the Mine or Production Operation has been unable to fill for a period longer than 12 months despite concerted effort to recruit suitable candidates, if any, in the format of Form R.

Career Progression (path) Plan

The following should be provided: Career development matrices of each discipline (inclusive of minimum entry requirements and timeframes); Develop individual development plans for employees; Identify a talent pool to be fast tracked in line with the needs; and Provide a comprehensive plan with targets, timeframes and how the plan would be implemented.

Mentorship Plan

The following should be provided:

Mentorship plan for employees Identify areas of development that require mentoring, Provide a detailed plan highlighting number of mentors and mentees with target and timeframes and how the plan will be implemented; Link with individual development programmes; Focus on learners, career progression targets, employment equity targets, interns and bursars; and Detailed plan with targets, timeframe and how they will be achieved.

Bursary and Internship Plan

The purpose is to provide bursary and experiential learning opportunities to employees and mine communities. The following should be considered:

The company must, however, apply fair selection criteria in this regard. The plan must conform to the skills development plan, and should focus on building capacity in various skills and careers for employees and mine communities reflective of demographics as defined in the Mining Charter.

Bursary Plan

Provide targets, timeframes and budget; Provide areas of learning in line with the needs of the company; Separate internal and external bursars; and indicate whether bursaries are continuous or new intakes.

Internship Plan

Provide targets, timeframes and budget; Provide areas of learning in line with the needs of the company; Provide how interns would be afforded the opportunity for experiential learning; Separate internal and external internships; The plan should be inclusive of own funded studies; and The plan should be reflective of demographics as defined in the amended Mining Charter.

Employment equity plan

The purpose of the plan is to ensure diversity as well as participation of HDSA at all decision-making positions and core occupational categories in the mining industry. Every mining company must achieve a minimum of 40% HDSA in management reflective of demographic representation. The plan should reflect the annual progressive targets. The following should be considered:

Provide form S and the current management structure as reflected below;

Executive Management (Board);
Senior management (EXCO);
Core and Critical skills;
Middle management level; and
Junior management level.

Provide the current management structure reflective of demographics;
The plan should reflect the annual progressive targets; and Provide a detailed plan on how the targets would be met.

Mine community development

Social and economic background information
Provide the social and economic baseline information of the mine community.
The background information must include but not limited to the following: Gender Profile; Population Profile; Health and HIV/AIDS Prevalence; Economic Profile; Education Levels; Expenditure Profile; Employment Profile; Income Profile; Infrastructure, Housing; Water and Sanitation as well as Electricity.

Key economic activities
Provide the key economic activities of the mining community.
Provide names of other mining companies that operate in your area of operation.

Negative Impact of the mining operation
Relocation of people;
Exhumation of graves; and
Influx of people –Informal settlements.

Infrastructure and poverty eradication projects that the mine would undertake in line with the (IDP) of the areas and other relevant frameworks in which the mine operates and the major sending areas.

Having specified the needs, identify projects that will be implemented in line with the needs; Provide an implementation plan of the identified projects that will be implemented to address the needs; and Provide the impact that the identified projects would have on the Community(ies) and the areas in line with the duration of the mining right.

Development Projects

Projects to be implemented should be classified as follows:

Infrastructure projects; Income generating projects. The following is an example of a project implementation template. Additions to provide more information are acceptable.

Measures to address housing and living conditions

The following should be considered: Provide the current status of available dwelling for employees; Provide current status of houses within the community; Provide the municipality's strategy to address housing; Establish the preferred requirements for housing and living conditions of the workforce; and The plan should include but is not limited to: Promotion of home ownership; Converting hostels into single quarters and family units; and Reduction of occupancy rate reflecting the following targets:
•2011 = 25% •2012 – 50 % •2013 = 75 % •2014 = 100%

Processes pertaining to management of downscaling and Retrenchment

Organizations have to retrench workers from time to time for economic reasons and to remain globally competitive. It is therefore important that employers should first make sure that no other viable options to achieve operational requirements are available before considering downscaling of workers. The Declaration of the Presidential Jobs Summit during October 1998 provided a framework for a Social Plan to prevent job losses where possible and to guide the affected parties who have to deal with retrenchments. The framework included a broad proposal for implementation of the Social Plan.

A detailed process, in conjunction with section 52 of the Act and regulation 46 (e), for saving jobs, managing downscaling and regenerating local economies must be developed for implementation at the time of such need. This process must also be in line with the Department of Labour's Social Plan Guidelines. Your company must take note of and follow the procedures for downscaling and retrenchment as set out by the Department of Labour (DoL) and the Labour Relations Act (LRA). The mine must develop turnaround strategies and mechanisms to save jobs, prevent unemployment and avoid downscaling. In particular, your operation must follow the "notification process" as outlined in the Social Plan Guidelines and the LRA. Your company, through the Future Forum, should anticipate downscaling, manage potential retrenchments on a basis that is informed by the skills development process relating to the preparation of employees for such events, and assist the affected employees with alternative forms of employment or sustainable livelihood opportunities. The communication process should strive for active participation by employees, mine management, communities, government authorities and community organisations.

Establishment of future forum

Provide an undertaking to establish a Future Forum within six months after the conversion of an old order mining right and two year after the new mining right has been granted. The Future Forum should comprise of management and workers or their representatives. The functions of the Future Forum include but are not limited to: Promote ongoing discussions between worker representatives and employers about the future of the mine; Look ahead to identify problems, challenges and possible solutions with regard to productivity and employment; Develop turnaround and redeployment strategies to help reduce job losses and to improve business sustainability; and Implement strategies agreed upon by both employer and worker parties.

Mechanisms to save jobs, provide alternative solutions and procedures for creating job security where job losses cannot be avoided.

Provide an undertaking to establish a Future Forum within six months after the conversion of an old order mining right and two year after the new mining right has been granted. The Future Forum should comprise of management and workers or their representatives. The functions of the Future Forum include but are not limited to: Promote ongoing discussions between worker representatives and employers about the future of the mine; Look ahead to identify problems, challenges and possible solutions with regard to productivity and employment; Develop turnaround and redeployment strategies to help reduce job losses and to improve business sustainability; and Implement strategies agreed upon by both employer and worker parties.

Management of retrenchments

Outline the process to be followed in managing retrenchments humanely in consultation with organized labour. The proposed plan should be in line with the terms of Section 52 (1) of the MPRDA, National Social plan guideline of DoL and Section 189 of the LRA.

Mechanisms to ameliorate the social and economic impact on individuals, regions and economies where retrenchment or closure of the operation is certain.

Outline the process to be followed to ameliorate the social and economic impact on individuals, regions and economies. The process must include but not limited to:
Comprehensive self-employment training programmes;
Comprehensive training and re-employment programmes;
Comprehensive portable skills development plan;
The projects earmarked for absorbing the retrenchees should be outlined; and
The abovementioned plans must be submitted to DMR 24 months prior to the commencement of the downscaling process.

Financial provision

In order to meet the requirements of Regulation 46 (e) (i), (ii), (iii), the following should be considered: In line with sections 23 (1) (e) and 84 (1) (g), the applicant for a mining and production right must provide financially and otherwise for the social and labour plan.
Financial provision should be in monetary value (Rand); and
The provision should cater for all components of SLP.

Undertaking

The person responsible for the social and labour plan, who is responsible to make known the social and labour plan to the employees and who must be contacted for follow-ups, requests, reports, queries, enquiries, discussions, etc. at time of such needs must make the following undertaking on behalf of the Mine or Production Operation. The Chief Executive Officer, Managing Director or any other person so appointed must approve the social and labour plan.

8. Prescribed fee.
   An amount of R1000.00 ZAR, being the application fee.
9. Copy of identity document.
   In the case of a natural person, a certified copy of the identity document must be attached.
10. A certified copy of the certificate of Incorporation, if applicable
11. A certified copy of the certificate to commence business, if applicable
12. Copy of resolution, if acting in a representative capacity
13. The Minister may require additional information to be submitted, in terms of the provisions of section 29 of the Act

Other Documents to upload

- Environmental Management Program

  Regulation 51 (a) - This regulation requires a description of the environmental objectives and specific goals for mine closure, the management of identified environmental impacts emanating from the mining operation, the socio economic conditions as identified in the social and labour plan, and historical and cultural impacts, if applicable.

  Regulation 51 (b) – Outline of the implementation programme. This Regulation read with the provisions of section 39 (3) (d) (i) of the Act requires a description of the technical and management option chosen (a) in respect of each action, activity or process which causes pollution or environmental degradation for (b) each environmental impact, socio economic condition, and historic and cultural aspect and (c) for each phase of the mining operation.

- Scoping
- BEE

The Environmental Management Program needs to include:

1. Description of environmental objectives and specific goals for the management of identified environmental impacts emanating from the proposed mining operation. This description must be informed by the information provided in the EIA in terms of Regulation 50 (h).

   1.1. Provide a list of environmental aspects that describe the pre-mining environment as informed by the description of the baseline environment contained in the foregoing environmental impact assessment that will serve to guide the setting of environmental objectives for mine closure.

   1.2. Provide a list of the measures required to contain or remedy any causes of pollution or degradation or the migration of pollutants, both for closure of the mine and post closure.

2. Description of environmental objectives and specific goals for the socio-economic conditions as identified in the social and labour plan.
   The applicant is required to:

   2.1. Provide a list of identified impacts which will require monitoring programmes.

   2.2. Provide a list of the source activities that are the cause of the impacts which require to be managed.

   2.3. List those management activities which, where applicable, will be conducted daily, weekly, monthly, quarterly, annually or periodically as the case may be in order to control any action, activity or process which causes pollution or environmental degradation.

   2.4. Define the roles and responsibilities for the execution of the monitoring and management programmes.

3. Description of environmental objectives and specific goals for mine closure. The applicant is required to modify, remedy, control or stop any action, activity or process that could impact negatively on the socio-economic conditions of the persons concerned.
   The applicant must:

   3.1. Provide a list describing various aspects of the socio-economic conditions in the vicinity of the mine, as identified in the Social and Labour plan.

3.2. Provide a list describing specific environmental objectives and goals to control, remedy or stop potential impacts emanating from the mine such as noise air quality, blasting vibrations, access roads, safety, etc. which may impact on communities and interested and affected parties identified in the social and labour plan.

4. Description of environmental objectives and specific goals for historical and cultural aspects.

4.1. Provide a list of stated environmental objectives and goals in respect of historical and cultural aspects identified in specialist studies conducted during the EIA phase.

5. Describe the appropriate technical and management options chosen for each environmental impact, socio-economic condition and historical and cultural aspect in each phase of the mining operation

5.1. Provide a list for each phase (construction, operational, closure and post closure) of the mining operation, describing each action, activity or process, including any NEMA EIA Regulation listed activity, which causes pollution or environmental degradation that will be conducted during that phase.

5.1.1. Indicate which of the aforesaid actions, activities or processes will cause significant impacts on the environment, the socio-economic conditions of directly affected persons, and on historical and cultural aspects.

5.2. Provide a concomitant list describing the appropriate technical or management options chosen to modify, remedy, control or stop any action, activity, or process which will cause significant impacts on the environment, socio-economic conditions and historical and cultural aspects as identified.

5.2.1. Each technical or management option must be further described in detail, in suitably cross referenced format and where necessary, appendices must be attached.

6. Provide Action plans to achieve the objectives and specific goals contemplated in Regulation 50 (a).

6.1. Provide concomitant time schedules that describe in detail the deadlines for each action to be undertaken to implement each technical or management option chosen to prevent, manage and remediate each environmental impact, socio-economic condition and historical and cultural aspect, as identified. The time schedules must indicate:-

6.1.1. Specific timeframes during which each technical or management options chosen for the prevention of impacts will be in place such as, but not limited to the construction of clean and dirty water systems, access control during blasting, etc.

6.1.2. Specific timeframes for the implementation of each technical or management option chosen to remediate impacts such as, but not limited to, the various stages of rehabilitation work during the various phases of the mining operation, arrangements to remedy socio-economic or cultural impacts, etc

6.1.3. Specific timeframes for the management of environmental impacts such as, but not limited to dust suppression, noise control, environmental monitoring, etc.

6.1.4. Provide detail of those management activities which, where applicable, will be conducted daily, weekly, monthly, quarterly, annually or periodically as the case may be in order to manage the identified impacts effectively.

7. Procedures for environmentally related emergencies and remediation

7.1. Provide an Environmental Emergency plan, which plan must include

7.1.1. A description of the ongoing monitoring and management measures to be implemented, to provide the early warning systems necessary to avoid environmental emergencies.

7.1.2. A description of procedures that will be in place in cases of environmental related emergencies,

7.1.3. The technical, management and financial options that will be in place to deal with the remediation of impacts in cases of environmental emergencies.

8. Planned monitoring and environmental management programme performance assessment.

8.1. Provide a description of planned monitoring of the aspects of the environment which may be impacted upon. Such description must include;

8.1.1. A list of the environmental aspects that will be monitored.

8.1.2. A description of the manner in which the monitoring will be conducted, and the location where each monitoring activity will be carried out.

8.1.3. A description of the various standards that must be maintained, which standards must meet the requirements of the regulatory authority concerned, or the relevant SABS standard as the case may be.

8.1.4. A description of the frequency of the monitoring to be conducted in each specific case.

8.1.5. A description of the analysis to be conducted, the frequency thereof, and the records to be kept.

8.1.6. A description of the standard procedures for cases where the results of monitoring indicate non-compliance with the relevant standards.

8.2. Provide a description as to how the implementation of the action plans contemplated in regulation 51 (b) (ii) as described will be monitored as described in paragraph 6 of the EMP will be monitored.

8.3. State the frequency that the performance is proposed to be reported on for assessment purposes.

9. Financial provision in relation to the execution of the environmental management programme

The applicant is required to:

9.1. Provide a plan showing the location and aerial extent of the aforesaid main mining actions, activities, or processes anticipated to be conducted until the resource is depleted, as required to calculate the financial provision in accordance with the Department's published guideline. This plan must show the annual progress of the mining operation relative to the overall plan.

9.1.1. Ensure that the rehabilitation plan is compatible with the closure objectives determined in accordance with the baseline study as prescribed.

9.1.2. Complete the standard guideline document developed for financial provision. Complete the standard guideline in respect of all the main mining actions activities or processes anticipated to be conducted until the resource is depleted.

9.2. Complete 10 forecasts (one for each of the first 10 years of operation) and to then determine the progressive total in year 10 (excluding concurrent rehabilitation).

The progressive total determined for Year 10 must be specifically stated.

9.3. Confirm the amount that will be provided should the right be granted.
9.4. Provide details of the method of providing financial provision contemplated in Regulation 53.

10. Environmental Awareness Plan (Section 39 (3) (c)) - the applicant must in this section include an environmental awareness plan in accordance with Section 39 (3) (c).

    This plan must:
    10.1. Describe how the applicant intends to inform his or her employees of any environmental risk which may result from their work, and
    10.2. Describe the manner in which the risk must be dealt with in order to avoid pollution or degradation of the environment.
    10.3. Describe the general environmental awareness training and training on dealing with emergency situations and remediation measures for such emergencies.

11. Attachment of specialist reports, technical and supporting information.
    11.1. All supporting information that remains necessary to submit, and specialist reports not already attached in terms of the EIA should be attached as appendices

11. SECTION 39 (4) (a) (iii), Capacity to manage and rehabilitate the environment Section 39 (4) (a) (iii) of the Act, read together with section 37 (2) of the Act, requires that the applicant will have the capacity, or have provided for the capacity, to rehabilitate and manage negative impacts on the environment. This requirement is not the same as that for financial provision, which concerns the financial risk to the State and, which may not necessarily be accessible to the applicant to fund rehabilitation or manage the environment.

    The applicant is required to:-
    12.1. State the amount it requires to both manage and rehabilitate the environment, and provide a detailed explanation as to how the amount was derived; which amount should not be less than the sum of the amounts reflected in paragraph 9.1.3 herein, and the amount reflected in paragraph 6.5.3 of the EIA.
    12.2. Specifically confirm that the stated amount has been adequately provided for in the corresponding budget reflected in the Mining Work Programme as required in Accordance with Regulation 11 (1) (g) (iv).

13. Undertaking
    13.1. The Environmental Management Programme will, should it comply with the provisions of section 39 (4) (a) of the Act and the right be granted, be approved and become an obligation in terms of the right issued. As part of the proposed Environmental Management Programme, the applicant is required to provide an undertaking that it will be executed as approved and that the provisions of the Act and regulations thereto will be complied with.

2.2 The Granting and Duration of a mining right

1. Subject to subsection (4), the Minister must grant a mining right if:
   a)The mineral can be mined optimally in accordance with the mining work programme;
   b)The applicant has access to financial resources and has the technical ability to conduct the proposed mining operation optimally;
   c) The financing plan is compatible with the intended mining operation and the duration thereof;

d) The mining will not result in unacceptable pollution, ecological degradation or damage to the environment and an environmental authorization is issued;
e) The applicant has provided for the prescribed social and labour plan;
f) The applicant has the ability to comply with the relevant provisions of the Mine Health and Safety Act, 1996 (Act No, 29 of 1996);
g) The applicant is not in contravention of any provision of this Act; and
h) The granting of such right will further the objects referred to in section 2(d) and (f) in accordance with the charter contemplated in section 100 and the prescribed social and labour plan.

2. The Minister may, having regard to the nature of the mineral in question, take into consideration the provisions of section 26.

a) If the application relates to the land occupied by a community, the Minister may impose such conditions as are necessary to promote the rights and interests of the community, including conditions requiring the participation of the community.

3. The Minister must, within 60 days of receipt of the application from the Regional Manager, refuse to grant a mining right if the application does not meet the requirements referred to in subsection (1).

4. If the Minister refuses to grant a mining right, the Minister must, within 30 days of the decision, in writing notify the applicant of the decision and the reasons.

5. A mining right granted in terms of subsection (1) comes into effect on the effective date.

6. A mining right is subject to this Act, any relevant law, the terms and conditions stated in the right and the prescribed terms and conditions and is valid for the period specified in the right, which period may not exceed 30 years.

3 DECOMMISSIONING AND CLOSURE

Closure objectives, in general, are to return the land that was being mined to as closely as possible to the pre-mining condition. Before prospecting or mining rights can be approved, there needs to be a financial provision for rehabilitation and closure. This may be made by an approved contribution to a trust fund, a financial guarantee from a registered or DMR approved bank in South Africa, a deposit into a specified account, or any other method that is determined by the DMR.

The holder of a prospecting right, mining right, retention permit or mining permit remains responsible for any environmental liability, pollution or ecological degradation, and the management thereof, until the Minister has issued a closure certificate to the holder concerned.

- On written application by the holder of a prospecting right, mining right or mining permit in the prescribed manner, the Minister may transfer such environmental liabilities and responsibilities as may be identified in the environmental management plan or the environmental management programme and any prescribed closure plan to a person with such qualifications as may be prescribed.
- The holder of a prospecting right, mining right, retention permit or mining permit, as the case may be, must apply for a closure certificate upon:
  a) The lapsing, abandonment or cancellation of the right or permit in question;
  b) Cessation of the prospecting or mining operation;
  c) The relinquishment of any portion of the prospecting of the land to which a right, permit or permission relate; or

d) Completion of the prescribed closing plan to which a right, permit or permission relate.

- An application for a closure certificate must be made to the Regional Manager in whose region the land in question is situated within 180 days of the occurrence of the lapsing, abandonment, cancellation, cessation, relinquishment and must be accompanied by the prescribed environmental risk report.
- No closure certificate may be issued unless the Chief Inspector and the Department of Water Affairs and Forestry have confirmed in writing that the provisions pertaining to health and safety and management of potential pollution to water resources have been addressed.
- When the Minister issues a certificate he or she must return such portion of the financial provision contemplated in section 41 as the Minister may deem appropriate to the holder of the prospecting right, mining right, retention permit or mining permit in question, but may retain any portion of such financial provision for latent and or residual environmental impact which may become known in the future.
- This amount must be assessed annually and adjusted accordingly. A closure plan is also required, and must comply with the MPRDA. The holder of the mining licence will remain responsible for any environmental liability, ecological degradation and pollution until a closure certificate is issued (Endangered Wildlife Trust, 2012).

3.1 Removal of buildings, structures and other objects

1) When a prospecting right, mining right, retention permit or mining permit lapses, is cancelled or is abandoned or when any prospecting or mining operation comes to an end, the holder of any such right or permit may not demolish or remove any building, structure or object—

a) Which may not be demolished or removed in terms of any other law;
b) Which has been identified in writing by the Minister for purposes of this section; or
c) Which is to be retained in terms of an agreement between the holder and the owner or occupier of the land, which agreement has been approved by the Minister in writing.

2) The provision of subsection (1) does not apply to bona fide mining equipment, which may be removed.

3.2 Minister's power to recover costs in event of urgent remedial measures

1) If any prospecting, mining, reconnaissance or production operations cause or results in ecological degradation, pollution or environmental damage which may be harmful to the health or well-being of anyone and requires urgent remedial measures, the Minister may direct the holder of the relevant right, permit or permission to—

a) Investigate, evaluate, assess and report on the impact of any pollution or ecological degradation;
b) Take such measures as may be specified in such directive; and
c) Complete such measures before a date specified in the directive.

2a) If the holder fails to comply with the directive, the Minister may take such measures as may be necessary to protect the health and well-being of any affected person or to remedy ecological degradation and to stop pollution of the environment.

b) Before the Minister implements any measure, he or she must afford the holder an opportunity to make representations to him or her.

c) In order to implement the measures contemplated in paragraph (a), the Minister may by way of an ex parte application apply to a High Court for an order to seize and sell such property of the holder as may be necessary to cover the expenses of implementing such measures.

d) In addition to the application in terms of paragraph (c), the Minister may use funds appropriated for that purpose by Parliament to fully implement such measures.

e) The Minister may recover an amount equal to the funds necessary to fully implement the measures from the holder concerned.

3.3 Minister's power to remedy environmental damage in certain instances

1) If the Minister directs that measures must be taken to prevent pollution or ecological degradation of the environment or to rehabilitate dangerous occurrences but establishes that the holder of the relevant reconnaissance permission, prospecting right, mining right, retention permit or mining permit, as the case may be, or his or her successor in title, is deceased or cannot be traced or, in the case of a juristic person, has ceased to exist, has been liquidated or cannot be traced, the Minister may instruct the Regional Manager concerned to take the necessary measures to prevent further pollution or degradation, or to make the area safe.

2) The measures contemplated in subsection (1) must be funded from the financial provision made by the holder of the relevant reconnaissance permission, prospecting right, mining right, retention permit or mining permit, where appropriate, or if there is no such provision or if it is inadequate, from money appropriated by Parliament for that purpose.

3a) Upon completion of the measures contemplated in subsection (1), the Regional Manager must apply to the registrar concerned that the title deed of the land in question be endorsed to the effect that such land had been remedied.

> b) The registrar concerned must, on receipt of an application contemplated in paragraph a), make such endorsements as he or she may deem necessary so as to give effect to provisions of that paragraph, and no office fee or other charge is payable to the registrar in respect of such endorsement.

The Minerals and Petroleum Resources Development Act, 2002 provides for the issuing of a closure certificate by the Minister of Minerals and Energy, in which the environmental liabilities are transferred to a competent person. The application for a closure certificate must also have an environmental risk report, with supporting regulations for mine closure such as: the Principles for mine closure, the application for mine closure, the application to transfer environmental liabilities to a competent person (including the qualifications of such a person), the content for an Environmental Risk Report, and the content of a closure plan.

3.4 Restriction or prohibition of prospecting and mining on certain land

1) Subject to section 48 of the National Environmental Management: Protected Areas Act 2003 (Act No. 57 of 2003), and subsection (2), no reconnaissance permission, prospecting right, mining right may be granted or mining permit be issued in respect of:

- a) Land comprising a residential area;
- b) Any public road, railway or cemetery;
- c) Any land being used for public or government purposes or reserved in terms of any other law; or
- d) Areas identified by the Minister by notice in the Gazette in terms of section 49.

2) A reconnaissance permission, prospecting right, mining right or mining permit may be issued in respect of the land contemplated in subsection (1) if the Minister is satisfied that -

- a) Having regard to the sustainable development of the mineral resources involved and the national interest, it is desirable to issue it;
- b) The reconnaissance, prospecting or mining will take place within the framework of national environmental management policies, norms and standards; and
- c) The granting of such rights or permits will not detrimentally affect the interests of any holder of a prospecting right or mining right.

Mining agents need to comply with South Africa's constitutions and common laws, where section 24(a) of the Constitution states that all South Africans have the right to an environment that is not harmful to his or her health and well-being, which supersedes all other legislation. The Minerals Act. 1991 (Act 50 of 1991) provides the requirements for enforcing environmental protection, the management of environmental impacts and the rehabilitation of the affected environment of prospecting and mining. Other important legislation needed when closing a mine are the National Environmental Act, 1998, the National Water Act, 1998, the Atmospheric Pollution Prevention Act, 1965, and the National Nuclear Regulator Act, 1999, among other related legislation.

The Mine Health and Safety Act, 1996 (Act No. 29 of 1996) states that the employer must ensure and maintain a safe and healthy environment at the mine during closure, supply adequate health and safety equipment, training and access and respond to any risk or hazard where employees may be exposed, there needs to be a medical surveillance system, as well as the rights of employees to access information, duties for health and safety as well as permission to leave a dangerous working place if need be.

Atmospheric Pollution Prevention Act, 1965 prevents mines from disposing assets in certain circumstances, meaning that proper closure is the only way to avoid a prohibition on the disposal of mine assets.

The Nuclear Energy Act, 1999 require mines that deal with radioactive elements to meet radiological requirements before the closure certificate is granted.

The National Water Act, 1998 (Act No. 35 of 1998) sets a water management hierarchy, which is based on a precautionary approach, and consist of: Pollution prevention, Water re-use or reclamation, water treatment, discharge. In order for a mine to comply with this hierarchy, they require an integrated mine water management system which adhere to these principles: Comply to all legislation, follow a life-cycle approach for water management throughout the life of the mine, cradle-to-grave approach to waste streams and consequential impacts, the long-term and current risks of water management need to be quantified with a risk-based approach.

The National Water Act has regulations on the use of water for mining aimed at protecting the water resources.

With regards to restrictions on locality, no person in control of a mine or mining activity may:

a) locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on water-logged ground, or on ground likely to become water-logged, undermined, unstable or cracked;

b) except in relation to a matter contemplated in regulation 10, carry on any underground or open-cast mining, prospecting or any other operation or activity under or within the 1:50 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, whichever is the greatest;

c) place or dispose of any residue or substance, which causes or is likely to cause pollution of a water recourse, in the workings of any underground or open-cast mine excavation, prospecting diggings, pit or any other excavation; or

d) use any area or locate any sanitary convenience, fuel depots, reservoir or depots for any substance which causes or is likely to cause pollution of a water resource within the 1:50 year flood line of any watercourse or estuary.

This Act also covers restrictions on the use of materials on a mine. No person in control of a mine or activity may use any residue or substance which causes or is likely to cause pollution of a water resource for the construction of any dam or other impoundment or any embankment, road or railway, or for any other purpose which is likely to cause pollution of a water resource.

There are certain requirements of a person in control of a mine or activity with regards to their water systems, in why they must:

a) Confine any unpolluted water to a clean water system, away from any dirty area;

b) Design, construct, maintain and operate any clean water system at the mine or activity so that it is not likely to spill into any dirty water system more than once in 50 years;

c) Collect the water arising within any dirty area, including water seeping from mining operations, outcrops or any other activity, into a dirty water system;

d) Design, construct, maintain and operate any dirty water system at the mine or activity so that it is not likely to spill into any clean water system more than once in 50 years;

e) Design, construct, maintain and operate any dam or tailings dam that forms part of a dirty water system to have a minimum freeboard of 0.8 metres above full supply level, unless otherwise specified in terms of Chapter 12 of the Act; and

f) Design, construct and maintain all water systems in such a manner as to guarantee the serviceability of such conveyances for flows up to and including those arising as a result of the maximum flood with an average period of recurrence of once in 50 years.

Every person in control of a mine or activity needs to take reasonable measures in the protection of the water resources, as to:

a) Prevent water containing waste or any substance which causes or is likely to cause pollution of a water resource from entering any water resource, either by natural flow or by seepage, and must retain or collect such substance or water containing waste for use, re-use, evaporation or for purification and disposal in terms of the Act;

b) Design, modify, locate, construct and maintain all water systems, including residue deposits, in any area so as to prevent the pollution of any water resource through the operation or use thereof and to restrict the possibility of damage to the riparian or in-stream habitat through erosion or sedimentation, or the disturbance of vegetation, or the alteration of flow characteristics;

c) Cause effective measures to be taken to minimise the flow of any surface water or floodwater into mine workings, open-cast workings, other workings or subterranean caverns, through cracked or fissured formations, subsided ground, sinkholes, outcrop excavations, adits, entrances or any other openings;

d) Design, modify, construct, maintain and use any dam or any residue deposit or stockpile used for the disposal or storage of mineral tailings, slimes, ash or other hydraulic transported substances, so that the water or waste therein, or falling therein, will not result in the failure thereof or impair the stability thereof;

e) Prevent the erosion or leaching of materials from any residue deposit or stockpile from any area and contain material or substances so eroded or leached in such area by providing suitable barrier dams, evaporation dams or any other effective measures to prevent this material or substance from entering and polluting any water resources;

f) Ensure that water used in any process at a mine or activity is recycled as far as practicable, and any facility, sump, pumping installation, catchment dam or other impoundment used for recycling water, is of adequate design and capacity to prevent the spillage, seepage or release of water containing waste at any time;

g) At all times keep any water system free from any matter or obstruction which may affect the efficiency thereof; and

h) Cause all domestic waste, including wash-water, which cannot be disposed of in a municipal sewage system, to be disposed of in terms of a licence under the Act.

Every person in control of a mine or activity needs to have adequate security measures in place, and must:

a) Cause any impoundment or dam containing any poisonous, toxic or injurious substance to be effectively fenced-off so as to restrict access thereto, and must erect

warning notice boards at prominent locations so as to warn persons of the hazardous contents thereof;
b) Ensure access control in any area used for the stockpiling or disposal of any residue or substance which causes, has caused or is likely to cause pollution of a water resource so as to protect any measures taken in terms of these regulations;
c) Not allow the area contemplated in paragraph (a) and (b) to be used for any other purpose, if such use causes or is likely to cause pollution of a water resource; and
d) Protect any existing pollution control measures or replace any existing pollution control measures deleteriously affected, damaged or destroyed by the removing or reclaiming of materials from any residue deposit or stockpile, and establish additional measures for the prevention of pollution of a water resource which might occur, is occurring or has occurred as a result of such operations.

With regards to the temporary or permanent cessation of a mine or activity:

a) Any person in control of a mine or activity must at either temporary or permanent cessation of operations ensure that all pollution control measures have been designed, modified, constructed and maintained so as to comply with these regulations.
b) Any person in control of a mine or activity must ensure that the instream and riparian habitat of any water resource, which may have been affected or altered by a mine or activity, is remedied so as to comply with these regulations.
c) On either temporary or permanent cessation of a mine or activity the Minister may request a copy of any surface or underground plans as required in terms of the Minerals Act, 1991.

Coal residue deposits have additional regulations for rehabilitation, where any person mining or establishing coal residue deposits needs to rehabilitate the deposits in that:

a) All residue deposits are compacted to prevent spontaneous combustion and minimise the infiltration of water; and
b) The rehabilitation of the residue deposits is implemented concurrently with the mining operation.

1) Any person who contravenes or, subject to regulation 3, fails to comply with regulation 2, 4, 5, 6, 7, 8, 9, 10, 11, 12 or 13 is guilty of an offence and liable on conviction to a fine or to imprisonment for a period not exceeding five years.

2) Whenever an act or omission by a manager or employee of a mine or activity:

a) Constitutes an offence in terms of these regulations, and takes place with the express or implied permission of the person in control of a mine or activity, that person is, in addition to the manager or employee, liable to conviction for that offence; or
b) Would constitute an offence by the person in control of a mine or activity in terms of these regulations that manager or employee is, in addition to that person, liable to conviction for that offence.

Mining may also need other authorisations and rights in order to proceed with their activities. If a mine requires a water use, such as abstraction, storage, discharge, waste disposal, removal of underground water and alternation to a water course, according to the National Water Act, 36 of 1998, a water license is required. The mine will need to submit an integrated water and waste management plan to the Department of Water Affairs (DWA) together with their water use licence application (Endangered Wildlife Trust, 2012)

A mine will need to comply with the National Environmental Management: Waste Act, 59 of 2008 (Waste Act) with regards to any waste management activities. The applicability to prospecting and mining activities is limited due to the fact that the Waste Act excludes ambit residue deposits and stockpiles. A holder of a prospecting or mining right may have to comply with general duties imposed on them by the Waste Water Act, which include the obligations to avoid generating waste, to minimise the toxicity and amount of waste to unavoidably produced waste, to reuse, reduce, recycle and recover waste among others.
The National Environmental Management: Air Quality Act, 39 of 2004 (AQA) is the law that governs air quality in South Africa. In terms of mining, any activities which impact air quality require licencing. These include dust control (which should be addressed in the EMP or EMPR), noise and offensive odours.

Heritage Resources are protected by the The National Heritage Resources Act, 25 of 1999 (NHRA). These resources include movable and immovable objects of historical, archaeological, paleontological or astronomical interest. A heritage impact assessment needs to be done in such areas for certain linear developments (such as a pipeline), which is submitted in the EIA process, which must take into account the Heritage Resources Agency's comments when considering the application (Endangered Wildlife Trust).
No mining activities may be conducted in: 1) a special nature reserve, national park or nature reserve, 2) in a protected area without permission of the Minister and Cabinet member responsible for minerals and energy, or 3) in a protected area referred to in section 9(b), (c) or (d), according to section 48(1) of the National Environmental Management: Protected Areas Act, 57 of 2003 (NEMPAA) (Swart, 2003).

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REPORT

WETLAND ASSESSMENT, CONSERVATION, MANAGEMENT AND REHABILITATION IN MINING ENVIRONMENTS ON THE MPUMALANGA HIGHVELD

3 May, 2016

Compiled by:
J.H. van der Waals
(PhD Soil Science, Pr.Sci.Nat.)
Member of:
Soil Science Society of South Africa (SSSSA)

Accredited member of:
South African Soil Surveyors Organisation (SASSO)

Registered with:
The South African Council for Natural Scientific Professions
Registration number: 400106/08

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WETLAND ASSESSMENT, CONSERVATION, MANAGEMENT AND REHABILITATION IN MINING ENVIRONMENTS ON THE MPUMALANGA HIGHVELD

1. INTRODUCTION

1.1 TERMS OF REFERENCE

I, Johan van der Waals, was appointed by Victor Munnik Consulting to generate a report on the various soil and wetland aspects that influence and determine the assessment, conservation, management and rehabilitation wetlands and their associated water and ecological related parameters in opencast (or shallow) mining environments on the Mpumalanga Highveld. The focus of the report is on the unpacking, elucidation and discussion of the biophysical determinants of wetland assessment and functionality in environments where landscape hydrology is compromised or altered through mining activities.

1.2 BACKGROUND

The conservation of wetlands within mining environments with the specific impacts poses several challenges. These challenges include 1) the correct assessment techniques for wetlands in opencast mining environments, 2) the correct assessment of hydrological drivers of the wetland systems, 3) integration of the hydrological data for the wetland with the surface and groundwater hydrological data and management objectives of the mine and catchment, and 4) implementation of the most desirable and economically viable rehabilitation approach taking into account the requirements of the regulator and commitments attainable in the EMP.

The biophysical context of most open cast coal mining operations is the Mpumalanga Highveld with its characteristic plinthic catena landscapes. The dominance of plinthic soils is a function of the specific geology, topography, climate and hydrology of the Highveld. The plinthic soils exhibit very specific morphology related to periodic wetness and hydrology and wetland delineation exercise are readily conducted with a large degree of accuracy in this landscape. The philosophical approach to wetland delineation and the management and mine planning approaches based on these philosophies are inherently flawed due to the broader lack of understanding regarding the hydrological linkages in the plinthic catena landscapes.

1.3 AIM OF THIS REPORT

The aim of this report is to provide a systematic breakdown of the different components required for adequate wetland assessment, focussing specifically on hydrologically based assessment processes. This entails the description and elucidation of hydrological functioning of landscapes in order to propose realistic landscape and wetland management and rehabilitation procedures.

2. AREA LOCALITY AND DESCRIPTION

2.1 DISCUSSION AREA BOUNDARY

The area of discussion in this document is the Mpumalanga Highveld or the Eastern Highveld of South Africa (**Figure1**). Due to the dominant geology this is the area that currently constitutes the dominant opencast mine coal production area.

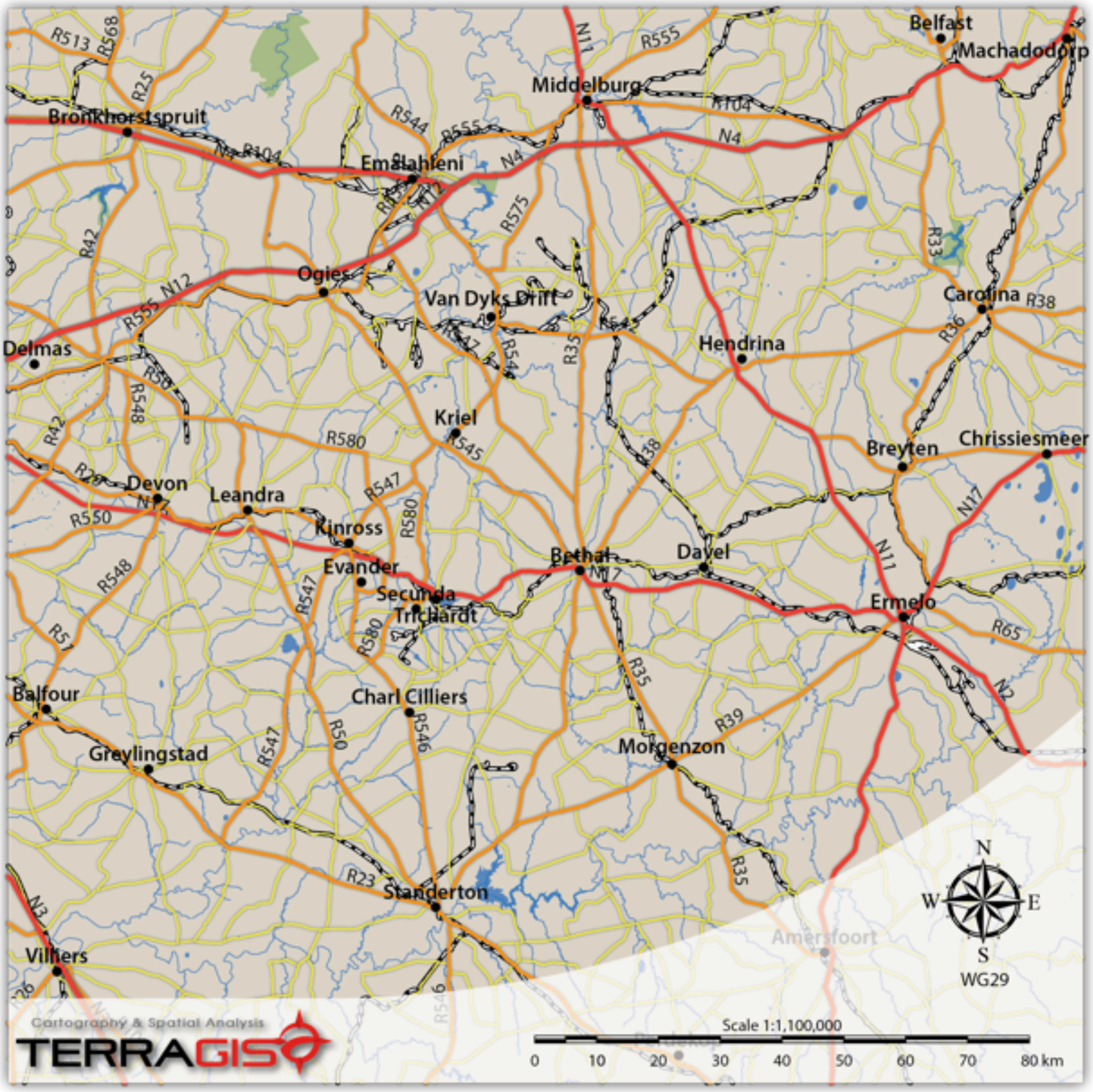

Figure 1 Locality of the discussion area

2.2 LAND TYPE DATA AND SOILS

Land type data for the area was obtained from the Institute for Soil Climate and Water (ISCW) of the Agricultural Research Council (ARC). The land type data is presented at a scale of 1:250 000 and entails the division of land into land types, typical terrain cross sections for the land type and the presentation of dominant soil types for each of the identified terrain units (in the cross section). The soil data is classified according to the Binomial System (MacVicar et al., 1977). The soil data was interpreted and re-classified according to the Taxonomic System (Soil Classification Working Group, 1991).

The land types associated with coal reserves and coalmines on the Mpumalanga Highveld are predominantly of the Ba and Bb land types (**Figure 2**).

A dedicated discussion of the Ba and Bb land types is provided in section 5 of this report.

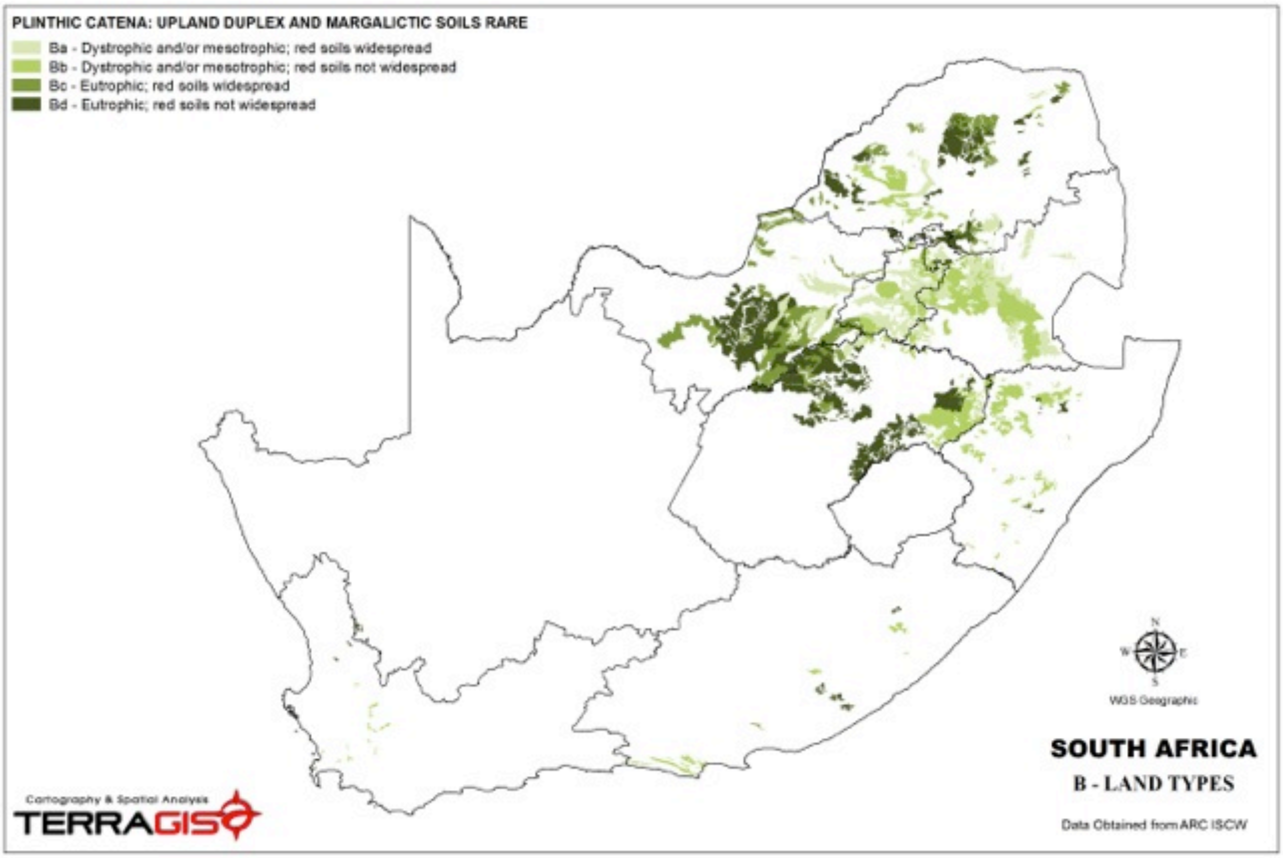

Figure 2 Plinthic land types in South Africa

Figure 3 provides a generalised soil associate map for the investigation area. The dominance of the plinthic landscapes is evident and is the main motivation for the focus of this investigation in the form of discussions on the impacts of opencast coal mining activities. Even though a large area of the Mpumalanga Highveld consists of structured soil landscapes these will not be discussed in detail as the coalmines in these areas are predominantly deeper and underground mines. The impacts of coal mining activities in structured and vertic soil environments warrants a separate discussion due to the distinct difference in landscape and soil hydrological drivers.

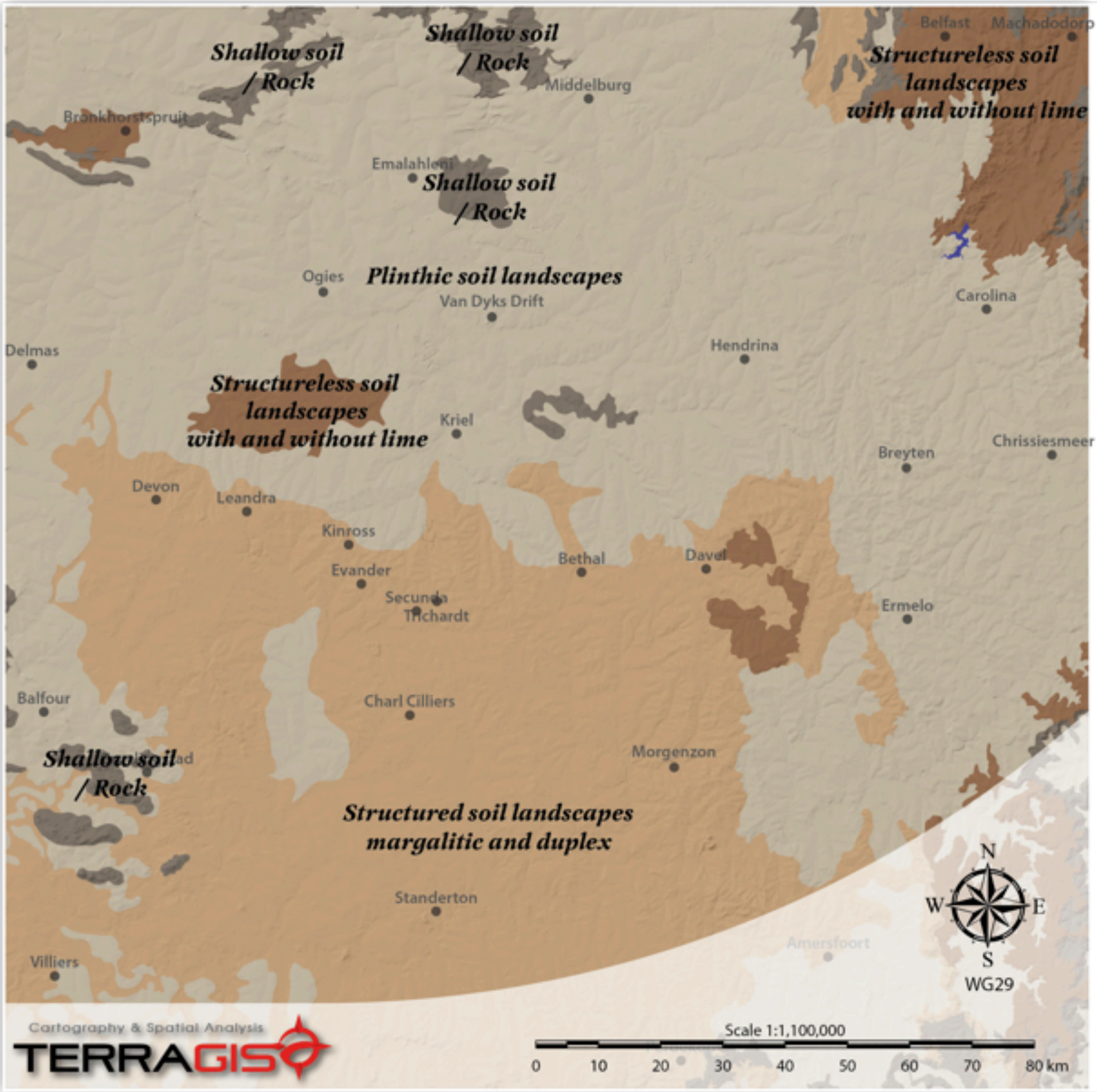

Figure 3 Generalised soil associate map of the investigation area

2.3 TOPOGRAPHY

The topography of the investigation area is undulating to hilly with very distinct drainage depressions and watercourses feeding some of the main rivers in South Africa (**Figure 4**). The eastern and southern sections are the highest with a decrease in altitude from east to west and towards the north.

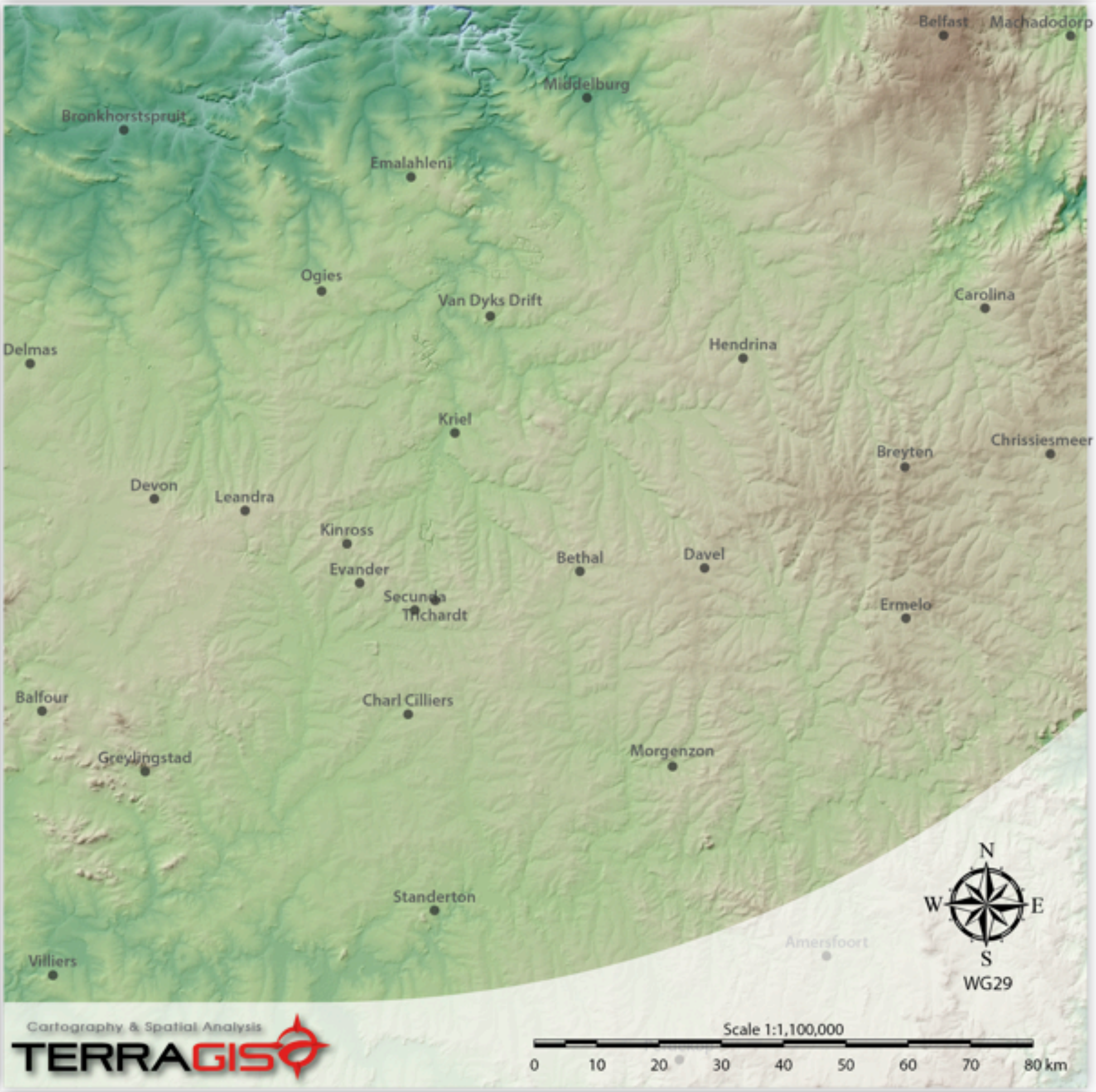

Figure 4 Topography of the investigation area

3. STATUTORY CONTEXT

The following is a brief summary of the statutory context of wetland delineation and assessment. Where necessary, additional comment is provided on problematic aspects or aspects that, according to this author, require specific emphasis.

Disclaimer: The following section represents a discussion that I use as standard in describing the statutory context of wetland delineation and assessment. This implies that the section is verbatim the same as in other reports provided to clients and the authorities. Copyright is strictly reserved.

3.1 WETLAND DEFINITION

Wetlands are defined, in terms of the National Water Act (Act no 36 of 1998) (NWA), as:

"Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil."

3.2 WATERCOURSE DEFINITION

"Catchment" is defined, in terms of the National Water Act (Act no 36 of 1998) (NWA), as:

"…, in relation to a watercourse or watercourses or part of a watercourse, means the area from which any rainfall will drain into the watercourse or watercourses or part of a watercourse, through surface flow to a common point or common points;"

"Watercourse" is defined, in terms of the National Water Act (Act no 36 of 1998) (NWA), as:

"*(a)* a river or spring;
(b) a natural channel in which water flows regularly or intermittently;
(c) a wetland, lake or dam into which, or from which, water flows; and
(d) any collection of water which the Minister may, by notice in the *Gazette*, declare to be a water course,
and a reference to a watercourse includes, where relevant, its bed and banks;"

3.3 THE WETLAND DELINEATION GUIDELINES

In 2005 the Department of Water Affairs and Forestry published a manual entitled "A practical field procedure for identification and delineation of wetland and riparian areas" (DWAF, 2005). The "…manual describes field indicators and methods for determining whether an area is a wetland or riparian area, and for finding its boundaries." The definition of a wetland in the guidelines is that of the NWA and it states that wetlands must have one or more of the following attributes:

- "**Wetland (hydromorphic) soils** that display characteristics resulting from prolonged saturation"
- "The presence, at least occasionally, of **water loving plants (hydrophytes)**"
- "A **high water table** that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50cm of the soil."

The guidelines further list four indicators to be used for the finding of the outer edge of a wetland. These are:

- Terrain Unit Indicator. The terrain unit indicator does not only identify valley bottom wetlands but also wetlands on steep and mild slopes in crest, midslope and footslope positions.
- Soil Form Indicator. A number of soil forms (as defined by MacVicar et al., 1991) are listed as indicative of permanent, seasonal and temporary wetland zones.
- Soil Wetness Indicator. Certain soil colours and mottles are indicated as colours of wet soils. The guidelines stipulate that this is the primary indicator for wetland soils. (Refer to the guidelines for a detailed description of the colour indicators.) In essence, the reduction and removal of Fe in the form of "bleaching" and the accumulation of Fe in the form of mottles are the two main criteria for the identification of soils that are periodically or permanently wet.
- Vegetation Indicator. This is a key component of the definition of a wetland in the NWA. It often happens though that vegetation is disturbed and the guidelines therefore place greater emphasis on the soil form and soil wetness indicators as these are more permanent whereas vegetation communities are dynamic and react rapidly to external factors such as climate and human activities.

The main emphasis of the guidelines is therefore the use soils (soil form and wetness) as the criteria for the delineation of wetlands. The applicability of these guidelines in the context of the survey site will be discussed in further detail later in the report.

Due to numerous problems with the delineation of wetlands there are a plethora of courses being presented to teach wetland practitioners and laymen the required techniques. Most of the courses and practitioners focus on ecological or vegetation characteristics of landscapes and soil characteristics are often interpreted incorrectly due to a lacking soil science background of these practitioners. As such this author regularly presents, in conjunction with a colleague (Prof. Cornie van Huysteen) from the University of the Free Sate, a course on the aspects related to soil classification and wetland delineation.

3.4 THE RESOURCE DIRECTED MEASURES FOR PROTECTION OF WATER RESOURCES

The following are specific quotes from the different sections of the "Resource Directed Measures for Protection of Water Resources." as published by DWAF (1999).

3.4.1 The Resource Directed Measures for Protection of Water Resources: Volume 4: Wetland Ecosystems.

From the Introduction:

"This set of documents on Resource Directed Measures (RDM) for protection of water resources, issued in September 1999 in Version 1.0, presents the procedures to be followed in undertaking **preliminary determinations of the class, Reserve and resource quality objectives for water resources**, as specified in sections 14 and 17 of the South African National Water Act (Act 36 of 1998).

The development of procedures to determine RDM was initiated by the Department of Water Affairs and Forestry in July 1997. Phase 3 of this project will end in March 2000. Additional refinement and development of the procedures, and development of the full water resource classification system, will continue in Phase 4, until such time as the detailed procedures and full classification system are ready for publication in the Government Gazette.

It should be noted that until the final RDM procedures are published in the Gazette, and prescribed according to section 12 of the National Water Act, all determinations of RDM, whether at the rapid, the intermediate or the comprehensive level, will be considered to be preliminary determinations."

3.4.2 The Resource Directed Measures for Protection of Water Resources: Generic Section "A" for Specialist Manuals – Water Resource Protection Policy Implementation Process

"Step 3: Determine the reference conditions of each resource unit"

"What are reference conditions?"

"The determination of reference conditions is a very important aspect of the overall Reserve determination methodology. Reference conditions describe the natural unimpacted characteristics of a water resource. Reference conditions quantitatively describe the ecoregional type, specific to a particular water resource."

3.4.3 The Resource Directed Measures for Protection of Water Resources: Appendix W1 (Ecoregional Typing for Wetland Ecosystems)

Artificial modifiers are explained namely:

"Many wetlands are man-made, while others have been modified from a natural state to some degree by the activities of humans. Since the nature of these alterations often greatly influences the character of such habitats, the inclusion of modifying terms to accommodate human influence is important. In addition, many human modifications, such as dam walls and drainage ditches, are visible in aerial photographs and can be easily mapped. The following Artificial Modifiers are defined and can be used singly or in combination wherever they apply to wetlands:
Farmed: the soil surface has been physically altered for crop production, but hydrophytes will become re-established if farming is discontinued
Artificial: substrates placed by humans, using either natural materials such as dredge spoils or synthetic materials such as concrete. Jetties and breakwaters are examples of Non-vegetated Artificial habitats
Excavated: habitat lies within an excavated basin or channel
Diked/Impounded: created or modified by an artificial barrier which obstructs the inflow or outflow of water
Partially Drained: the water level has been artificially lowered, usually by means of ditches, but the area is still classified as wetland because soil moisture is sufficient to support hydrophytes."

3.4.4 The Resource Directed Measures for Protection of Water Resources: Appendix W4 IER (Floodplain Wetlands) Present Ecological Status (PES) Method

In Appendix W4 the methodology is provided for the determination of the present ecological status (PES) of a palustrine wetland.

The present ecological state (PES) of the wetland was determined according to the method described in "APPENDIX W4: IER (FLOODPLAIN WETLANDS) PRESENT ECOLOGICAL STATUS (PES) METHOD" of the "Resource Directed Measures for Protection of Water Resources. Volume 4: Wetland Ecosystems" as published by DWAF (1999). However, the PES methodology already forms an adaptation from the methodology to assess palustrine wetlands. Hillslope seepage wetlands have a range of different drivers and as such some modification of the criteria has been made by this author to accommodate the specific hydropedology drivers of hillslope seepage wetlands.

The criteria as described in Appendix 4 is provided below with the relevant modification or comment provided as well.

The summarised tasks in the PES methodology are (for detailed descriptions refer to the relevant documentation):

1. Conduct a literature review (review of available literature and maps) on the following:
   a. Determine types of development and land use (in the catchment in question).
   b. Gather hydrological data to determine the degree to which the flow regime has been modified (with the "virgin flow regime" as baseline). The emphasis is predominantly

on surface hydrology and hydrology of surface water features as well as the land uses, such as agriculture and forestry, that lead to flow modifications. Important Note: The hydropedology of landscapes is not explicitly mentioned in the RDM documentation and this author will make a case for its consideration as probably the most important component of investigating headwater systems and seepage wetlands and areas.

c. Assessment of the water quality as is documented in catchment study reports and water quality databases.
d. Investigate erosion and sedimentation parameters that address aspects such as bank erosion and bed modification. Important Note: The emphasis in the RDM documentation is again on river and stream systems with little mention of erosion of headwater and seepage zone systems. Again a case will be made for the emphasis of such information generation.
e. Description of exotic species (flora and fauna) in the specific catchment in question.

2. Conduct and aerial photographic assessment in terms of the parameters listed above.
3. Conduct a site visit and make use of local knowledge.
4. Assess the criteria and generate preliminary PES scores.
5. Generation of report.

Table 1 presents the scoresheet with criteria for the assessment of habitat integrity of palustrine wetlands (as provided in the RDM documentation).

Table 1 "Table W4-1: Scoresheet with criteria for assessing Habitat Integrity of Palustrine Wetlands (adapted from Kleynhans 1996)"

Criteria and attributes	**Relevance**	**Score**	**Confidence**
Hydrologic			
Flow modification	Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland.		
Permanent Inundation	Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.		
Water Quality			
Water Quality Modification	From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow		

	delivered to the wetland		
Sediment load modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.		
Hydraulic/Geomorphic			
Canalisation	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.		
Topographic Alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railway lines and other substrate disruptive activities, which reduces or changes wetland habitat directly or through changes in inundation patterns.		
Biota			
Terrestrial Encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.		
Indigenous Vegetation Removal	Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion.		
Invasive plant encroachment	Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).		
Alien fauna	Presence of alien fauna affecting faunal community structure.		
Overutilisation of biota	Overgrazing, Over-fishing, etc		
TOTAL MEAN			

<u>Scoring guidelines per attribute:</u>
natural, unmodified = 5; Largely natural = 4, Moderately modified = 3; largely modified = 2; seriously modified = 1; Critically modified = 0.
Relative confidence of score:

Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1.

Important Note: The present ecological state (PES) determination is, as discussed earlier in the report, based on criteria originally generated for palustrine and floodplain wetlands. Seepage wetlands very rarely have the same degree of saturation or free water and consequently often do not have permanent wetland zones. These wetlands are therefore often characterised by seasonal or temporary properties and as such a standard PES approach is flawed. The existing criteria is provided below as is a comment on the applicability as well as proposed improvements.

Criteria

Hydrological Criteria

- "Flow modification: Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland." Comment: Although the description is wide it is very evident that seepage or hillslope wetlands do not become inundated but rather are fed by hillslope return flow processes. The main criterion should therefore be the surface and subsurface hydrological linkages expressed as a degree of alteration in terms of the surface, hydropedology and groundwater hydrology.
- "Permanent inundation: Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota." Comment: Mostly not applicable to hillslope seepage wetlands.

Water Quality Criteria

- "Water quality modification: From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland." Comment: Water quality in this context applies generally but cognisance should be taken of seepage water quality that can be natural but significantly different to exposed water bodies. The main reason for this being the highly complex nature of many redox processes within the hillslope.
- "Sediment load modification: Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats." Comment: This is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences.

Hydraulic / Geomorphic Criteria

- "Canalisation: Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage." Comment: Again this is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences. This concept does however not address the influences on the hydropedology of the hillslope. These aspects should be elucidated and contextualised.

- "Topographic Alteration: Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railwaylines and other substrate disruptive activities which reduces or changes wetland habitat directly or through changes in inundation patterns." Comment: Again this is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences. This concept does however not address the influences on the hydropedology of the hillslope. These aspects should be elucidated and contextualised.

Biological Criteria

- "Terrestrial encroachment: Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions." Comment: Again this is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences. This concept does however not address the influences on the hydropedology of the hillslope. These aspects should be elucidated and contextualised.
- "Indigenous vegetation removal: Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion."
- "Invasive plant encroachment: Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading)."
- "Alien fauna: Presence of alien fauna affecting faunal community structure."
- "Overutilisation of biota: Overgrazing, Over-fishing, etc."

Scoring Guidelines

Scoring guidelines per attribute:
Natural, unmodified = 5
Largely natural = 4
Moderately modified = 3
Largely modified = 2
Seriously modified = 1
Critically modified = 0

Relative confidence of score:
Very high confidence = 4
High confidence = 3
Moderate confidence = 2
Marginal/low confidence = 1

3.4.5 The Resource Directed Measures for Protection of Water Resources: Appendix W5 IER (Floodplain Wetlands) Determining the Ecological Importance and Sensitivity (EIS) and the Ecological Management Class (EMC)

In Appendix W5 the methodology is provided for the determination of the ecological importance and sensitivity (EIS) and ecological management class (EMC) of floodplain wetlands.

"Ecological importance" of a water resource is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. "Ecological sensitivity" refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred. The Ecological Importance and sensitivity (EIS) provides a guideline for determination of the Ecological Management Class (EMC)." Please refer to the specific document for more detailed information.

The following primary determinants are listed as determining the EIS:

1. Rare and endangered species
2. Populations of unique species
3. Species / taxon richness
4. Diversity of habitat types or features
5. Migration route / breeding and feeding site for wetland species
6. Sensitivity to changes in the natural hydrological regime
7. Sensitivity to water quality changes
8. Flood storage, energy dissipation and particulate / element removal

The following modifying determinants are listed as determining the EIS:

1. Protected status
2. Ecological integrity

3.5 NATIONAL NORMS AND STANDARDS FOR THE REMEDIATION OF CONTAMINATED LAND (NSCLA) (GN R.331 OF 2014)

3.5.1 Background to the NSCLA

The assessment of contaminated land is conducted in accordance with the National Norms and Standards for the Remediation of Contaminated Land (NSCLA) (GN R.331 of 2014). The NSCLA is an outflow of Part 8 (Sections 35 to 41) of the National Environmental Management Waste Act (Act 59 of 2008) and it was implemented on the 2nd of May, 2014 (Papenfus, et al, 2015).

3.5.2 Limitations of the NSCLA

Papenfus et al, (2015) discusses some of the challenges regarding the use of the NSCLA in various soils. These challenges pertain to the main assumptions that were made in the generation of the soil screening values (SSV) in that soil pH values were assumed to be 7 and set distribution coefficients (K_d values – indicative of the soil and water mobile fraction of a particular element/compound) were adopted. The thrust of the challenge is the fact that soils are much more variable and investigations conducted by Papenfus et al, (2015) confirm these concerns. The implication is that the NSCLA cannot be used with certainty as the variables in natural and polluted environments render the SSV values moot.

The NSCLA does not address acidified soils and the subsequent alteration of pollutant mobility. Although the NSCLA addresses sulphate as an anion salt it is clear that soil variation in terms of natural sulphate and gypsum contents has not been considered.

The NSCLA also omits elements that are of concern in mining environments such as uranium and does not indicate how to deal with highly acidified and salt impacted soils and materials present in current and old mining impact areas.

3.6 SUMMARY AND PROPOSED APPROACH

When working in environments where the landscape and land use changes are significant (such as urban and mining environments) it is important to answer the following critical questions regarding the assessment and management planning for wetlands:

1. What is the reference condition?
2. What is the difference between the reference condition and the current condition and how big is this difference from a hydrological driver perspective?
3. What are the hydrological drivers (as a function of geology, topography, rainfall and soils) and what are the relative contributions of these drivers to the functioning of the wetland system?
4. What is the intended or planned land use in the wetland as well as terrestrial area and how will these developments impact on the hydrology of the landscape and wetlands?
5. How can the intended land use be plied to secure the best possible hydrological functioning of the landscape in terms of storm water attenuation, erosion mitigation and water quality?
6. What are the site and wetland remedial actions to be taken to assess and prevent pollutant mobilisation on the site and reduce the risk of future site development to workers and inhabitants / land users.

The key to the generation of adequate information lies in the approach that is to be followed. In the next section an explanation about and motivation in favour of will be provided for a hydropedology assessment approach. Due to the detailed nature of the information that can be generated through such an approach it is motivated that all wetland assessments be conducted with the requirements of criminal law in mind. The main reason for this is the fact that many well-meaning administrative exercises often yield not tangible results due to the gap in terms of information that is required should there be a compliance process followed.

To Summarise:

During wetland assessments and delineations it is important to provide a perspective on assessment tools, the original or reference state of the wetland, the assessment process and outcome as well as the intended or possible state of the wetland and site post development. Urban and mining developments are good examples of cases where surrounding developments and land use changes have significant effects on wetland integrity and water quality emanating from the site.

4. GAPS IN EXISTING WETLAND ASSESSMENT TOOLS

4.1 PHILOSOPHICAL AND PRACTICAL CHALLENGES REGARDING THE FOUNDATION OF WETLAND ASSESSMENT

Leading up to and during the generation of the first rehabilitation report it became evident that there were several challenges regarding the assessment and delineation of wetlands. Most of these challenges are grounded in the philosophy underpinning wetland science and assessment. Although these aspects will be addressed in detail later in the report the essence of the problem includes:

1. Wetlands are often viewed as discrete entities with measurable properties and boundaries. Most wetlands, however, are in essence entities that are visible reflections/expressions of water in a landscape. It is the hidden component of wetlands, the water feeding mechanisms and processes in the larger landscape, which are often overlooked or merely addressed superficially. This implies that for a thorough wetland assessment all hydrological parameters have to be elucidated in as much detail (at least conceptual) as is practically achievable.
2. Wetland assessments are often biased towards ecological parameters. Although this is understood and supported to a degree the main relevance of wetland assessments stems from the inclusion of the definition in the National Water Act as well as its link with water courses. The fact that wetlands are protected in the National Water Act therefore implies a bias towards the water resource with the ecological parameters being dependent on the water – and not the other way round.
3. Due to the linked nature of wetlands and their supporting landscape it is evident that development or land use impacts that do not alter the landscape's hydrology have very little impact on the hydrological functioning of the wetland. The opposite is true for impacts that alter the landscape's hydrology in such a way that surface, subsurface and groundwater flow paths of water are severed or severely modified (examples include opencast mining operations and urban developments with extensive excavated foundations). It follows therefore that the delineation, ecological assessment and superficial hydrological assessment of a wetland cannot provide meaningful answers regarding the maintenance (through mitigation and adequate intervention) of water flow regimes – regimes that are responsible for the presence and functioning of the wetland in the first place.

It is in this context that the existing tools and guidelines regarding wetland assessment are considered to be problematic as they do not address any of the requirements for detailed wetland rehabilitation plan in an opencast mining environment.

The existing tools for the assessment and characterisation of wetlands are predominantly restricted to the:

1. Delineation of the outer boundary of a wetland;
2. Assessment of the ecological status of a wetland; and
3. Assessment of the related services that wetlands perform.

None of these tools address in adequate detail the hydrological functioning of the landscapes in which the wetlands occur. As wetlands are inherently and explicitly dependent on water, the omission of adequate hydrological parameters from wetland assessment processes is considered a critical flaw. The discussion below is restricted to a brief description of the specific tools as well as their shortcomings. A detailed discussion will follow at a later stage as I am, with several other colleagues, in the process of consultation and advising to DWA on the matter. This consultation and advisory process will continue for a significant period of time as the development of adequate tools is a protracted process.

4.2 WETLAND DELINEATION CHALLENGES

The wetland delineation guidelines have their origin in the "Resource Directed Measures for Protection of Water Resources. Volume 4: Wetland Ecosystems" as published by DWAF (1999) and then specifically in "Appendix W6: Guidelines for delineation of wetland boundary and wetland zones".

Although a major step forward in the approach to wetlands, these guidelines were published in 1999 and it was without considering detailed soil morphological and chemical parameters that influence the expression of wetness in soil. As the science has developed and expanded it has become apparent that the original approach is limited and scientifically flawed in some instances. This aspect has major ramifications in the event that prosecutions are based on such information. The detail regarding the proposed changes to the guidelines cannot be discussed here but will be elucidated in a set of documents currently in preparation for discussion by DWA and the broader scientific fraternity.

4.2.1 Detailed Disaggregation and Interpretation of the Definition of a Wetland

Wetlands are defined in the NWA as:

> *"Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil."*

From a scientific, practical and legal perspective the interpretation of the definition poses a number of challenges. In order to address the challenges it is necessary to disaggregate the definition and discuss the challenges as follows:

1. "Land which is transitional between terrestrial and aquatic systems …": this implies areas with variable hydrological and ecological characteristics of which the variation can be described as the linear (assumed) transition from one pole (terrestrial/dry) to another (aquatic/wet).
2. "… where the water is usually at or near the surface …": Although the regular condition is implied there is no reference to any empirical interpretation. This aspect therefore introduces uncertainty and the potential for significantly variable interpretation.
3. "… or the land is periodically covered with shallow water …": This statement introduces and alternative to the above statement but, again there is no reference to any empirical interpretation and it therefore introduces uncertainty and the potential for significantly variable interpretation
4. "and which land in normal circumstances …": Normal circumstances are not defined with a subsequent introduction of uncertainty and variability in interpretation. According to Mernewecke and Kotze (1999) "normal circumstances" in the definition refers to "without human modifications".
5. "… supports or would support vegetation typically adapted …": Vegetation species and communities can be described and named and can provide distinctly measurable indicators of wetland conditions. This is therefore a clear indicator if the requisite scientific knowledge is available.
6. "… to life in saturated soil.": Soil saturation (degree, intensity and duration) can be measured empirically (although at significant financial and time cost) or deduced from the soil morphology to varying degrees of certainty. The soil morphological indictors (all functions of soil forming factors and processes) have been studied and described extensively in the soil science literature.

An evaluation of the disaggregation above yields that the only certain descriptors, from a scientific, practical and legal perspective, are vegetation and soil indicators. In this sense the then Department of Water Affairs and Forestry (DWAF) generated "Resource Directed Measures for the Protection of Water Resources" (DWAF, 1999). In Appendix W6 of the document guidelines for the delineation of wetlands are provided (Mernewecke and Kotze, 1999). In this document distinct emphasis is placed on the use of soil characteristics in conjunction with vegetation characteristics (if present) for the delineation of wetlands. The document also refers specifically to the fact that a certain degree of proficiency in terms of soil classification with the SA Taxonomic System (Soil Classification Working Group, 1991) is required for such surveys. In the event of challenging sites it advises that qualified soils scientists conduct the delineation exercises.

Additionally, from the definition and the purpose of the water act it can be assumed that wetlands are merely the expression of wetness in landscapes and that the water resource can occur in landscapes in many other forms. One form that is not explicitly mentioned is seasonally perched water tables and their associated vadose zones that are instrumental in the "feeding" of wetlands through lateral flow mechanisms in the landscape. From the purpose of the NWA it is assumed that these water resources are included explicitly in the NWA. This aspect has a significant bearing on the contents of the rehabilitation plan and report and it will therefore be elucidated in more detail later in the report.

4.2.2 Auditable Process

The manual aims to provide a "… scientifically robust, simple to apply and … standardised, affordable and auditable method of spatially defining …" hydrologically sensitive areas.

The delineation guidelines refer to the prescribed delineation procedure as being "auditable". Several challenges exist with the concept of an auditable interpretation of soil indicators (form as well as signs of wetness). The following comments are made regarding the "auditable" nature of the procedure:

1. The fixed nature of the interpretation is based on depth of mottles in the soil and that being 50 cm as the cutoff. Anecdotal evidence suggests that this figure is based on the assumed rooting depth of wetland plants meaning that a water table below 50 cm will not be expressed through the presence of wetland plants due to their roots growing only to 50 cm. This assumption is based on the inference that all wetlands are fed by regional water tables where the water level fluctuates (as fed from below) and then fluctuation is predominantly vertical (up and down). Even though a 50 cm criterion is distinctly auditable the assumption is highly erroneous and limited in that plants exhibit much wider variation and that most seasonal and temporary wetlands are fed through interflow and surface water ingress processes – therefore implying a horizontal fluctuation of water dependent on topographic characteristics. This aspect will be described in further detail later in the report
2. An "auditable" process does not make allowance for variable interpretation or environmental variability induced by geology, topography and climate. These parameters induce very distinct variation in the morphological expression of wetness in soil – variation that is at best interpreted with varying opinions by pedologists.
3. No allowance made for return flow processes that may produce daylighting of water in soils or on rock outcrops. These processes are hillslope driven and the guidelines do not even allude to such.
4. Auditing of vegetation is problematic due to its dynamic nature (regional, edaphic, climatic variation) as well as due to human influences.

4.2.3 Wetland Indicators

The wetland indicators discussed above are limited to a degree in the following manner:

1. The topographic indicator is limited to wetlands that are associated with surface topographical variation and it is therefore limited to specific landscape positions. The topographic indicator does not make allowance for variation in physical properties below the soil surface. In this sense aspects such as return-flow zones and interflow zones (that

often occur in midslope or footslope positions) are not accommodated. In practice these areas prove the most problematic in terms of interpretation and delineation.

2. The vegetation indicator is limited predominantly by regional and local variation in edaphic and climatic conditions. The regionalization of vegetation guidelines should address this aspect satisfactorily.
3. The soil form indicator suffers from a number of limitations namely:
   a. Soil forms present in an area do not necessarily indicate wetlands. Soil forms have to be viewed in wider context as their classification is also not an auditable process. (Unfortunately pedologists often have significant variation in interpretation!) The presence of a specific soil form may indicate the presence of a wetland though but this aspect will have to be confirmed on the site through additional indicators.
   b. Certain soil forms are erroneously assigned to specific wetland conditions viz. the Rensburg that is assigned to permanent wetland areas but which is actually characterized by dominance of smectite clay minerals that can only form in seasonal wetland conditions. This discussion warrants a report in itself and will therefore not be further elucidated in this report.
   c. Improved elucidation of the presence of soil forms in landscapes is required. This is especially relevant as the roles of the soils in wetlands and wetland functioning is often poorly understood. On this topic there are current research projects underway that focus on the description of hillslope hydrology and the soil morphological indicators of such hydrology. Linked to this is the established concept of soil variation along a topographic sequence (catena concept) for specific environments or land types. This aspect links up to the concept of soil formation (pedogenesis) and hydropedology which is finding new and very relevant application in the elucidation of environmental processes.
4. The soil wetness indicator is in all probability the most problematic as there are numerous physical and chemical determinants. The main indicator of reduction is the very handy redox morphological variation of Fe – and this is the assumption that most wetland delineation exercises are based upon. (A dedicated discussion of this aspect is provided later in the report.) There is a distinct variability in expression of the quantity / intensity parameters of mottles in different soil environments. This variation is in most cases linear for simple parameters but soils always exhibit combinations of variable parameters that make linear interpretation highly suspect and problematic. A brief elucidation of the problem components include:
   a. The Fe content and reserve of soils and parent material vary significantly and impart varying expression of Fe redox morphology with consequent challenges in interpretation. This aspect induces variation between landscapes with homogenous parent materials (within the specific landscape) or within landscapes where variation in parent materials is found within the landscape.
   b. The Mn content of soils influence redox poise processes that in turn influence the expression of Fe redox morphology. Additional sources of variation include:
      i. Textural influences on expression of mottles;
      ii. Climatic / rainfall gradients; and

    iii. Variation in pH gradients linked to electron activity (Eh). The redox morphology changes linearly with these parameters with the distinct expression of mottles (intensity, colour, contrast) decreasing linearly with increasing pH (even if Eh remains constant).

c. Soil colour varies significantly between different chemical and physical environments (even if pH and Eh remains relatively similar) and as such one set of wetness criteria cannot be applied universally.
d. With the advancement of science concepts that were accepted to be true 30 years ago are now considered erroneous. A distinct example of this is references to "blue green colouration" in soils classification texts that indicate conditions of distinct saturation in those texts. This colouration has, with recent research, been proven to occur under very specific redox conditions that indicate only intermediate reduction, even though the soil may be saturated. The historically held conviction that "saturation equals reduction" has been proven to not apply religiously in all environments. It is therefore imperative that the application (wetland delineation) keeps up with the science.

4.2.4 Proposed Improvements

Having indicated that there are numerous limitations to the current wetland delineation approach it is important to focus on dedicated improvements that can implemented/incorporated easily. These improvements include:

1. Updating of the current delineation guidelines (including the draft version from 2008) to serve as a national standard document indicating variability in SA (broadly) through:
    a. Improvement of the landscape indicator to include seepage (including interflow, seepage and return-flow wetlands)
    b. Improvement and correction of the soil form indicator description. Introduction of the concept of "driest soils on crests and wettest soils in depressions" as a method of determining the range of soil variation in specific landscapes.
    c. Improvement and correction of the soil wetness indicator description to reflect differing pH/Eh/parent material environments. Linking of soil wetness indicators to the concept of "driest soils on crests and wettest soils in depressions" as a method of determining range of soil variation in different landscapes.
    d. Introduction of measuring and inference tools for generation of empirical data on wetness.
    e. Introduction of regional and/or land type based detailed guidelines that will include:
        i. Localized topographic indicators and pointers / aids;
        ii. Localized soil form sequences (catena) and soil form variability. (Utilize method of soil form variation range in land type); and
        iii. Localized variation in terms of soil wetness indicators. (Utilize method of soil form variation range in land type).

2. Correction of scientific inaccuracies and inconsistencies in the current documents and improvement of the principles and guidelines to a proper standard through focused research, peer review and formal publication.

4.3 PES AND EIS

The present ecological state (PES) and ecological importance and sensitivity (EIS) parameters prescribed for wetland investigations are provided for in "Appendix W4: IER (Floodplain wetlands) Present ecological status (PES) method" and "Appendix W5: (IER) (Floodplain wetlands) Determining the ecological importance and sensitivity (EIS) and ecological management class (EMC)" of the RDM.

It is very important to note that the PES is and ecological assessment at an "intermediate" level of detail that includes surface hydrological parameters of a wetland and catchment. As these assessments are performed by ecologists it must be assumed that the hydrological information is not of a detailed nature. A detailed assessment would have to be conducted by a suitably registered hydrologist to have relevance in court. The PES ranks a wetland from A to F depending on the degree of alteration. It must be assumed that all the wetlands that have been impacted hydrologically in a significant manner constitute wetlands with an F rating. Wetlands that have been mined out completely do not exist anymore and cannot be rated. The guidelines do not indicate how to handle wetlands that have sections that are without impact and sections that have been mined out completely.

The EIS is based primarily on ecological parameters and it becomes irrelevant in a mined-out environment.

Although it is understood that DWA prescribes the PES and EIS values for broader planning purposes these parameters are near nonsensical in the context of Leliefontein. The main reason being that data does not exist to generate a rating for the pre-mining condition of the wetlands/watercourses. This is exacerbated by the fact that a number of water courses were mined out completely. The mined watercourses therefore do not exist anymore and can therefore not be rated. During the rehabilitation planning for the site new water courses will have to be constructed and these will differ substantially from the original ones.

5. CHALLENGES REGARDING WETLAND DELINEATION AND HYDROPEDOLOGY ASSESSMENTS IN PLINTHIC MINING ENVIRONMENTS FOR THE PURPOSE OF WETLAND REHABILITATION AND RE-ESTABLISHMENT

Disclaimer: The following section represents a discussion that I use as standard in describing the challenges regarding wetland delineation and management in plinthic mining environments. This implies that the section is verbatim the same as in other reports provided to clients and the authorities. Copyright is strictly reserved.

In order to discuss the procedures followed and the results of the wetland identification exercise it is necessary at the outset to provide some theoretical background on soil forming processes, soil wetness indicators, water movement in soils and topographical sequences of soil forms (catena).

5.1 RECOMMENDED ASSESSMENT APPROACH – HYDROPEDOLOGY INVESTIGATION

In order to discuss the procedures followed and the results of the hydropedology exercise it is necessary at the outset to provide some theoretical background on the discipline of hydropedology in the context of soil forming processes, soil wetness indicators, water movement in soils and topographical sequences of soil forms (catena). Plinthic environments are those where numerous lateral water flow mechanisms occur within a relatively shallow distance from the soil surface leading to the expression of mottles and fluctuating water tables within the soil profiles. The expression redox morphology in the soil profile is therefore the ideal/optimal indicator of hydropedological parameters in the landscape.

5.1.1 Hydropedology Background

The identification and delineation of wetlands rest on several parameters that include topographic, vegetation and soil indicators. Apart from the inherent flaws in the wetland delineation process, as discussed earlier in this report, the concept of wetland delineation implies an emphasis on the wetlands themselves and very little consideration of the processes driving the functioning and presence of the wetlands. One discipline that encompasses a number of tools to elucidate landscape hydrological processes is “hydropedology” (Lin, 2012). The crux of the understanding of hydropedology lies in the fact that pedology is the description and classification of soil on the basis of morphology that is the result of soil and landscape hydrological, physical and chemical processes. But, the soils of which the morphology are described, also take part in and intimately influence the hydrology of the landscape. Soil is therefore both an indicator as well as a participator in the processes that require elucidation.

Wetlands are merely those areas in a landscape where the morphological indicators point to prolonged or intensive saturation near the surface to influence the distribution of wetland vegetation. Wetlands therefore form part of a larger hydrological entity that they cannot be separated from.

The crux of a hydropedology assessment should be the accurate contextualisation of morphological properties of soils (used in describing and classification – pedology) as well as the physical properties that will determine the hydrological functioning of the soils.

5.1.2 Hydropedology – Proposed Approach

In order to provide detailed pedohydrological information both detailed soil surveys and hydrological investigations are needed. In practice these intensive surveys are expensive and very seldom conducted. However, with the understanding of soil morphology, pedology and basic soil physics parameters as well as the collection and interpretation of existing soil survey information, assessments at different levels of detail and confidence can be conducted. In this sense four levels of investigation are proposed namely:

1. Level 1 Assessment: This level includes the collection and generation of all applicable remote sensing, topographic and land type parameters to provide a "desktop" product. This level of investigation rests on adequate experience in conducting such information collection and interpretation exercises and will provide a broad overview of dominant hydropedological parameters of a site. Within this context the presence, distribution and functioning of wetlands will be better understood than without such information.
2. Level 2 Assessment: This level of assessment will make use of the data generated during the Level 1 assessment and will include a reconnaissance soil and site survey to verify the information as well as elucidate many of the unknowns identified during the Level 1 assessment.
3. Level 3 Assessment: This level of assessment will build on the Level 1 and 2 assessments and will consist of a detailed soil survey with sampling and analysis of representative soils. The parameters to be analysed include soil physical, chemical and mineralogical parameters that elucidate and confirm the morphological parameters identified during the field survey.
4. Level 4 Assessment: This level of assessment will make use of the data generated during the previous three levels and will include the installation of adequate monitoring equipment and measurement of soil and landscape hydrological parameters for an adequate time period. The data generated can be used for the building of detailed hydrological models (in conjunction with groundwater and surface hydrologists) for the detailed water management on specific sites.

For most wetland delineation exercises a Level 2 or Level 3 assessment should be adequate. For this investigation a Level 2 assessment was conducted.

5.2 PEDOGENESIS

Pedogenesis is the process of soil formation. Soil formation is a function of five (5) factors namely (Jenny, 1941):

- Parent material;
- Climate;
- Topography;
- Living Organisms; and
- Time.

These factors interact to lead to a range of different soil forming processes that ultimately determine the specific soil formed in a specific location. Central to all soil forming processes is water and all the reactions (physical and chemical) associated with it. The physical processes include water movement onto, into, through and out of a soil unit. The movement can be vertically downwards, lateral or vertically upwards through capillary forces and evapotranspiration. The chemical processes are numerous and include dissolution, precipitation (of salts or other elements) and alteration through pH and reduction and oxidation (redox) changes. In many cases the reactions are promoted through the presence of organic material that is broken down through aerobic or anaerobic respiration by microorganisms. Both these processes alter the redox conditions of the soil and influence the oxidation state of elements such as Fe and Mn. Under reducing conditions Fe and Mn are reduced and become more mobile in the soil environment. Oxidizing conditions, in turn, lead to the precipitation of Fe and Mn and therefore lead to their immobilization. The dynamics of Fe and Mn in soil, their zones of depletion through mobilization and accumulation through precipitation, play an important role in the identification of the dominant water regime of a soil and could therefore be used to identify wetlands and wetland conditions.

5.3 WATER MOVEMENT IN THE SOIL PROFILE

In a specific soil profile, water can move upwards (through capillary movement), horizontally (owing to matric suction) and downwards under the influence of gravity.

The following needs to be highlighted in order to discuss water movement in soil:

- Capillary rise refers to the process where water rises from a deeper lying section of the soil profile to the soil surface or to a section closer to the soil surface. Soil pores can be regarded as miniature tubes. Water rises into these tubes owing to the adhesion (adsorption) of water molecules onto solid mineral surfaces and the surface tension of water.

  The height of the rise is inversely proportional to the radius of the soil pore and the density of the liquid (water). It is also directly proportional to the liquid's surface tension and the degree of its adhesive attraction. In a soil-water system the following simplified equation can be used to calculate this rise:

  $$\text{Height} = 0.15/\text{radius}$$

  Usually the eventual height of rise is greater in fine textured soil, but the rate of flow may be slower (Brady and Weil, 1999; Hillel, 1983).

- Matric potential or suction refers to the attraction of water to solid surfaces. Matric potential is operational in unsaturated soil above the water table while pressure potential refers to water in saturated soil or below the water table. Matric potential is always expressed as a negative value and pressure potential as a positive value.

  Matric potential influences soil moisture retention and soil water movement. Differences in the matric potential of adjoining zones of a soil results in the movement of water from the moist zone (high state of energy) to the dry zone (low state of energy) or from large pores to small pores.

The maximum amount of water that a soil profile can hold before leaching occurs is called the field capacity of the soil. At a point of water saturation, a soil exhibits an energy state of 0 $J.kg^{-1}$. Field capacity usually falls within a range of -15 to -30 $J.kg^{-1}$ with fine textured soils storing larger amounts of water (Brady and Weil, 1999; Hillel, 1983).

- Gravity acts on water in the soil profile in the same way as it acts on any other body; it attracts towards earth's centre. The gravitational potential of soil water can be expressed as:

  $$\text{Gravitational potential} = \text{Gravity} \times \text{Height}$$

  Following heavy rainfall, gravity plays an important part in the removal of excess water from the upper horizons of the soil profile and recharging groundwater sources below.

  Excess water, or water subject to leaching, is the amount of water that falls between soil saturation (0 $J.kg^{-1}$) or oversaturation (> 0 $J.kg^{-1}$), in the case of heavy rainfall resulting in a pressure potential, and field capacity (-15 to -30 $J.kg^{-1}$). This amount of water differs according to soil type, structure and texture (Brady and Weil, 1999; Hillel, 1983).

- Under some conditions, at least part of the soil profile may be saturated with water, resulting in so-called saturated flow of water. The lower portions of poorly drained soils are often saturated, as are well-drained soils above stratified (layers differing in soil texture) or impermeable layers after rainfall.

  The quantity of water that flows through a saturated column of soil can be calculated using Darcy's law:

  $$Q = Ksat.A.\Delta P/L$$

  Where Q represents the quantity of water per unit time, Ksat is the saturated hydraulic conductivity, A is the cross sectional area of the column through which the water flows, ΔP is the hydrostatic pressure difference from the top to the bottom of the column, and L is the length of the column.

  Saturated flow of water does not only occur downwards, but also horizontally and upwards. Horizontal and upward flows are not quite as rapid as downward flow. The latter is aided by gravity (Brady and Weil, 1999; Hillel, 1983).

- Mostly, water movement in soil is ascribed to the unsaturated flow of water. This is a much more complex scenario than water flow under saturated conditions. Under unsaturated conditions only the fine micropores are filled with water whereas the macropores are filled with air. The water content, and the force with which water molecules are held by soil surfaces, can also vary considerably. The latter makes it difficult to assess the rate and direction of water flow. The driving force behind unsaturated water flow is matric potential. Water movement will be from a moist to a drier zone (Brady and Weil, 1999; Hillel, 1983).

The following processes influence the amount of water to be leached from a soil profile:

- Infiltration is the process by which water enters the soil pores and becomes soil water. The rate at which water can enter the soil is termed infiltration tempo and is calculated as follows:

  $$I = Q/A.t$$

  Where I represents infiltration tempo ($m.s^{-1}$), Q is the volume quantity of infiltrating water (m^3), A is the area of the soil surface exposed to infiltration (m^2), and t is time (s).

  If the soil is quite dry when exposed to water, the macropores will be open to conduct water into the soil profile. Soils that exhibit a high 2:1 clay content (swelling-shrinking clays) will exhibit a high rate of infiltration initially. However, as infiltration proceeds, the macropores will become saturated and cracks, caused by dried out 2:1 clay, will swell and close, thus leading to a decline in infiltration (Brady and Weil, 1999; Hillel, 1983).

- Percolation is the process by which water moves downward in the soil profile. Saturated and unsaturated water flow is involved in the process of percolation, while the rate of percolation is determined by the hydraulic conductivity of the soil.

  During a rain storm, especially the down pouring of heavy rain, water movement near the soil surface mainly occurs in the form of saturated flow in response to gravity. A sharp boundary, referred to as the wetting front, usually appears between the wet soil and the underlying dry soil. At the wetting front, water is moving into the underlying soil in response to both matric and gravitational potential. During light rain, water movement at the soil surface may be ascribed to unsaturated flow (Brady and Weil, 1999; Hillel, 1983).

  The fact that water percolates through the soil profile by unsaturated flow has certain ramifications when an abrupt change in soil texture occurs (Brady and Weil, 1999; Hillel, 1983). A layer of course sand, underlying a fine textured soil, will impede downward movement of water. The macropores of the coarse textured sand offer less attraction to the water molecules than the macropores of the fine textured soil. When the unsaturated wetting front reaches the coarse sand, the matric potential is lower in the sand than in the overlying material. Water always moves from a higher to a lower state of energy. The water can, therefore, not move into the coarse textured sand. Eventually, the downward moving water will accumulate above the sand layer and nearly saturate the fine textured soil. Once this occurs, the water will be held so loosely that gravitational forces will be able to drag the water into the sand layer (Brady and Weil, 1999; Hillel, 1983).

  A coarse layer of sand in an otherwise fine textured soil profile will also inhibit the rise of water by capillary movement (Brady and Weil, 1999; Hillel, 1983).

Field observations and laboratory-based analysis can aid in assessing the soil-water relations of an area. The South African soil classification system (Soil Classification Working Group, 1991.) comments on certain field observable characteristics that shed light on water movement in soil. The more important of these are:

- Soil horizons that show clear signs of leaching such as the E-horizon – an horizon where predominantly lateral water movement has led to the mobilisation and transport of sesquioxide minerals and the removal of clay material;
- Soil horizons that show clear signs of a fluctuating water table where Fe and Mn mottles, amongst other characteristics, indicate alternating conditions of reduction and oxidation (soft plinthic B-horizon);
- Soil horizons where grey colouration (Fe reduction and redox depletion), in an otherwise yellowish or reddish matrix, indicate saturated (or close to saturated) water flow for at least three months of the year (Unconsolidated/Unspecified material with signs of wetness);
- Soil horizons that are uniform in colouration and indicative of well-drained and aerated (oxidising) conditions (e.g. yellow brown apedal B-horizon).

5.4 WATER MOVEMENT IN THE LANDSCAPE

Water movement in a landscape is a combination of the different flow paths in the soils and geological materials. The movement of water in these materials is dominantly subject to gravity and as such it will follow the path of least resistance towards the lowest point. In the landscape there are a number of factors determining the paths along which this water moves. **Figure 5** provides a simplified schematic representation of an idealised landscape (in "profile curvature". The total precipitation (rainfall) on the landscape from the crest to the lowest part or valley bottom is taken as 100 %. Most geohydrologists agree that total recharge, the water that seeps into the underlying geological strata, is less than 4 % of total precipitation for most geological settings. Surface runoff varies considerably according to rainfall intensity and distribution, plant cover and soil characteristics but is taken as a realistic 6 % of total precipitation for our idealised landscape.

The total for surface runoff and recharge is therefore calculated as 10 % of total precipitation. If evapotranspiration (from plants as well as the soil surface) is taken as a very high 30 % of total precipitation it leaves 60 % of the total that has to move through the soil and/or geological strata from higher lying to lower lying areas. In the event of an average rainfall of 750 mm per year it results in 450 mm per year having to move laterally through the soil and geological strata. In a landscape there is an accumulation of water down the slope as water from higher lying areas flow to lower lying areas.

To illustrate: If the assumption is made that the area of interest is 100 m wide it follows that the first 100 m from the crest downwards has 4 500 m^3 (or 4 500 000 litres) of water moving laterally through the soil (100 m X 100 m X 0.45 m) per rain season. The next section of 100 m down the slope has its own 4 500 m^3 of water as well as the added 4 500 m^3 from the upslope section to contend with, therefore 9 000 m^3. The next section has 13 500 m^3 to contend with and the following one 18 000 m^3. It is therefore clear that, the longer the slope, the larger the volume of water that will move laterally through the soil profile.

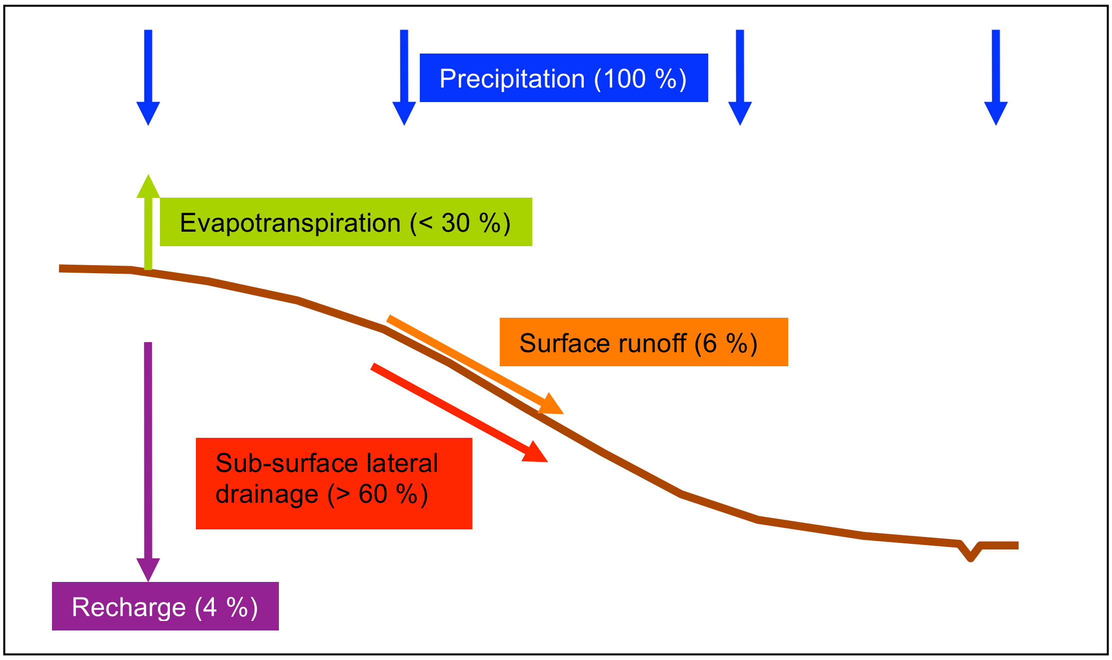

Figure 5 Idealised landscape with assumed quantities of water moving through the landscape expressed as a percentage of total precipitation (100 %).

Flow paths through soil and geological strata, referred to as "interflow" or "hillslope water", are very varied and often complex due to difficulty in measurement and identification. The difficulty in identification stems more from the challenges related to the physical determination of these in soil profile pits, soil auger samples and core drilling samples for geological strata. The identification of the morphological signs of water movement in permeable materials or along planes of weakness (cracks and seams) is a well-established science and the expression is mostly referred to as "redox morphology". In terms of the flow paths of water large variation exists but these can be grouped into a few simple categories. **Figure 6** provides a schematic representation of the different flow regimes that are usually encountered. The main types of water flow can be grouped as 1) recharge (vertically downwards) of groundwater; 2) lateral flow of water through the landscape along the hillslope (interflow or hillslope water); 3) return flow water that intercepts the soil/landscape surface (referred to as response zone or soils); and 4) surface runoff. Significant variation exists with these flow paths and numerous combinations are often found. The main wetland types associated with the flow paths are: a) valley bottom wetlands (fed by groundwater, hillslope processes, surface runoff, and/or in-stream water); b) hillslope seepage wetlands (fed by interflow water and/or return flow water); and wetlands associated with surface runoff, ponding and surface ingress of water anywhere in the landscape.

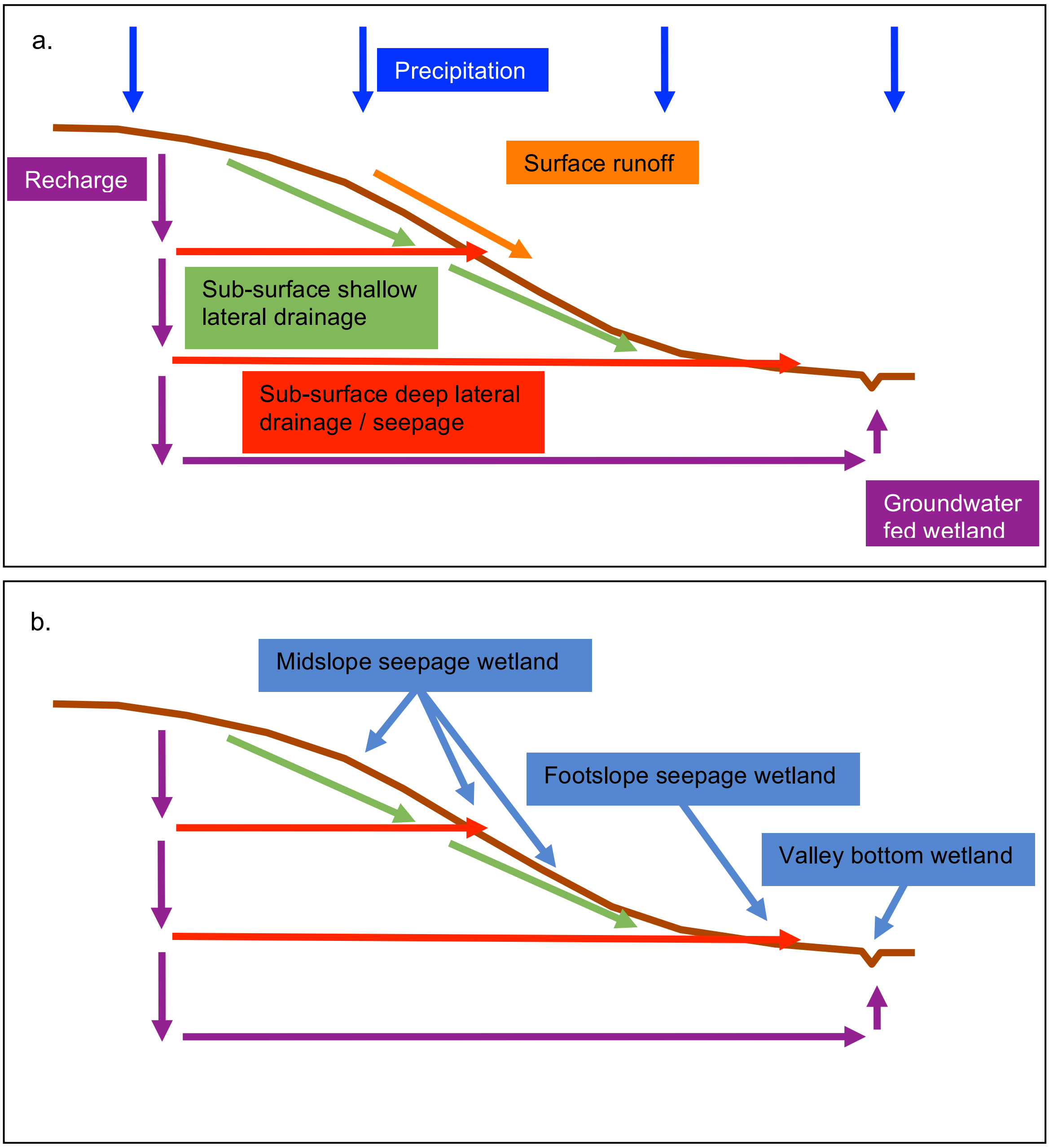

Figure 6 Different flow paths of water through a landscape (a) and typical wetland types associated with the water regime (b)

Amongst other factors, the thickness of the soil profile at a specific point will influence the intensity of the physical and chemical reactions taking place in that soil. **Figure 7** illustrates the difference between a dominantly thick and a dominantly thin soil profile. If all factors are kept the same except for the soil profile thickness it can be assumed with confidence that the chemical and physical reactions associated with water in the landscape will be much more intense for the thin soil profile than for the thick soil profile. Stated differently: The volume of water moving through the soil per surface area of an imaginary plane perpendicular to the direction of water flow is much higher for the thin soil profile than for the thick soil profile. This aspect has a significant influence on the expression of redox morphology in different landscapes of varying soil/geology/climate composition.

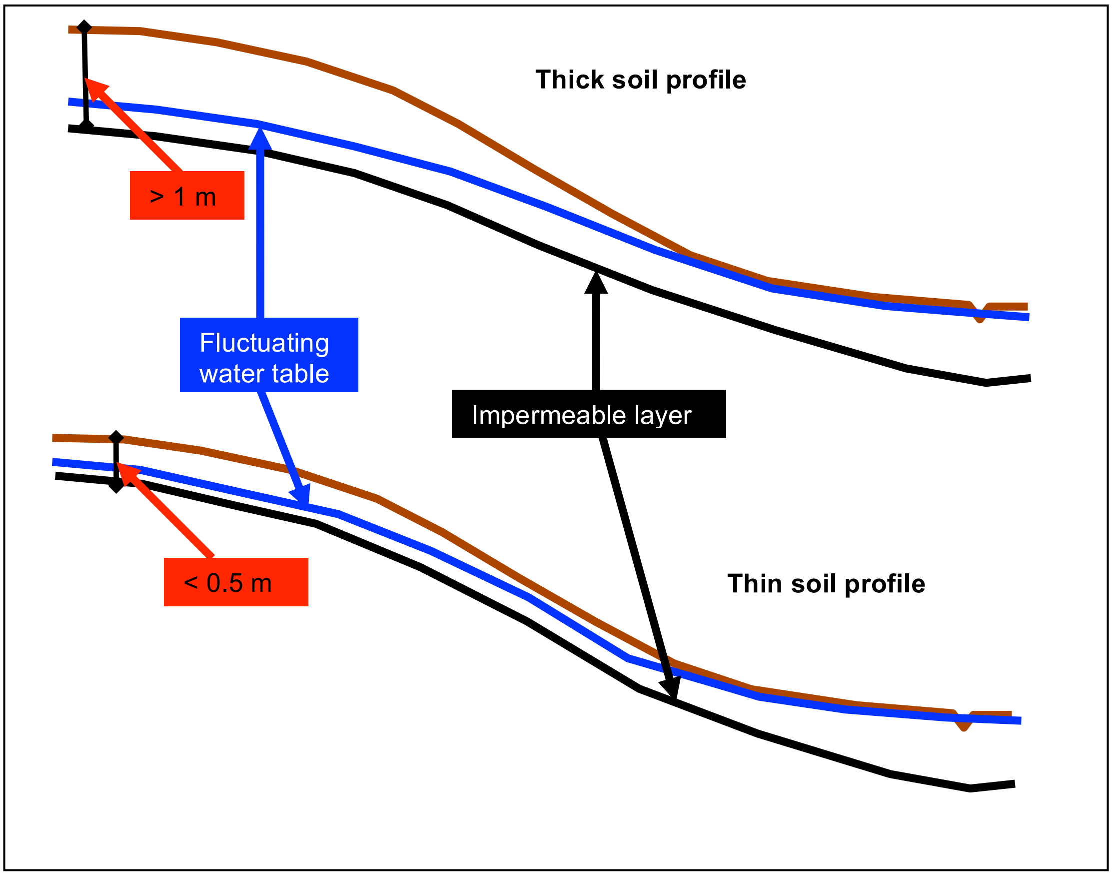

Figure 7 The difference in water flow between a dominantly thick and dominantly thin soil profile.

5.4 FREE DRAINING VERSUS INWARD FLOWING SYSTEMS

Free draining systems in this case refer to typical hillslopes where water drains towards the lowest point in the landscape and the flows out in a drainage feature or watercourse. Inward draining systems have no outflow (such as pans) and the dominant water removal is therefore through evaporation losses. **Figure 8** provides a topographic wetness index (TWI) of a mining area in which free draining (linear features) and inwardly draining (circular features) are indicated. The blue lines indicate concentration of water flows. The implication of the two systems on rehabilitation planning will be discussed later in the report.

The dominant hydrological functioning of the landscapes can be assumed to be very similar if only the side slopes are considered. **Figure 9** provides and indication of the hydrological processes experienced in such landscapes. The hydrological difference between the two systems is seen in the fact that the free draining systems reaches a maximum water content soon and releases water downstream in drainage features. The inwardly draining system accumulates water and theoretically can do such until it overflows or the water seeps away through more porous soils.

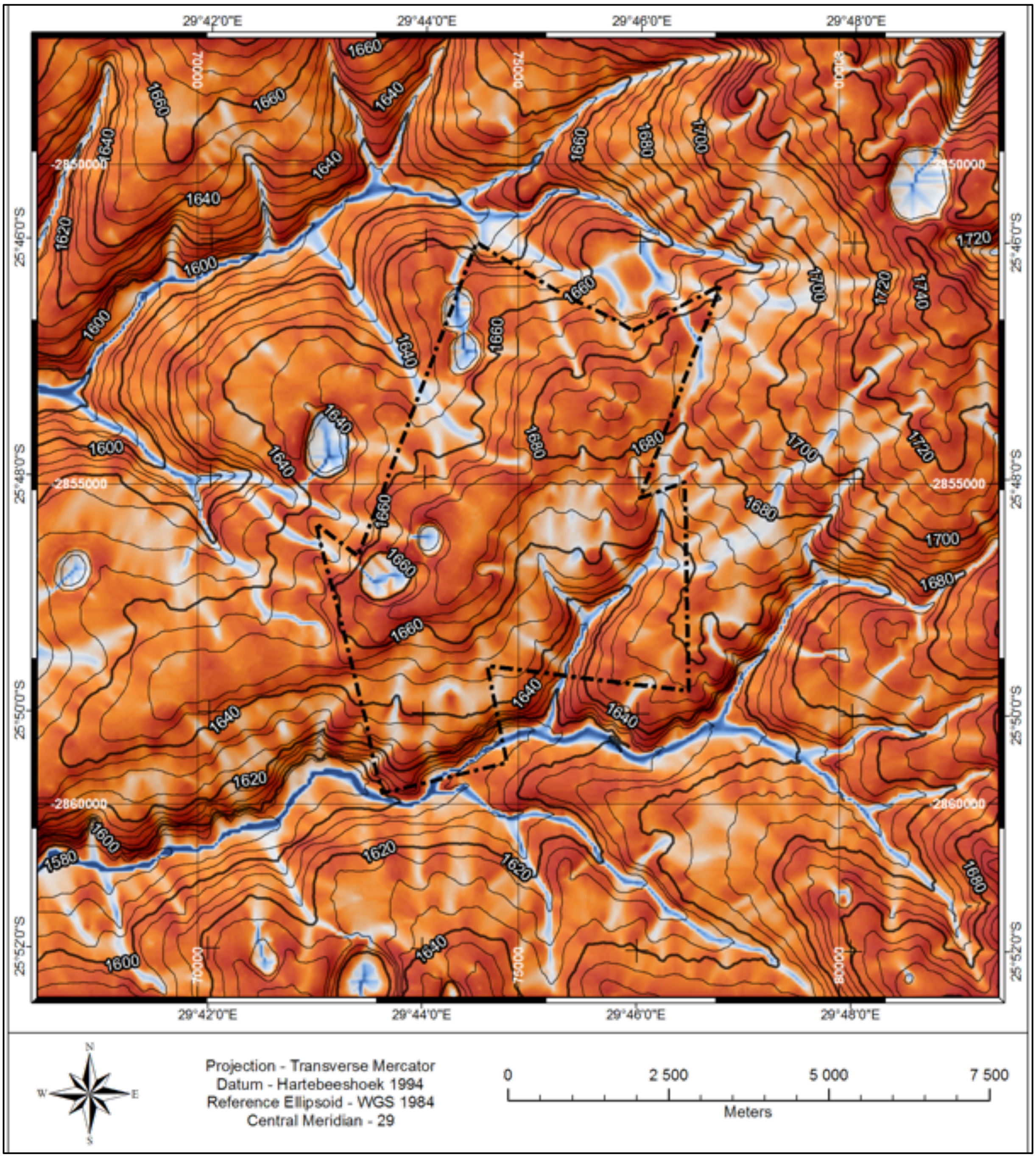

Figure 8 Topographic wetness index (TWI) of an area on the Mpumalanga Highveld indicating both free draining (linear) and inwardly draining (circular) features

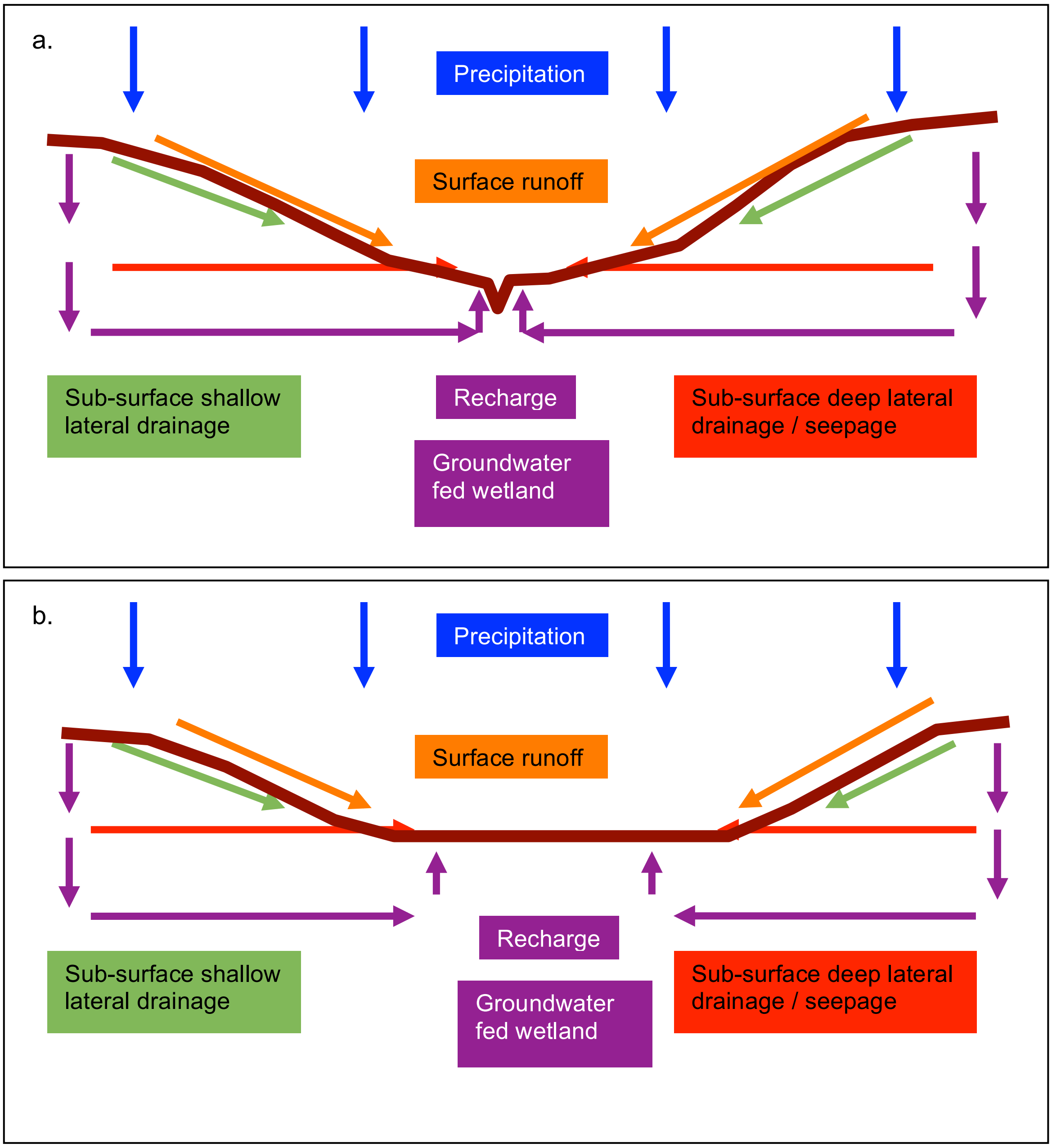

Figure 9 Similarity in flow paths for free draining (a) and inward draining (b) systems

5.5 THE CATENA CONCEPT

Here it is important to take note of the "catena" concept. This concept is one of a topographic sequence of soils in a homogenous geological setting where the water movement and presence in the soils determine the specific characteristics of the soils from the top to the bottom of the topography. **Figure 10** illustrates an idealised topographical sequence of soils in a catena for a quartz rich parent material. Soils at the top of the topographical sequence are typically red in colour (Hutton and Bainsvlei soil forms) and systematically grade to yellow further down the slope (Avalon soil form). As the volume of water that moves through the soil increases, typically in midslope areas, periodic saturated conditions are experienced and consequently Fe is reduced and removed in the laterally flowing water. In the event that the soils in the midslope positions are relatively sandy the resultant soil colour will be bleached or white due to the colour dominance of the sand quartz particles. The soils in these positions are typically of the Longlands and Kroonstad forms. Further down the slope there is an accumulation of clays and leaching products from higher lying soils and this leads to typical illuvial and clay rich horizons. Due to the regular presence of water the dominant conditions are anaerobic and reducing and the soils exhibit grey colours often with bright yellow and grey mottles (Katspruit soil form). In the event that there is a large depositional environment with prolonged saturation soils of the Champagne form may develop (typical peat land). Variations on this sequence (as is often found on the Mpumalanga Highveld) may include the presence of hard plinthic materials instead of soft plinthite with a consequent increase in the occurrence of bleached soil profiles. Extreme examples of such landscapes are discussed below.

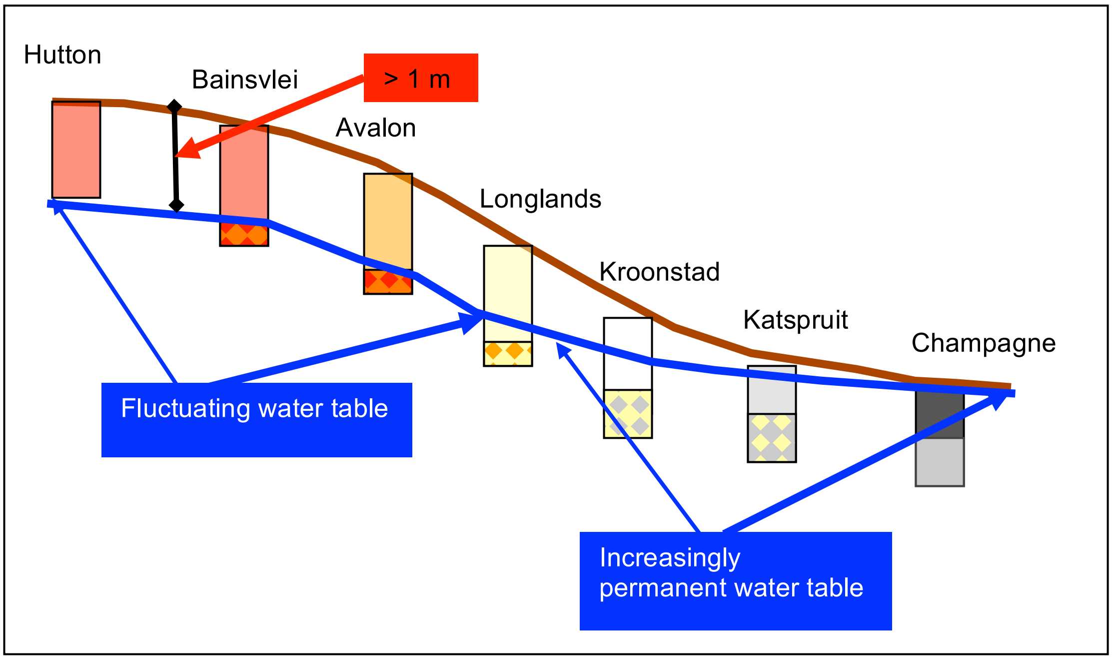

Figure 10 Idealised catena on a quartz rich parent material.

5.6 CONVEX VERSUS CONCAVE LANDSCAPES IN AN IDEALISED CATENA

An additional factor of variation in all landscapes is the shape of the landscape along contours (referred to a "plan curvature"). Landscapes can be either concave or convex, or flat. The main difference between these landscapes lies in the fact that a convex landscape is essentially a watershed with water flowing in diverging directions with a subsequent occurrence of "dryer" soil conditions. In a concave landscape water flows in converging directions and soils often exhibit the wetter conditions of "signs of wetness" such as grey colours, organic matter and subsurface clay accumulation. **Figure 11** presents the difference between these landscapes in terms of typical soil forms encountered in an idealised catena. In the convex landscape the subsurface flow of water removes clays and other weathering products (including Fe) in such a way that the midslope position soils exhibit an increasing degree of bleaching and relative accumulation of quartz (E-horizons).

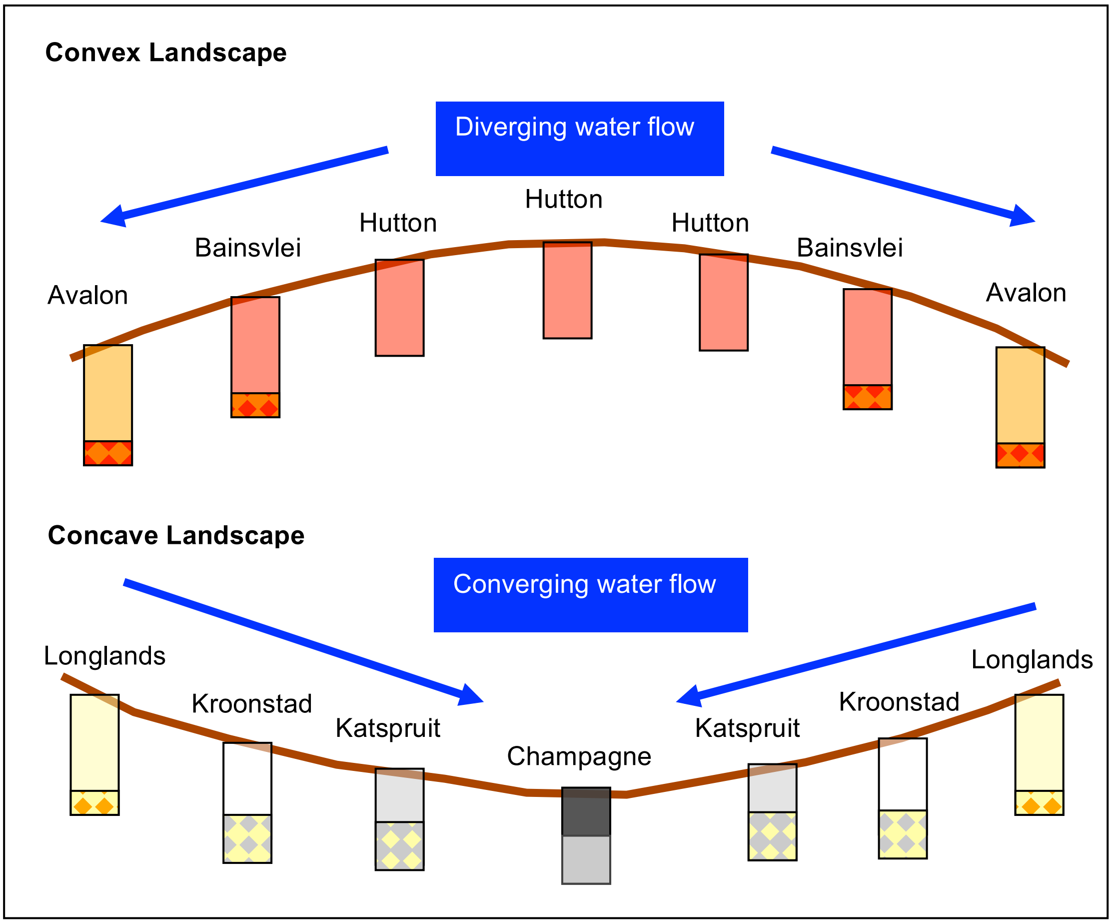

Figure 11 Schematic representation of the soils in convex and concave landscapes in an idealised catena

In the concave landscapes clays and weathering products are transported through the soils into a zone of accumulation where soils start exhibiting properties of clay and Fe accumulation. In addition, coarse sandy soils in convex environments tend to be thinner due to the removal of sand particles through erosion and soils in concave environments tend to be thicker due to colluvial accumulation of material transported from upslope positions. Similar patterns are observed for other geological areas with the variation being consistent with the soil variation in the catena.

Often these concave and convex topographical environments occur in close proximity or in one topographical sequence of soils. This is often found where a convex upslope area changes into a concave environment as a drainage depression is reached (**Figure 12**). The processes in this landscape are the same as those described for the convex and concave landscapes above.

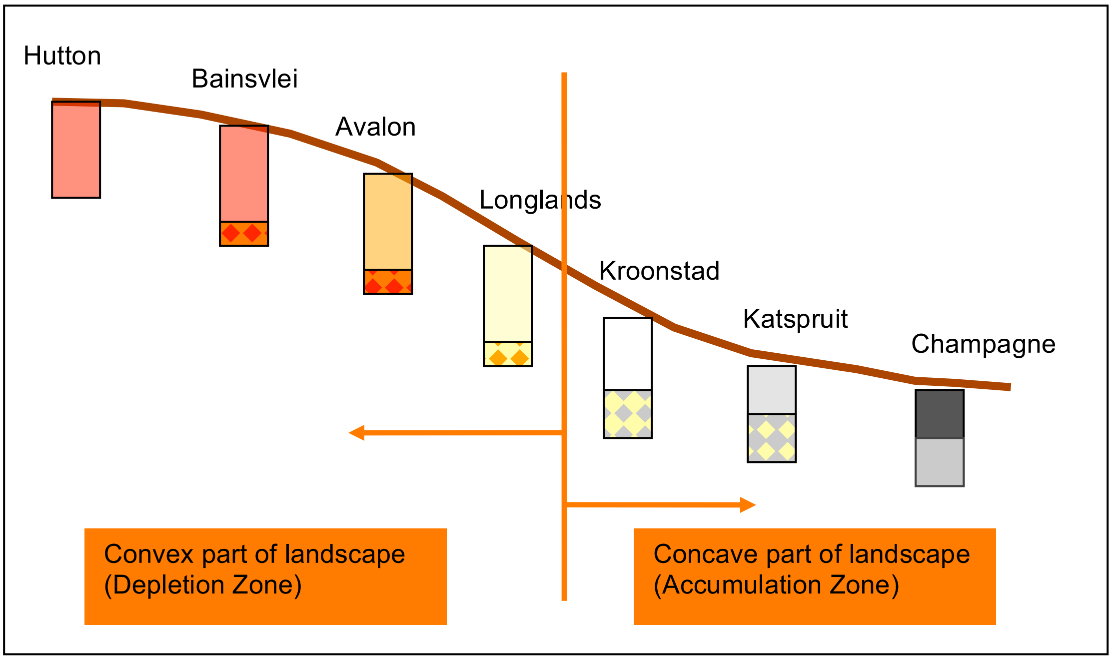

Figure 12 Schematic representation of the soils in a combined convex and concave landscape in an idealised catena

5.7 Ba and Bb Plinthic Catena

The plinthic catena specifically found on the Mpumalanga Highveld is dominated by Ba and Bb land types. The Ba land types denote areas where red soils dominate and are conceptually the same as the idealised catena described above. The Bb land types denote areas where yellow and bleached soils dominate (**Figure 13**). Additional variation is found in the form of soil depth as well as the extent of soft versus hard plinthic material occurrence.

Due to the emphasis placed on soil colour (and colours associated with wetness) in the wetland delineation guidelines (DWAF, 2005) the difference between the red and yellow/bleached soil dominated land types leads to a slight over representation of wetlands in the Bb land types as the bleached colours are used as wetland indicators. The difference is considered an artefact associated with a less intense influence of dolerite in certain landscapes. The subsequent exaggeration of wetland spatial extent in these landscapes is not considered to be significant in terms of the mining impacts discussed later in the report.

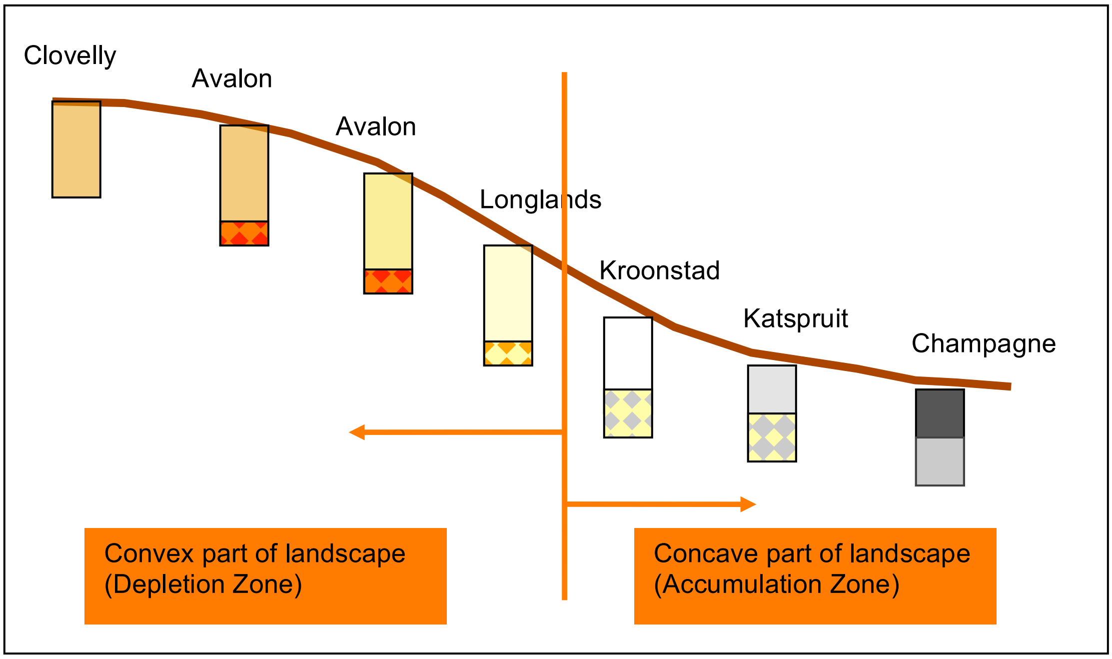

Figure 13 Schematic representation of the soils in a combined convex and concave landscape in an yellow and bleached soil dominated landscapes

5.8 WETLAND – TERRESTRIAL SOIL LINKAGES AND AGRICULTURAL POTENTIAL CONUNDRUM

The soils and landscape discussed in the previous sections can be divided into terrestrial and wetland soil areas (**Figure 14**). Although the main discussion in this document centres around wetlands and hydrological linkages it is important to note that the terrestrial area has 1) high agricultural potential and 2) functions as the recharge area for the wetlands. The conundrum in this discussion is evident when one considers the mining authorisation process often conducted by consultants / specialists and adjudicated by the specific competent authority. Due to the intense emphasis on wetlands it is found that wetland areas are 1) identified, 2) delineated, and 3) conserved with a buffer. The tragedy in the process lies in the fact that the terrestrial areas are often perceived to be the most impacted parts of the site (due to historical agricultural use, tillage and ecological alteration) and therefore easily sacrificed for opencast mining and therefore completely compromising the headwaters and feeding areas of the wetlands. It follows therefore that the exact process followed to protect the wetlands is so flawed that it leads to a drastic decrease in water supply and therefore a significant degradation in the functioning of the wetland.
See figure 8 and explain agricultural potential and

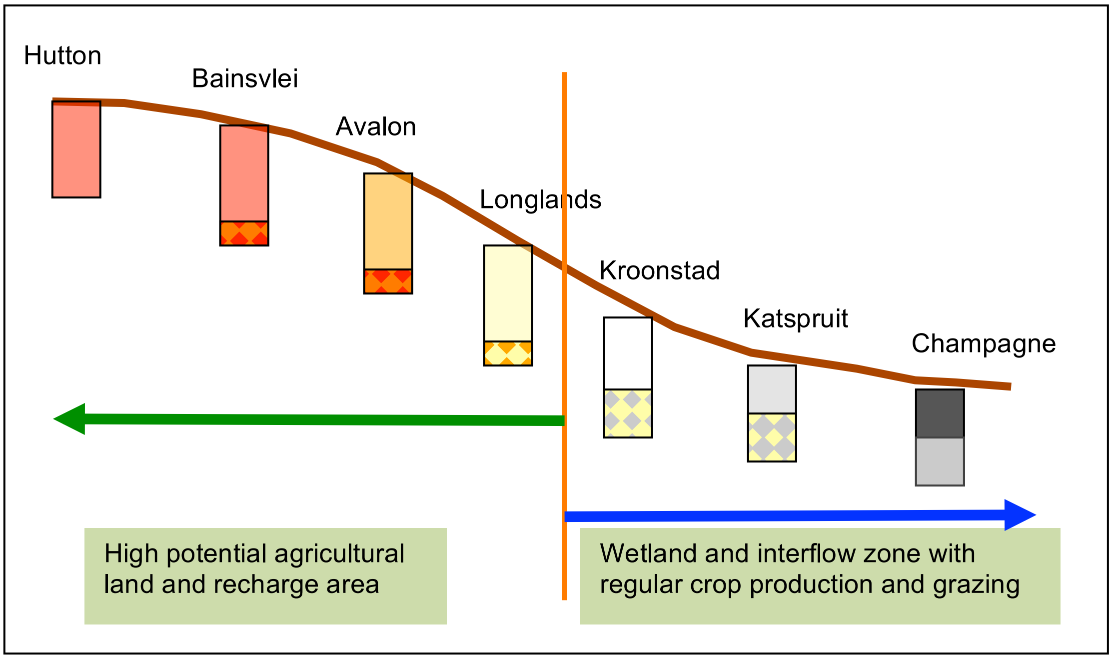

Figure 14 Schematic representation of the soils in a combined convex and concave landscape with an indication of land capability split along agricultural and wetland soils

5.9 Implications for Wetland Conservation in Opencast Mining Environments

5.9.1 Free Draining Systems

Whether an area is designated a wetland or not loses some of its relevance once drastic influences on landscape hydrology are considered. If wetlands are merely the expression of water in a landscape due to proximity to the land surface (viz. the 50 cm mottle criterion in the delineation guidelines) it follows that potentially large proportions of the water moving in the landscape could fall outside of this sphere – as discussed in detail above. **Figure 15** provides a schematic representation (as contrasted with **Figure 6**) of water dynamics in an opencast mining environment in a free draining system. **Figures 16** to **23** indicate examples of the flow regimes on a specific mine indicated schematically in **Figure 15**.

With the typical opencast mining the "topsoil" and overburden rock is stripped to access the ore body at depth. The "topsoil" often includes the entire weathered zone (entire soil profile) without consideration of specific soil layers or horizons. As indicated earlier, it is within these soil layers that a large proportion of water in the landscape flows. The stripping of overburden rock destroys further flow paths. Once the void is "rehabilitated" it is filled with loose and unconsolidated material with vastly different physical properties (porous and unconsolidated versus solid or sparingly permeable bedrock). Due to the drastic change in physical properties the filled-in mine void area becomes an area of drastically increased recharge. Some workers in the field indicate a 10 to 20 fold increase in recharge. The recharge into the filled-in material implies that water will percolate down to the original mine floor with a subsequent filling of the void until it decants at the lowest point. If there is an elevated pyrite content associated with rock layers (that have now been broken up with a drastically increased surface area) these voids start generating sulphates and acid. The mine drainage water exiting the mine area at the decant point then leads to the establishment of an acid and/or sulphate rich seep. These have many wetland characteristics but with the difference that they are highly altered chemically and biologically.

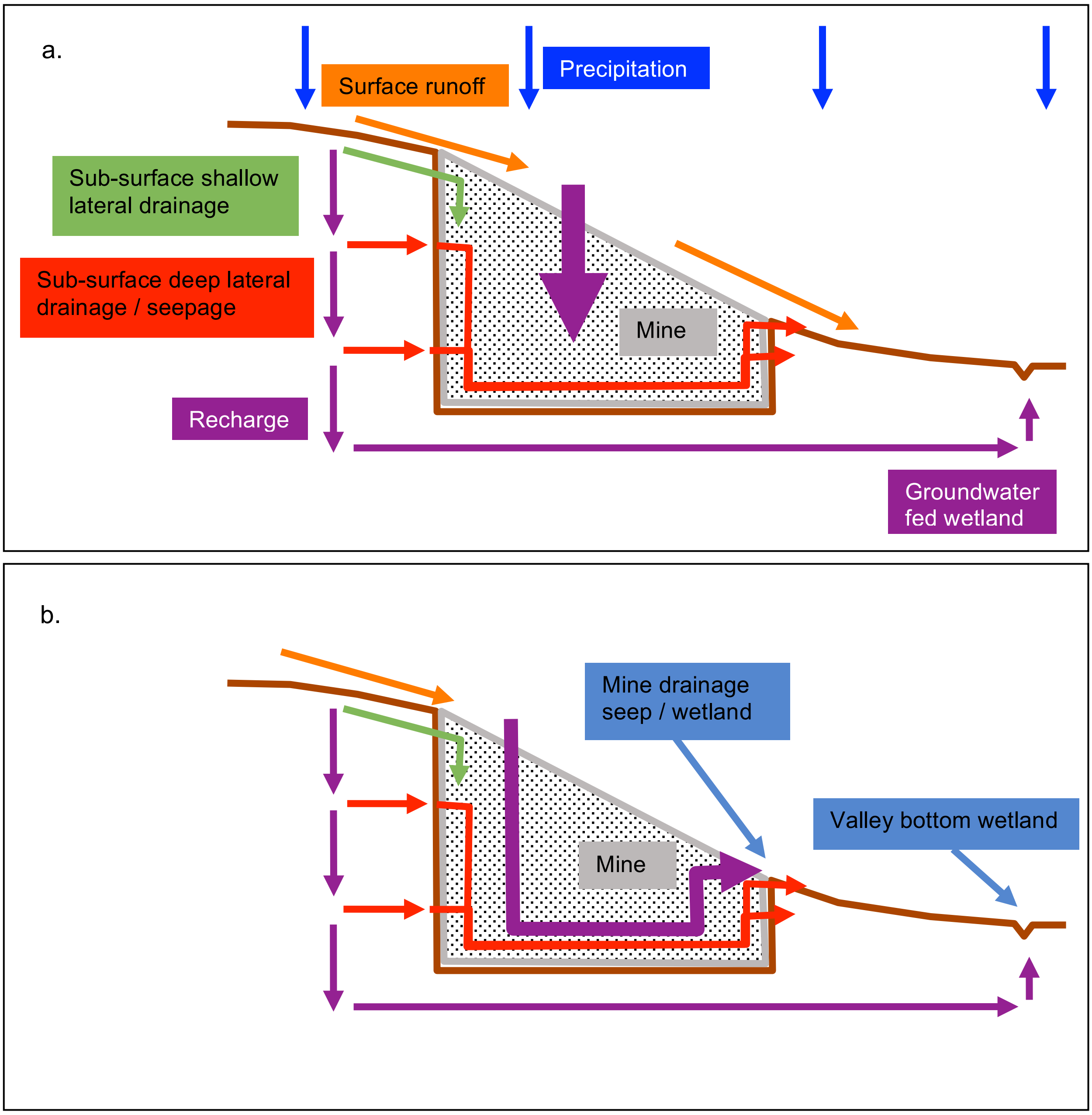

Figure 15 Different flow paths of water through a landscape with an opencast mine (a) and typical wetland types associated with the water regime (b)

Figure 16 Opencast mine profile indicating a thin bleached soil profile (arrow)

Figure 17 Opencast mine profile indicating 1) a thin bleached soil profile overlying 2) a hard plinthic layer and 3) weathered sandstone

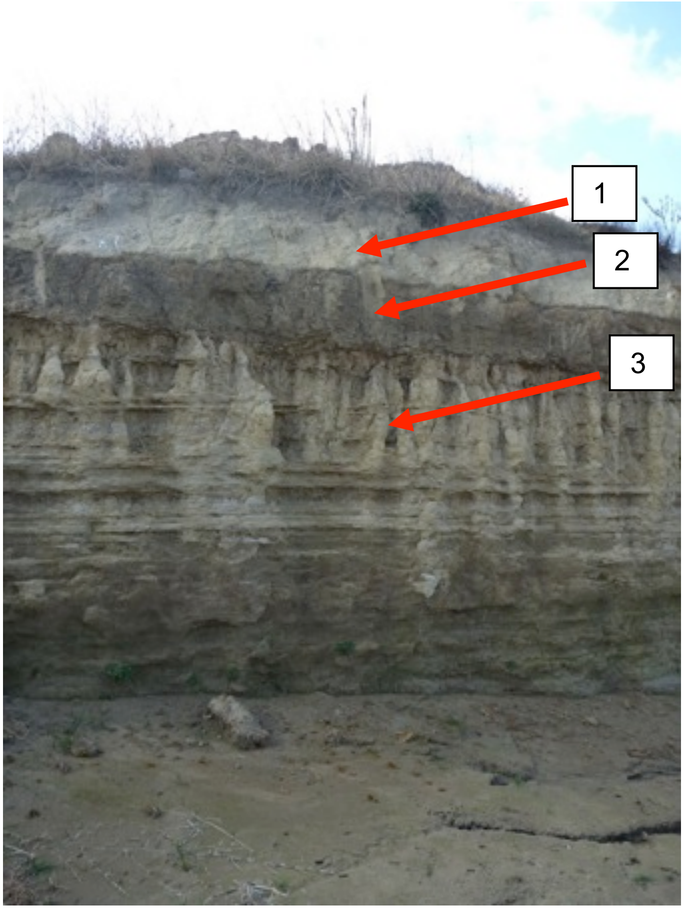

Figure 18 Opencast mine profile indicating 1) a thin bleached soil profile overlying 2) a hard plinthic layer and 3) weathered sandstone

Figure 19 Opencast mine profile indicating a distinct flow path (arrow) beneath the soil profile

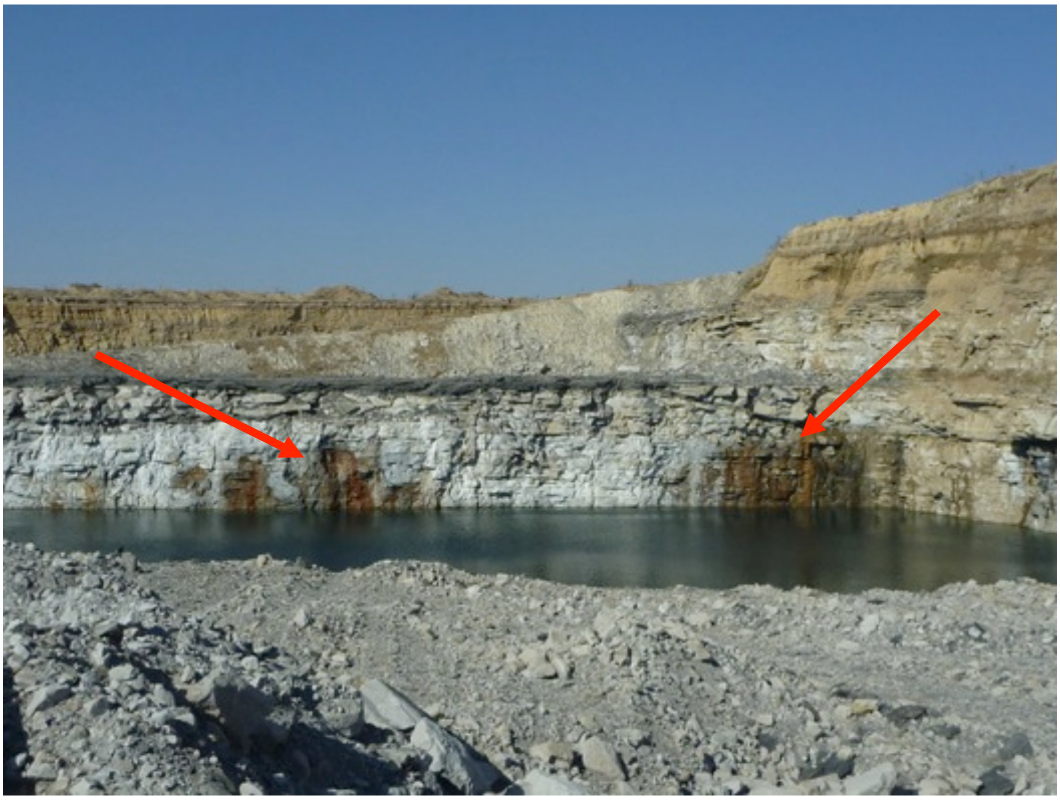

Figure 20 Opencast mine profile indicating a distinct flow path (arrows) in the bedrock

Figure 21 Opencast mine profile indicating numerous distinct flow paths (arrows) through the exposed profile (soil, weathered sandstone, carbonaceous shale, hard sandstone)

Figure 22 Road cutting with exposed flow (outside of a wetland area) at the end of July 2013

Figure 23 Road cutting with exposed flow (outside of a wetland area) at the end of July 2013

5.9.2 Inwardly Draining Systems

The same principles as above, but in this case for an inward draining system, are illustrated in **Figure 24**. In the case where the landscape around the depression (pan) has been mined up to the “wetland buffer” (or often practically the 1:100 flood line) there is 1) a decrease in ground level due to a volume decrease through coal removal and 2) a raising of the depression above the surrounding landscape. The consequence is a depression (pan) system with a drastically decreased catchment that leads to a significant drying out of the system and concomitant change in ecological character over time. This aspect is illustrated by the pan system indicated in **Figures 25** and **26** with the wetland area making up only a small section of the entire catchment. The drop in ground level surrounding the pan (**Figure 24b**) decreases water supply.

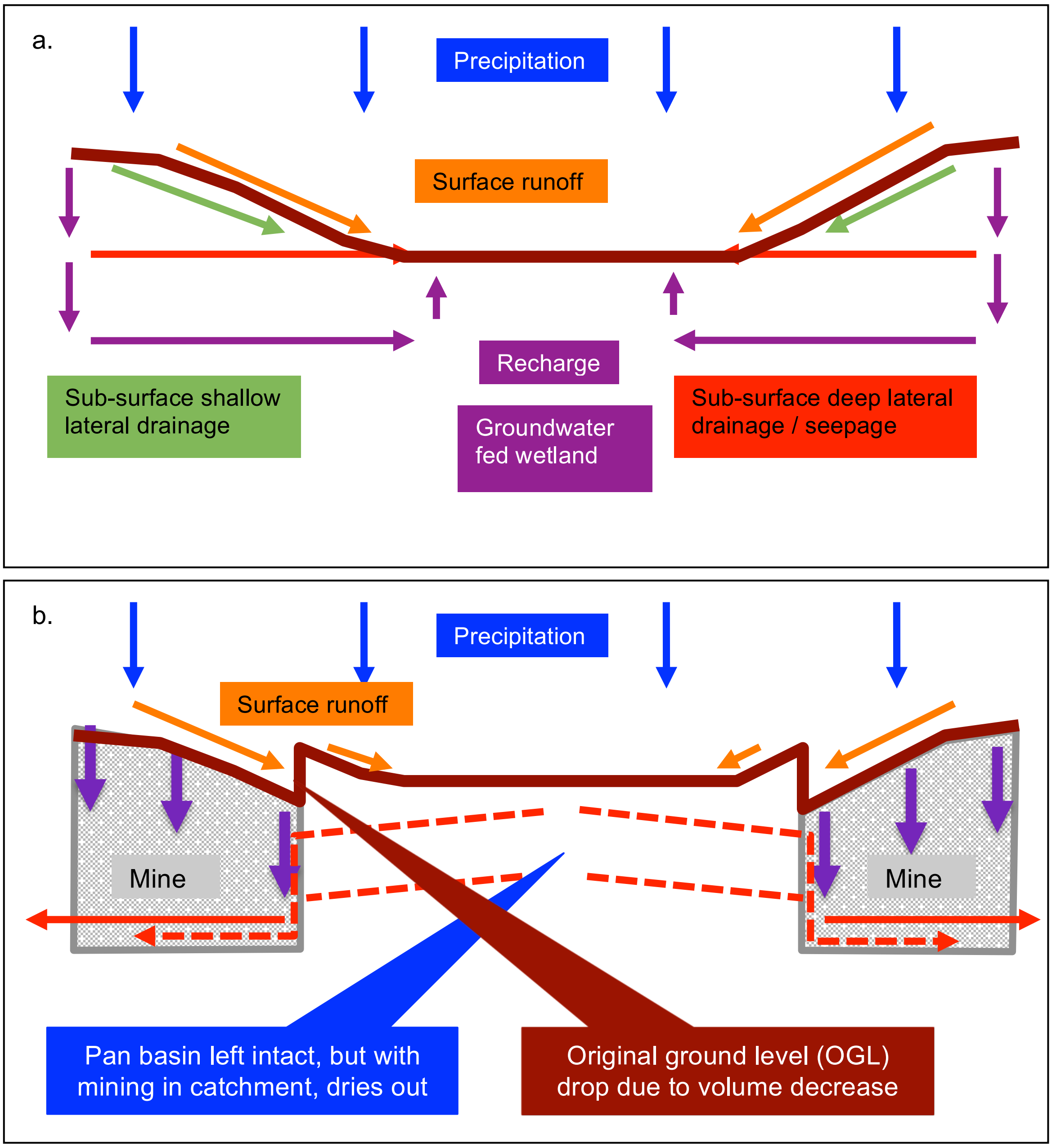

Figure 24 Water dynamics in an inwardly draining system under natural conditions (a) and under conditions where the area surrounding the depression has been mined (b)

Figure 25 Pan system with two pans that are not connected to drainage features on the surface

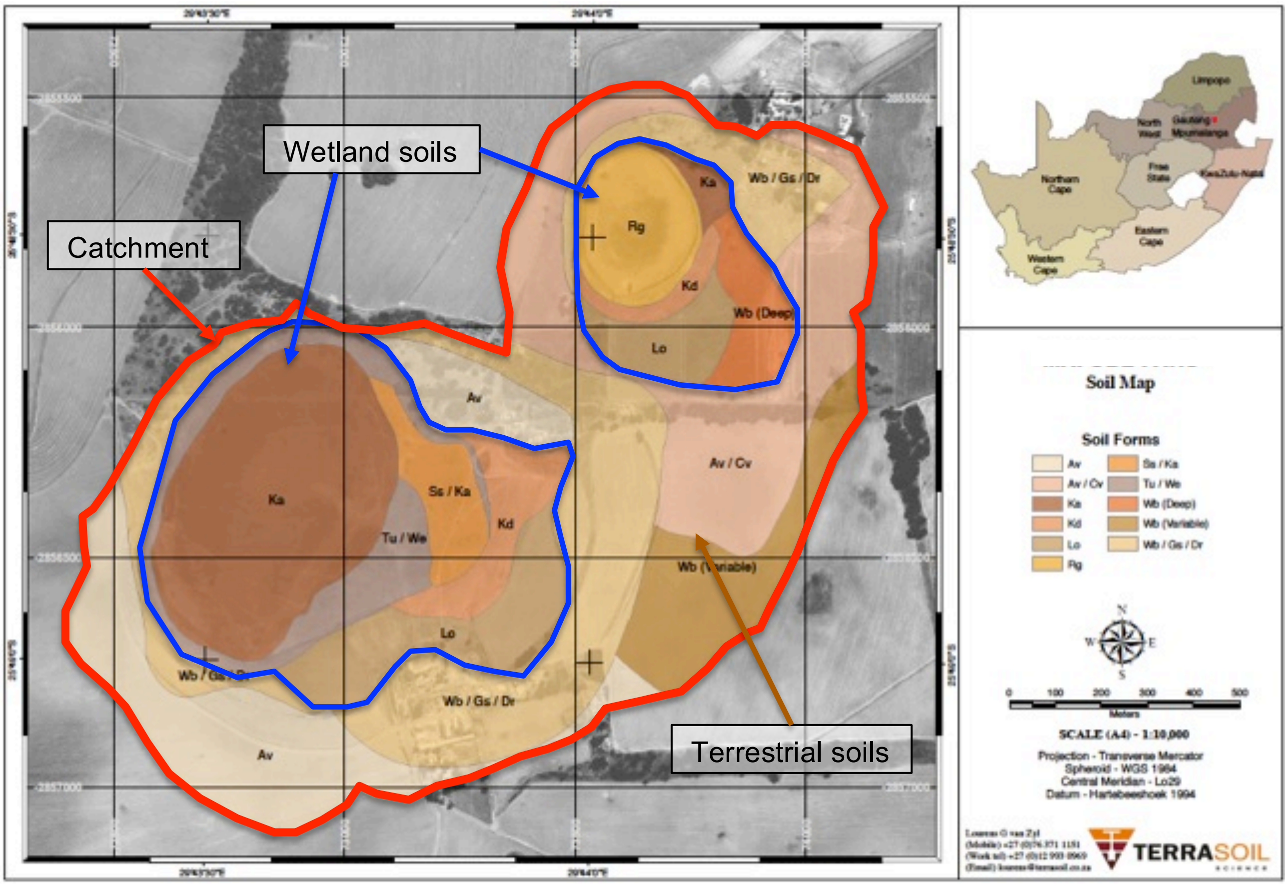

Figure 26 Soil map of the pan system indicating wetland and terrestrial soils and the catchment

5.9.3 Complete Mining of Terrestrial and Wetland Zones

In the case where the entire landscape is mined a complete destruction of the hydrological processes is experienced and the entire landscape is “rehabilitated”. The complete mining of a pan system requires a change in hydrology to a free draining system in order to minimise stability risks on the post-mining site. A 3D model of the pan system before mining and a conceptual reestablishment design is provided in **Figure 19**.

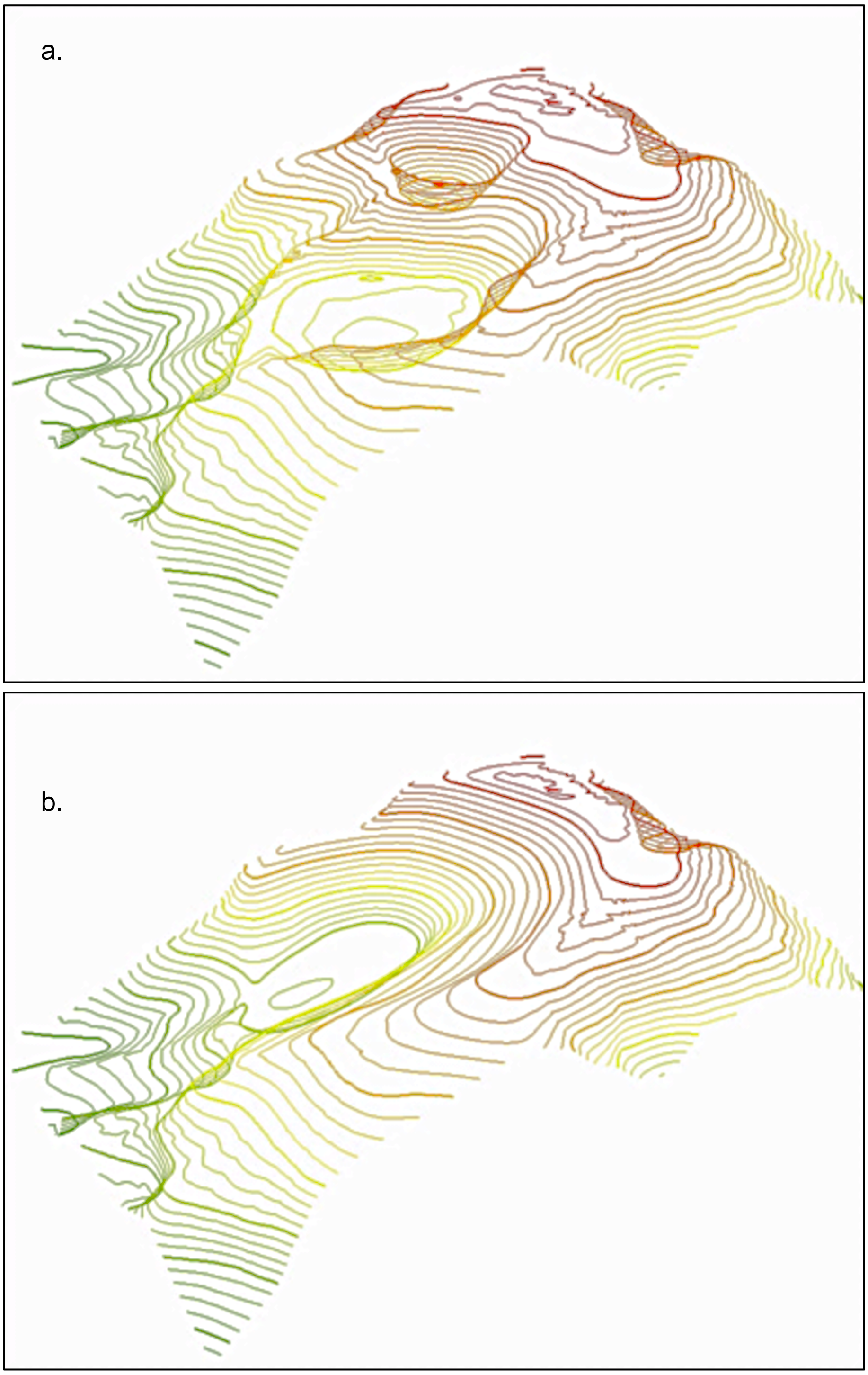

Figure 27 3D model of a pan system before mining (a) and a conceptual design for a post mining landscape reestablishment (b)

The pre-mining hydrology is inward draining and therefore saturated with water and with free water standing in the pan basin (**Figures 28** and **29**). The soil profiles indicate depression conditions with an accumulation of salts and weathering products – often in the form of specific clay minerals having formed in the accumulation environments over millennia (**Figure 30**). The chemistry of the pan basin floors (data not presented here) usually indicate and accumulation of Na to very high levels, which is indicative of poor or non-existent drainage in a landscape such as the Eastern Highveld that usually exhibits very low Na levels in free draining environments. A distinct example of this phenomenon is the soil profiles in **Figure 30** that indicate a soil morphology similar to vertic properties but where the dominant clay mineral is kaolinite in the presence of very high Na levels. The swelling properties erroneously attributed to smectite clay dominance was afterwards correctly assigned to the effect of Na dispersion of kaolinitic clays. The high Na levels impart dispersive properties to the clay minerals with a subsequent instability and distinct tendency for erosion should these soils be deposited on slopes.

Figure 28 Free water standing in the pan basin

Figure 29 Saturated soil forming the pan basin floor

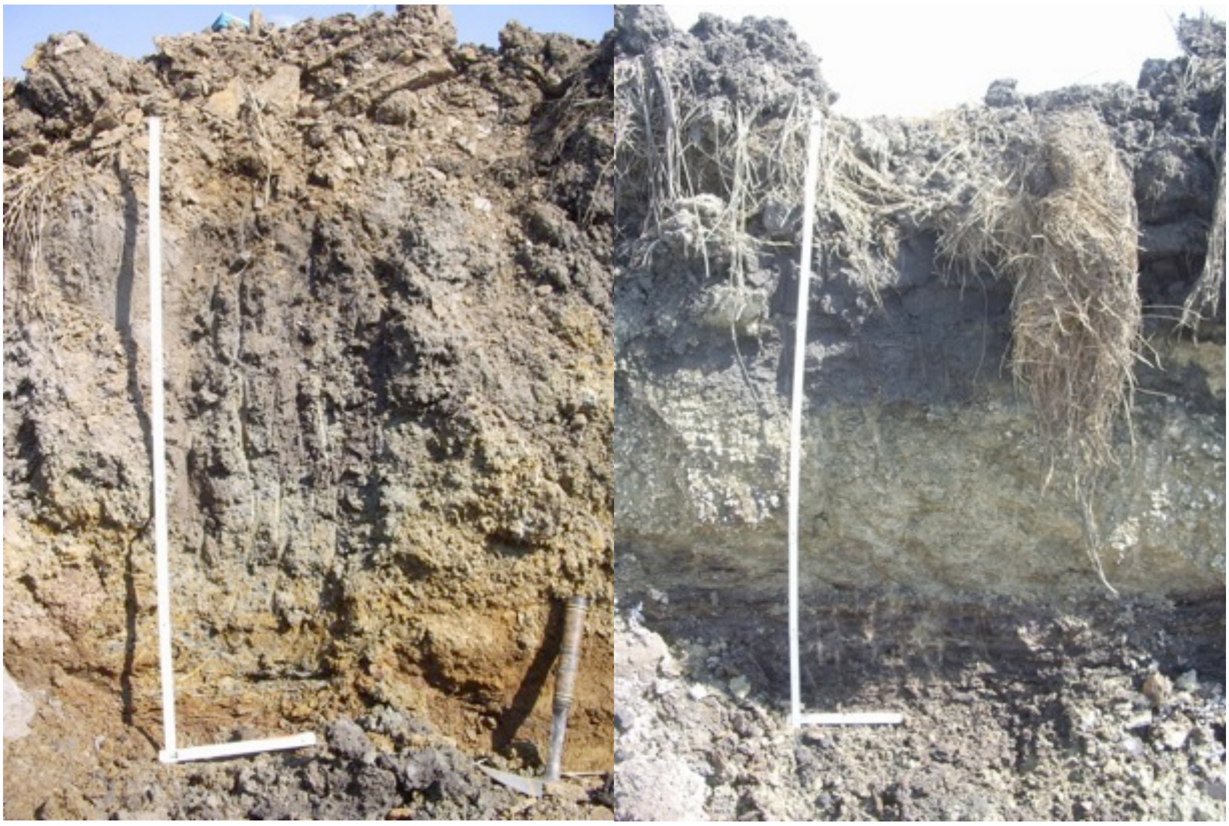

Figure 30 Saturated soil (Katspruit form), with swelling properties due to the effect of high Na levels, forming the pan basin floor

6. GEOTECHNICAL, SOIL STABILITY AND HYDROLOGICAL FUNCTIONING CONSIDERATIONS IN WETLAND REHABILITATION AND RE-ESTABLISHMENT

The reestablishment of plinthite layers is also often proposed as a means to ensure the hydrological functioning of a post-mining landscape. At the outset it needs to be emphasised that the stripping of soils before mining is a process that is described in the “soil utilisation guide” provided with the EIA and EMP for mining applications. These guides are based on detailed soil surveys and provide stripping, stockpiling and soil placement guidelines. In practice these plans are practically difficult and financially restricting to execute and most, if not all, mining operations therefore do not execute the plans.

The establishment of plinthic layers poses another challenge in that the plinthic layers are the products of landscape hydrological processes rather than the cause of these hydrological processes. The same applies to extensive E horizon profiles that act as lateral conduits for water in most plinthic landscapes. It is therefore counter intuitive to promote the re-establishment of such layers in the post-mining landscape positions without being able to re-establish the hydrological functioning of the landscape as discussed in the previous section.

6.1 SOIL AND MATERIAL HANDLING PLANNING FOR REHABILITATION

In order to plan and execute a mine stripping, storage and placement plan for mined material the assessment of a proposed mining site should consist of the following parameters (ideal):

1. Conduct a detailed soil survey to identify, classify and map the soils of the site.
2. Conduct a detailed geological assessment of the coal bearing strata and overlying material to determine material characteristics (nature, acid generation capacity, etc.).
3. Generate a mine plan.
4. Generate a soil stripping, stockpile and placement plan in line with the mine plan.
5. Generate a rehabilitation plan in line with national guidelines and / or requirements of the competent authority.
6. Implement the rehabilitation plan and conduct monitoring with interventions where required.

Due to the cost associated with the above exercise most mines execute components of the above. In in many cases the soil stripping, stockpiling and placement guidelines are either very generic or very detailed – in which case they are too costly to execute. Detailed wetland rehabilitation requires a higher level of intensity than that described above and is therefore even more costly than generic rehabilitation processes.

6.2 GEOTECHNICAL CONSIDERATIONS

If the process set out above is followed in detail then the geotechnical stability of the materials come in to play with respect to the long term integrity of rehabilitation efforts and its planning. A pre-mining landscape consists of a hard and temporally stable geological base with the weathered zone with soils and wetlands at the surface. The hydrological functioning of the landscape is a function of the hardness and permeability of the varying materials in the various layers. As indicated in **Figures 15** and **24** the mine voids are filled with unconsolidated materials with a permeability that is rather homogenous with variation in depth. The alteration in permeability is the main cause of the increase in recharge characteristics of the landscape. However, the unconsolidated materials are not stable and will undergo different degrees of settling and consolidation as a function of the dry and wet conditions of the material with the wetness changing over time due to the increased recharge. A decrease in material volume is therefore inevitable but difficult to predict as a result of several factors that introduce variability in the material characteristics, cohesion between particles and loading of overlying layers. Additionally, the settlements may be differ spatially and the total settlement and consolidation will continue for many years with a decrease in intensity over time (**Figure 31**)

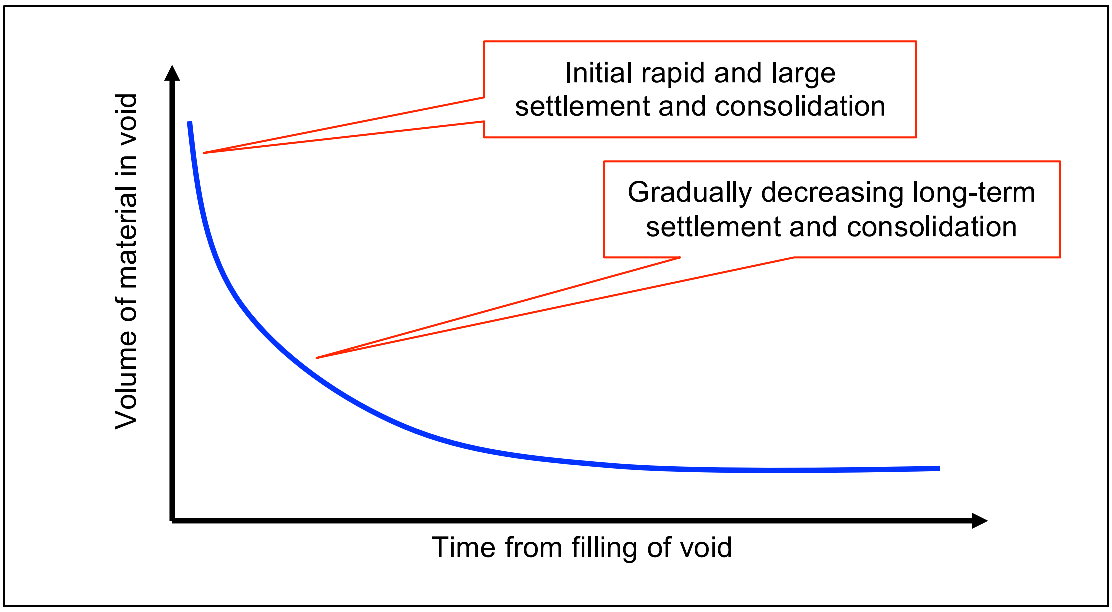

Figure 31 Change in settlement and consolidation intensity over time

6.3 SOIL STABILITY AND HYDROLOGICAL FUNCTIONING CONSIDERATIONS

The post-mining landscape's hydrological functioning is therefore significantly different to the pre-mining landscape with a consequent drastic alteration in flow regimes and wetland feeding processes. Interested and affected parties, as well as the regulator, often indicate that the pre-mining landscape's hydrology should be mimicked with the rehabilitation design. This requirement is near impossible to meet as the re-establishment of pre-mining hydrological processes would require the construction or installation of impermeable liners to counteract and arrest the high permeability of the newly placed unconsolidated materials. These liners however have to remain intact in order to maintain functionality. The significant settling and consolidation, and the spatial variability of such processes, preclude the successful long-term functioning of such liners. The only way to increase the probability of success and maintenance of integrity of the liners is to significantly increase the compaction and shaping of the underlying spoil layers. The cost of such intensive exercises often exceeds the value of the coal in the mine in the first place and these approaches are therefore never implemented.

A compounding factor in the above consideration is the fact that the post-mining landscapes have to be free draining to prevent accelerated consolidation, failure of containment structures due to compromised integrity upon settling differentially, adverse human safety and environmental impacts and processes such as sediment generation. Whereas the planning and rehabilitation of wetlands require minimal professional certification, the design and construction of stable structures requires the sign-off of a professional engineer. In practice engineers are very loathe to sign-off on structures of which the integrity and stability poses uncertainties.

Additionally, the placement of pan basin soils on slopes is risky due to the dispersive nature of the clay soils that have elevated Na levels. The elevated Na levels in comparison to Ca levels lead to a distinct instability of the clays due to dispersion induced by the Na. On slopes these soils therefore have no cohesion when wet and they will readily erode and “flow” downslope.

6.4 RE-ESTABLISHMENT OF PLINTHIC LAYERS

An argument that is often put forward is that if plinthic layers can be re-established that the hydrological functioning of the post-mining landscape can mimic that of the pre-mining landscape. The argument rests on a number of exaggerated expectations however. The following aspects are of critical relevance to the above argument.

1. It is important to understand that the occurrence of plinthic layers is not a function of the soil itself but rather of the underlying weathered and hard rock materials. The plinthic layers originate predominantly due to return flow of water out of the landscape where the lateral flow paths in fractured or stratified rock layers intercept the topography. It therefore follows that these flow paths have to be established first in the filled-in spoil before the plinthic layers will function in a similar way as in the pre-mining landscape.
2. The establishment of lateral flow paths in unconsolidated spoil material is not feasible due to the design, placement, compaction and sealing efforts required to attain such. These lateral flow paths pose significant geotechnical stability challenges that are to costly and risky to address.
3. The consolidation and settlement characteristics of the spoil material lead to a constantly changing material environment from a physical strength and void characteristic perspective. It is inevitable that deliberately constructed seals and flow paths will be severed or compromised through shifts in layers and material.
4. The lateral movement of water within a plinthic landscape is often characterised by slow, almost horizontal, seepage through sandy E-horizons. These soils are stable in-

situ as they are in equilibrium with the hydrological processes that dominate the landscape. The construction of such seepage zones with similar flow rates and stability is not readily performed and these lateral seepage areas will require significant maintenance and stabilisation (in contrast to the natural conditions.

Taking into account the above challenges regarding the establishment of plinthite type lateral flow paths leads to the preferred option of keeping water flows on the surface in post-mining landscapes. On the surface the water is visible, treatable and the erosion and stability impacts can be managed more efficiently that if these flow paths were buried.

6.5 IMPLICATIONS FOR POST MINING LAND CAPABILITY

In the EMP process for a standard opencast mine there is a distinct irony. Whereas these mines are often licensed to mine in "terrestrial" areas that comprise high potential agricultural land the relevant authorities (DAFF) require the land to be rehabilitated to as close to the original land capability as possible. In order for crops to grow the infiltration of the soil must be at a maximum to ensure enough water in the soil profile. On the other hand, DWS would require that the water infiltrating into the porous material should be a minimum in order to minimise acid and sulphate generation in the porous spoil material – the aim therefore being to minimise acid mine drainage decants. The above description indicates that there is a distinct conflict in what is advised and required for mines during the EIA/EMP process. What is more disconcerting is that this issue is not adequately addressed at regulator level and the mines are often provided with conflicting guidelines.

6.6 IMPLICATIONS FOR POST MINING WATER QUALITY MANAGEMENT

As indicated in **Figure 15** the seepage of mine impacted water from spoil deposits is a distinct risk in mining environments. The implication is that 1) new wetlands can occur in mining environments as water drains out on toe seep areas or 2) wetlands that are established can experience ingress of poorer quality water in terms of acidity, metals and sulphates. The change in water quality has an adverse effect on the ecological characteristics of the wetland systems into which the water flows. The extent of the effect is determined by the difference in pH and salt load of the polluted water compared to the natural wetland water.

7. CASE STUDIES

A number of case studies are discussed below to illustrate the concepts discussed earlier in this report. Many of the cases will be dealt with as anonymous sites due to the sensitivity of the projects and client privilege and non-disclosure considerations. Some of the sites were physically assessed by the author and others were identified on Google Earth only as examples of the topics discussed above. The format used for the different case studies is not the same throughout as the information presented is either 1) similar to the information provided in reports to clients or 2) a brief summary of the conditions identifiable in Google Earth.

7.1 Free Draining System with Wetland Mined: Mining Activities in Unnamed Tributary of the Holbankspruit and its Associated Wetland (Leliefontein)

The impacts in the Holbankspruit from the Leliefontein mine activities are wider than the discussion provided here. However, the specific wetland / watercourse area that was mined provides a clear example and application of the conceptual aspects addressed earlier in the report.

7.1.1 Locality

The position of this impact is indicated in **Figure 32**. The yellow arrow indicates the direction in which an oblique aerial photograph was taken (image 2067; taken 23/01/2013; presented in **Figure 33**). The site lies in the Bb21 land type meaning that the entire landscape is dominated by yellow and bleached soils leading to a potential overestimation of wetland zones.

Figure 32 Position of the impacted wetland with direction of image 2067

7.1.2 Form of Wetland Identification

This wetland was identified by making use of the following:

1. Aerial photographs / satellite images: Google Earth images (satellite) as well as aerial photographs (Mowbray) were used to identify aspects (colour and texture on image) that are consistent the presence of wetland features in other parts of the same landscape. The darker green colour within this area is consistent with other non-impacted wetlands in the same landscape and indicates that an area with seasonal wetland characteristics was

present before mining. A distinct incised drainage channel, as is present upslope from this wetland, was absent – indicating that it was an un-channelled valley bottom wetland.

2. Topographic data: This data includes contours as well as a watercourse that is indicated on 1:50 000 and 1:10 000 scale topographic maps. From this data it is evident that the drainage feature conforms to the definition of a watercourse and that the levelled-out (or flared) area next to the Holbankspruit constitutes an area with regular presence of water following runoff from upslope.
3. Soil data: Soil data could not be generated for the site as the site had been mined. Peripheral soil data was generated.
4. Vegetation data: Due to the mining impacts vegetation data could not be generated for the site.

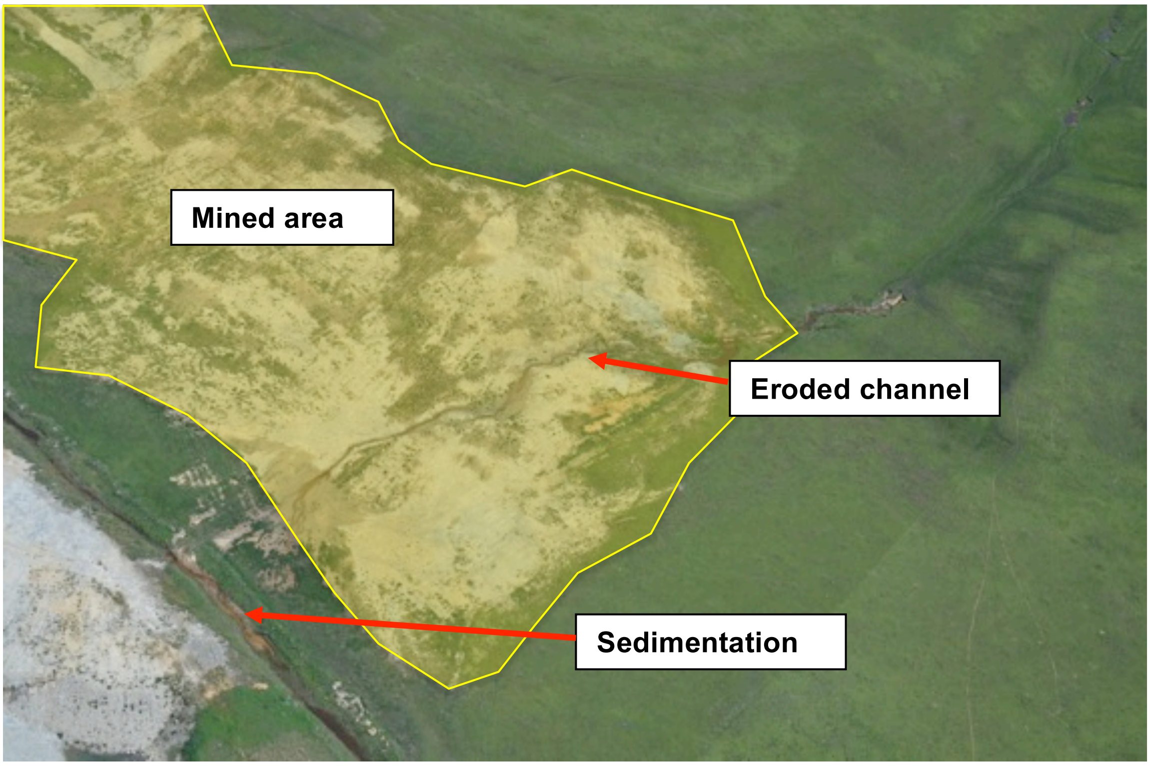

Figure 33 Image 2067 indicating bare soil in the mined area, significant erosion on site and sedimentation in the Holbankspruit

7.1.3 Description of Activity/Impact

The activities related to the impacted wetland and characteristics of the site entail the following:

1. The activity entails the recent historical mining of a watercourse and associated floodplain wetland area.
2. The area has been filled with spoil material (**Figures 34** and **35**). It is evident from field surveys that the spoil material contains large quantities of carbonaceous material (**Figure 36**) as well as pyritic sandstone (**Figures 37** to **39**). No contours or soil stabilization structures are evident.
3. At the time of the survey there has been no dedicated vegetation establishment on the site as part of the rehabilitation processes.

4. Significant erosion is evident on the site (**Figures 40** to **43**). The erosion is the result of an un-stabilized water course/channel that is forming due to water flowing from upland areas and the existing watercourse above the mining area as well as from overland flow from surrounding land.
5. Significant sedimentation, originating from the eroded areas of the unnamed tributary, is evident in the Holbankspruit river channel (**Figures 42** and **43**).

Figure 34 Wetland area filled-in with mine spoil and soil material

Figure 35 Wetland area filled-in with mine spoil material

Figure 36 Carbonaceous material in the mined wetland area

Figure 37 Pyritic sandstone rocks in the mined wetland area

Figure 38 Pyritic sandstone rocks in the mined wetland area

Figure 39 Sulfur salts on rock surfaces where pyritic materials have undergone oxidation

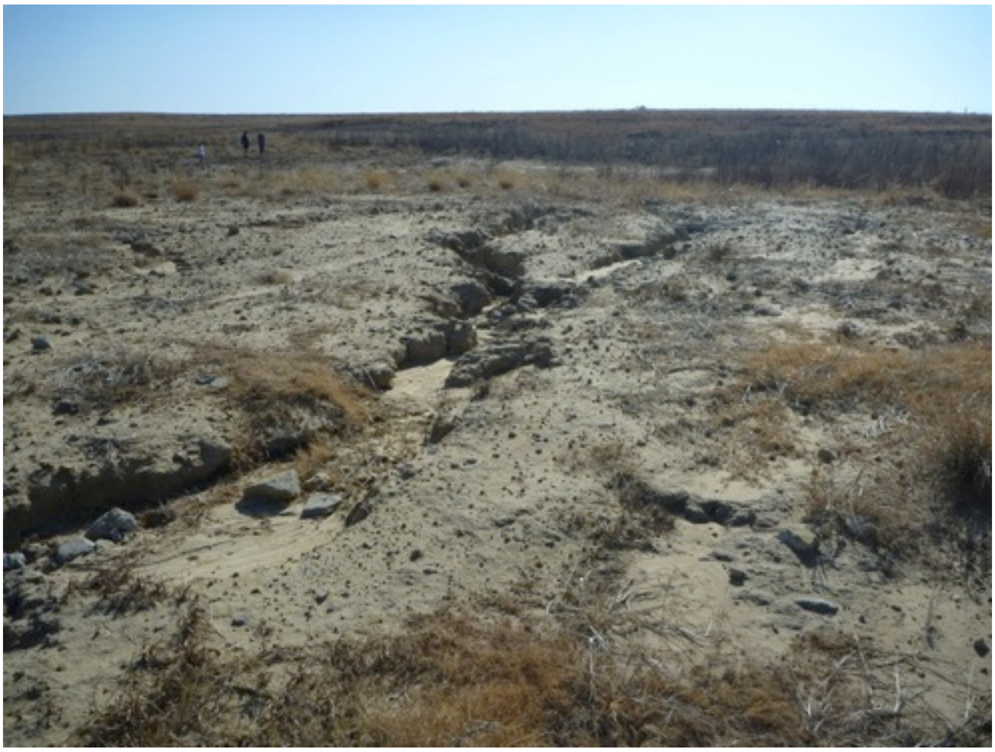

Figure 40 Eroded channel (sheet and gully erosion) on the in-filled wetland site

Figure 41 Eroded channel (gully erosion) of the unnamed tributary of the Holbankspruit on the in-filled wetland site

Figure 42 Eroded channel (gully erosion) of the unnamed tributary of the Holbankspruit on the in-filled wetland site with a sediment fan on the edge of the Holbankspruit

Figure 43 Sediment within the channel of the Holbankspruit

7.1.4 Conceptual Hydrology of Impacted Area

The hydrology of the impacted area will be elucidated during the detailed assessment of the site in terms of hydrogeology, vadose zone hydrology and surface hydrology. It is however possible to postulate (to an intermediate level of certainty) regarding the hydrology. These flow paths are the following (**Figure 44**):

1. Overland and channelled flow of water from upslope through the drainage feature.
2. Infiltration into the former void (or mined and backfilled area) that is approximately 10 m deep (anecdotal evidence – to be confirmed once detailed survey data has been obtained). The “recharge” into the backfilled material is postulated to be a factor of 10 to 50 higher than that of the original soil and geological material layers on the site.
3. Overland flow from areas surrounding upslope areas (**Figures 45** to **47**).
4. Hillslope subsurface flow process (interflow)
5. Ingress of water into the porous material with percolation down to the floor of the original void.
6. Filling of water in porous “void” with subsequent decant into the Holbankspruit.

The relative contribution of each component can only be quantified (relatively) once the hydrological assessments have been completed.

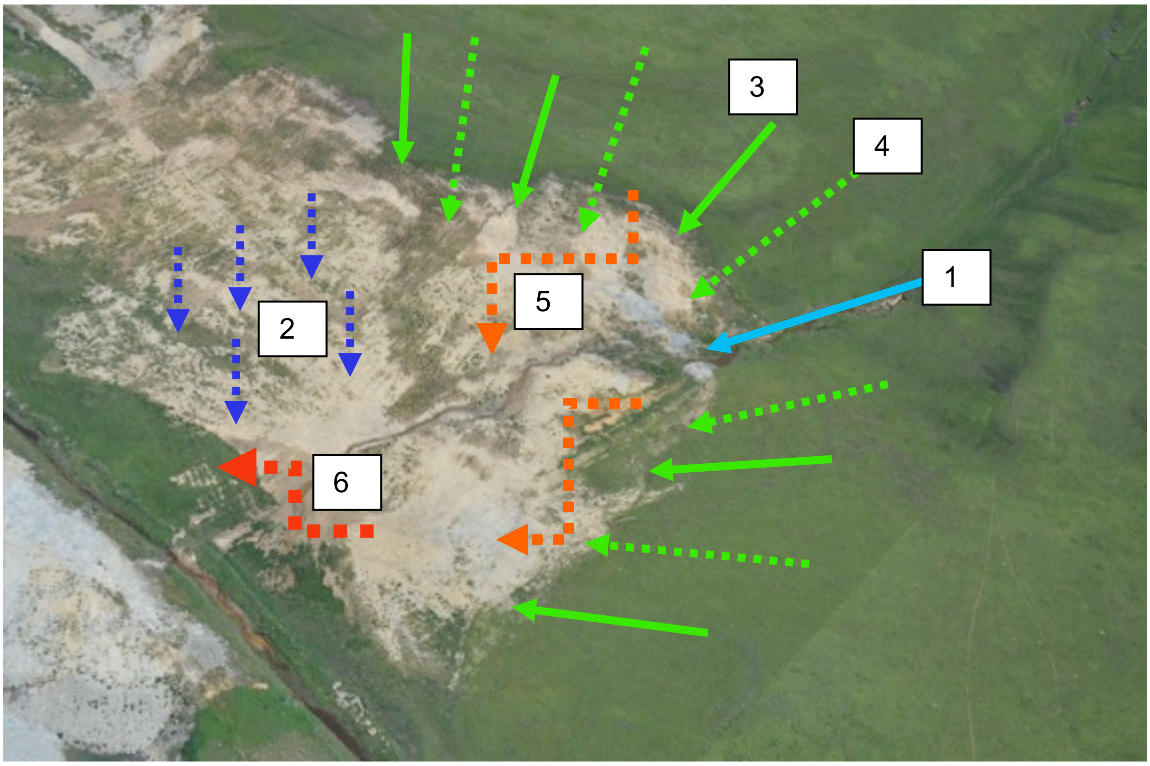

Figure 44 Flow dynamics of water on the impacted site

Figure 45 Daylighting of water from upslope areas of the mined wetland area (November 2011)

Figure 46 Daylighting of water on the upslope area of the mined wetland area (November 2011)

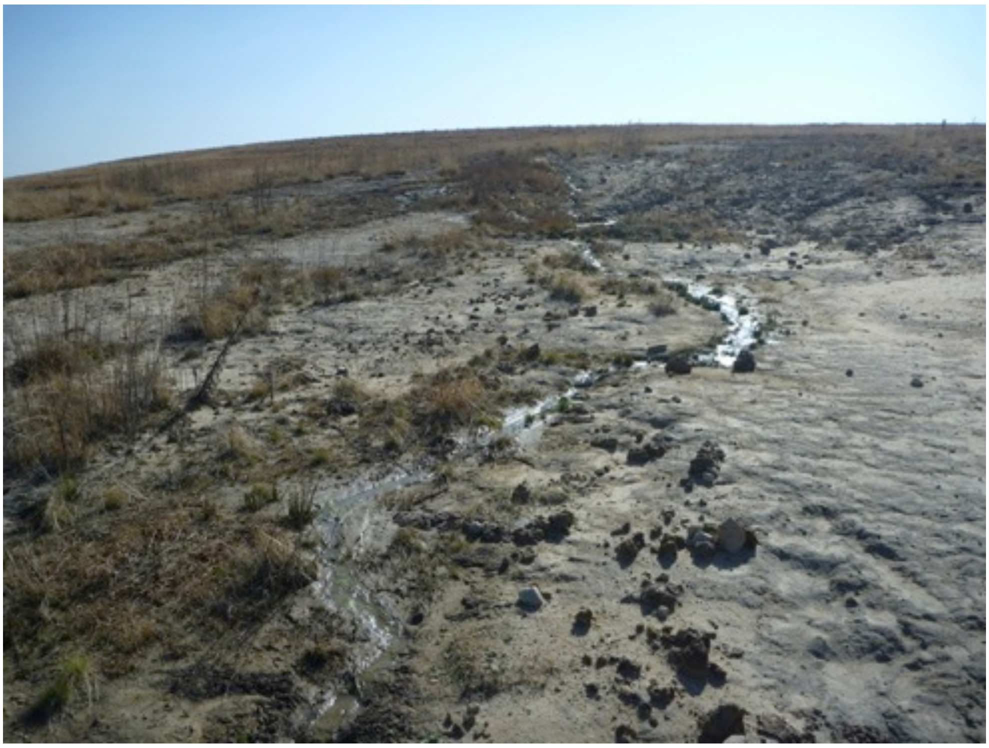

Figure 47 Daylighting of water from upslope areas of the mined wetland area (July 2013)

7.1.5 Required Rehabilitation Activities and Actions

The following rehabilitation activities and actions are required to rehabilitate the site:

1. Immediate intervention regarding stabilization of the channelled and eroded areas should be conducted to arrest erosion and sediment generation.
2. Detailed land survey to generate contours.
3. Clearing of surface (by hand or machine) of carbonaceous material and pyritic sandstone.
4. Topsoiling of site.
5. Design and construction of soil stabilization structures in the form of swales, berms and gabions to prevent erosion and sediment generation.
6. Installation of a lining within the channelled section of the site to prevent ingress of water into the porous backfilled material.
7. Assessment and prediction of soil wetness parameters that will result from the soft engineering interventions as well as hydrological modelling of the catchment area (in terms of water volumes and fluxes – hydrograph).
8. Generation of a re-vegetation strategy and plan to vegetate bare areas with plants adapted to the identified soil moisture regimes.
9. Medium to long-term assessment and monitoring of efficacy of rehabilitation measures.
10. Implementation of ad-hoc interventions as identified and required by the assessment and monitoring.

7.1.6 Practical Challenges Regarding the Application of Current Statutory Instruments and Guidelines

A number of practical challenges exist regarding the application of statutory instruments and guidelines driving the rehabilitation of the site. Below follows a dedicated discussion of each with specific practical reference to the site.

1. Application of PES/EIS assessment parameters. The PES assessment parameters cannot be applied to the mined-out areas even though it can be applied to the un-mined but impacted areas immediately upstream/upslope and downstream/downslope. The main reasons are:
    a. There is no correlation between the pre-mining hydrology and the post-mining hydrology within the mined area. With spoil and topsoil infilling processes there might be a visual correlation in terms of slopes and contours. However, the hydraulic conductivity (saturated and unsaturated) of the post-mining materials differs radically from that before mining.
    b. The generation of a PES rests primarily on the generation of anecdotal evidence on surface hydrology by a non-hydrology qualified person. With wetland feeding mechanisms being very varied and predominantly sub-surface it is clear that surface hydrological parameters do not provide an accurate indication of the dynamics of the water resource in the context of the landscape, with the original wetland being only the manifestation of the resource near the land surface.
    c. The PES parameter does not require significant input of water quality and feeding mechanisms. In order for a management tool such as this to be effective in opencast mining environments this glaring omission will have to be corrected as a matter of urgency.
    d. The determination of the PES would in all probability have yielded a value of and A or B before mining. Due to the mining impacts and alteration of hydrology (surface, vadose zone and groundwater) the only option is to class this area as an F. However, an F categorization does not accommodate the impacts on the site with the problem that significant input ito rehabilitation could yield a functioning wetland that can only qualify as an F after mining. The rehabilitated wetland would have to be assessed anew in terms of its hydrological drivers and a new category would have to be assigned. There will however be no correlation with the pre-mining wetland never mind the status of the post-mining wetland.
2. Legislation governing activities in wetlands/water courses. Due to the drastic alteration of the site and its associated hydrology there is no correlation with the area with any characteristics of a watercourse or wetland. It is therefore a debatable question as to whether the rehabilitated area constitutes a wetland/water course. If it does not qualify then no listed activities relating to wetlands/water courses are triggered through rehabilitation activities in this area. Under such conditions the only regulations/section of the act that could apply are:

a. Section 19 of the NWA (Prevention of pollution) – in terms of downslope sedimentation or pollution effects.
b. Rectification of unauthorized activities (Section 24 G NEMA) – in terms of the illegal mining of the original wetland.
c. Duty of care (Section 28 NEMA) in terms of downslope impacts.

3. Pragmatic decision on the wish list of the regulator. Due to the difficulty in finding clarity on the above aspects it is imperative that the regulator make a decision on its post-mining wish list. The options include:
   a. Solely a "rehabilitated" surface to the spoil material;
   b. A water course (which would require stabilization ito erosion, design and construction); or
   c. A new wetland (which would require stabilization ito erosion, design, construction and wetland establishment).

   The option decided upon must tie in with the water management measures implemented for the rest of the site as it all forms part of one overall management plan and objective.

7.2 FREE DRAINING SYSTEM WITH CATCHMENT (AGRICULTURAL SOILS) MINED: MINING ACTIVITIES IN CATCHMENT OF STEENKOOLSPRUIT AND TRIBUTARIES (KRIEL)

The area that has been mined between the Steenkoolspruit and its tributary as well as the area west of the tributary is indicated in **Figure 48**. This large area falls into the Bb4 land type with the drainage depressions falling into the Ea20 land type (vertic soil dominated), and the post-mining topography approximates the pre-mining topography. The difference between the two lies in the presence of final voids that are depressions in the landscape.

The challenge with the mined areas between the streams includes several aspects regarding the land and water management. These challenges are:

1. The landscape is free draining with the exception of the final voids that hold a significant volume of water. The water in these voids/dams has elevated sulphate levels (approximately 800 ppm at near neutral pH) and cannot be released into the Steenkoolspruit without 1) treatment to remove sulphates or 2) a relaxation in the water quality standards as enforced by DWA. As long as the water level remains low enough there is no risk of release into the stream. However, as the water levels in the voids rise and the rainfall continues contributing to surface water volumes the risk of release into the stream increases. The process is similar to the discussion provided in section 5.9.
2. The now porous spoil material (as opposed to the original hard rock material) continues to contribute sulphates to the water in the pores between soil and rock particles. As this water migrates to the lowest point in the landscape the supply of sulphate to the water in the final voids, and ultimately the Steenkoolspruit, will continue.
3. The final voids on the site allow for an opportunity to test, treat and / or pump the water elsewhere. The general feeling with the regulator is that final voids are unacceptable in post-mining landscapes. This author however feels differently and sees the final voids as water treatment points and access points to gauge the water quality that is seeping

through the landscape. With the advent of passive treatment technologies and processes the final voids afford an opportunity to access the polluted water. In a landscape without final voids the only way to access the water is through boreholes or in decant and outflow areas. These are often close to wetlands and the space available for treatment is therefore limited.

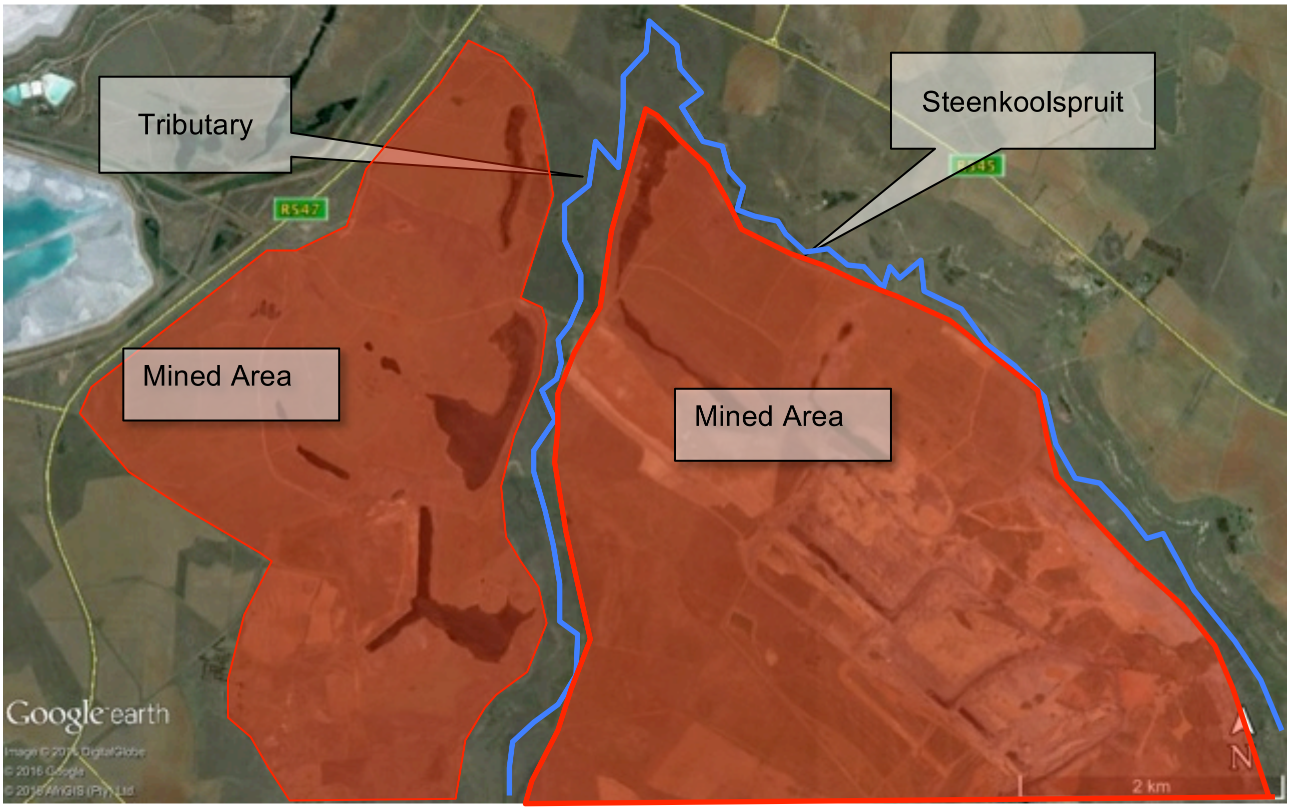

Figure 48 Mined area between and west of the Steenkoolspruit and its tributary near Kriel

7.3 FREE DRAINING SYSTEM WITH MINING IN CATCHMENT: JAGLUST

An example of a free draining system where the mine is situated within the headwaters (or recharge area) of the wetlands and streams is the Jaglust mine near Carolina. The site lies in the Bb15 land type. The pre- and during mining Google Earth images are provided in **Figure 49**. The hydrological setting is provided in **Figure 50** with **Figure 51** providing a more detailed indication of surface water flow paths on the site (with original contours superimposed on a recent satellite image with the mine footprint visible). From the maps it is evident that the mine is situated within the recharge zone of the streams and seepage wetlands as well as a pan that was situated on the crest.

A transect through the landscape perpendicular to the drainage lines (**Figure 52**) was generated and is provided in **Figure 53**.

Figure 49 Google Earth images (top: 2006/10/11; bottom: 2013/01/09) indicating the transition of the landscape and the mining impacts on the crest of the landscape with the disappearance of the pan

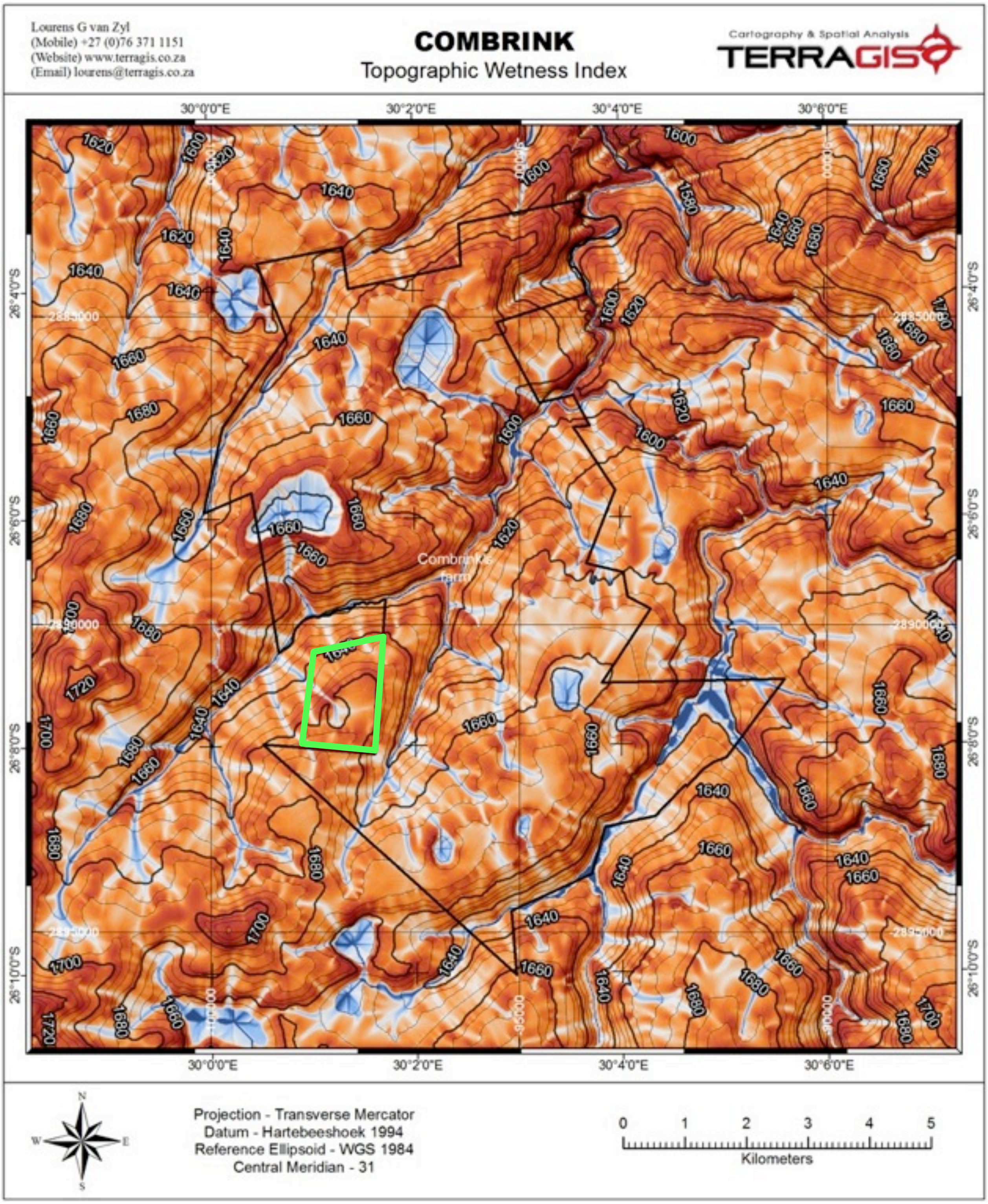

Figure 50 Position of the Jaglust mine (green polygon) relative to the farm area imposed on a TWI of the general area

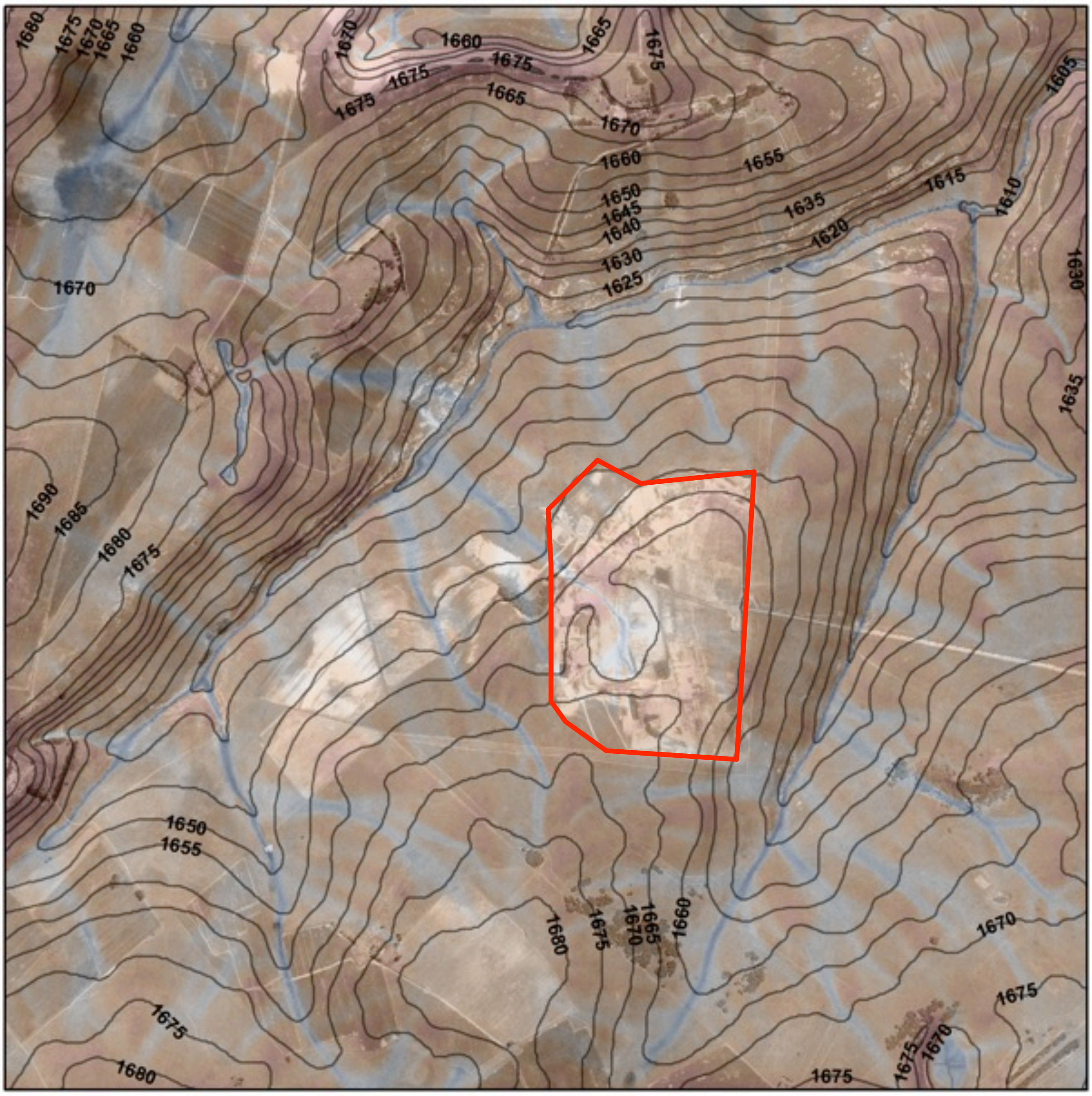

Figure 51 Position of the Jaglust mine (red polygon) relative to the two drainage features on the western and eastern side as well as the drainage depressions from the crest

The impacts that are expected in terms of hydrological functioning are similar to those discussed in section 5.9. The water quality parameters are not known for the site but the EMP of the mine should provide an indication of the acid-base accounting for the materials and the expected water quality that will flow out of the mine void over time. It is expected with a large degree of confidence that the mine will lead to an increase in sulphate levels in the streams surrounding the mine. The impact on acidy cannot be predicted without the data regarding the acid-base accounting. The challenges regarding the water yield and quality management of this site will depend entirely on the commitments made by the mine in the EMP and the successful execution of the commitments into the long-term future.

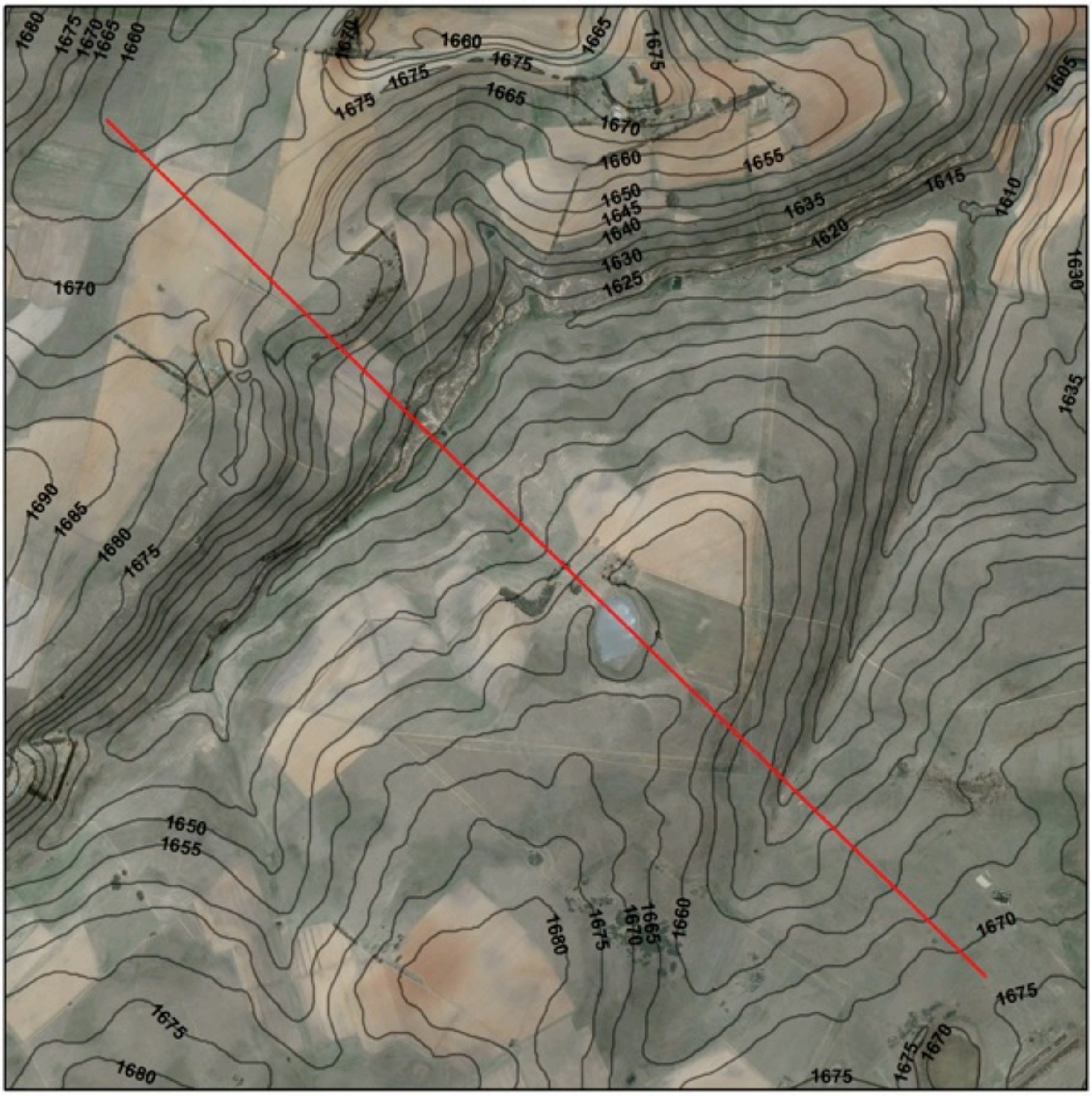

Figure 52 Transect along which a profile was generated

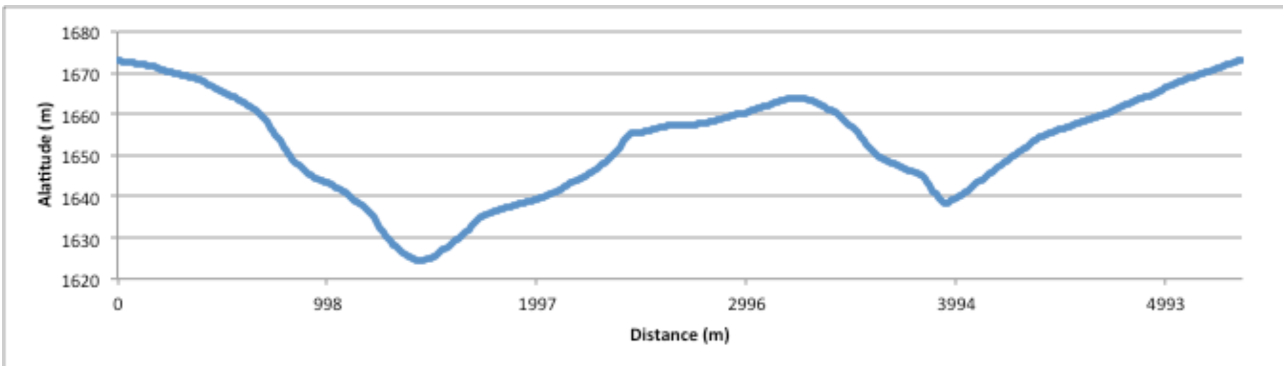

Figure 53 Transect through the Jaglust mining area site indicating the proximity of two drainage depressions

7.4 FREE DRAINING SYSTEM WITH MINING IN CATCHMENT: SEVERAL MINES IN ONE CATCHMENT - ELANDSPRUIT

An example of a situation where several mines occur in the same catchment is found in the case of the farm Elandspruit near Middelburg (Ba37 and Ba4 land types). The digital elevation model of the site is provided in **Figure 54**. The satellite image of the site with the catchment is provided in **Figure 55** and the TWI is provided in **Figure 56**.

It is important to note that the impacted watercourse has a catchment that is situated to the east. This catchment consists of the recharge zone for the subsoil lateral flow paths of water until these daylight close to the start of the watercourse.

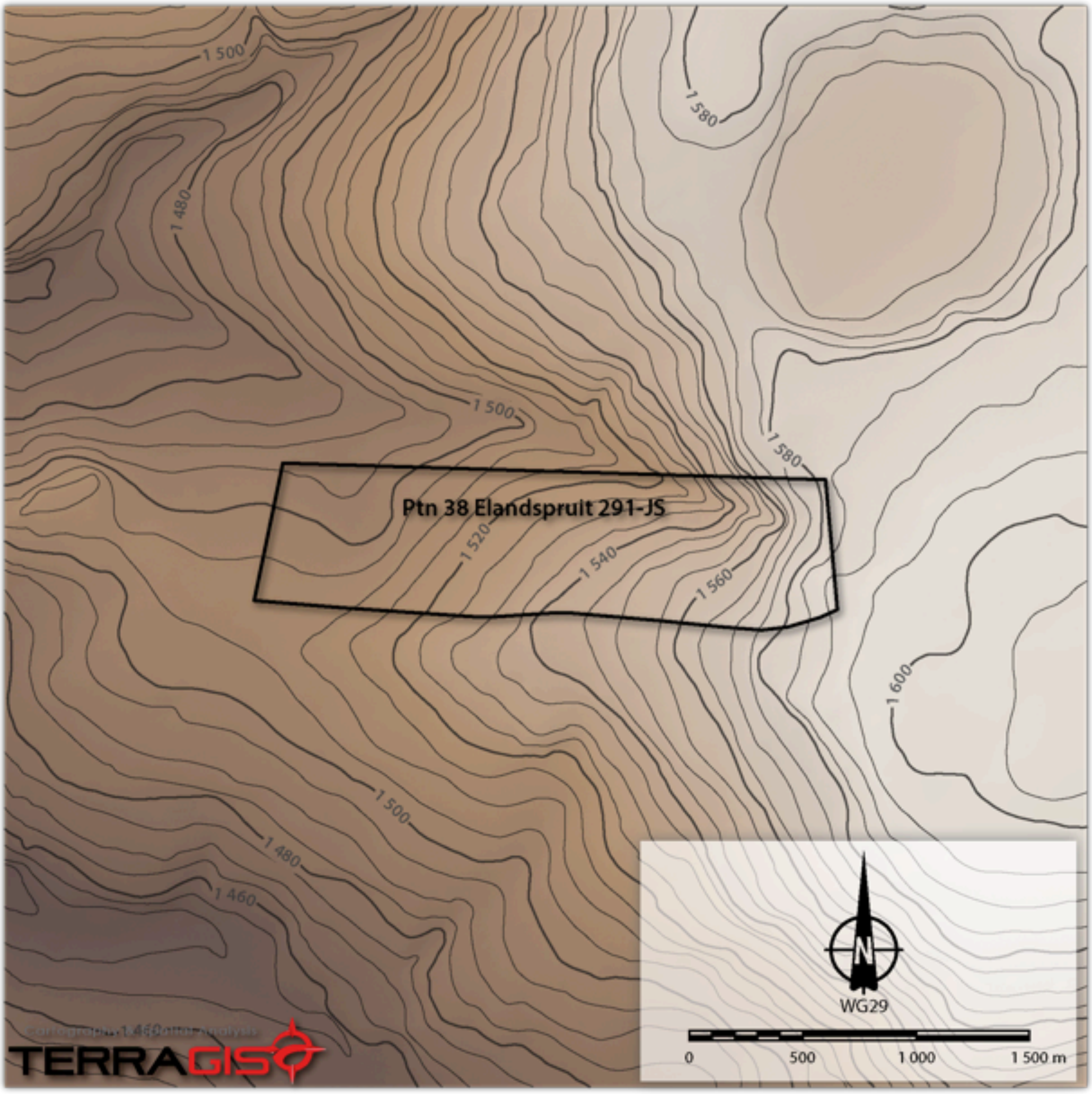

Figure 54 Digital elevation model (DEM) of the Elandspruit farm mining site and its drainage feature

Figure 55 Satellite image of the Elandspruit farm mining site and its drainage feature with the surface water catchment of the watercourse.

The catchment indicated in Figure 53 does not necessarily correspond with the “headwaters” of the wetland as the recharge zone for the watercourse may be larger or smaller due to the variability in the geological layers underlying the soils.

The challenges regarding this site are found in the following:

1. The fact that several small mines are situated within the catchment is a challenge. These mines are, as far as this author’s knowledge stretches, not required to generate an integrated water management plan This responsibility lies primarily with the mine closest to the watercourse – an aspect that does not make sense since the subsoil flow paths of water do not follow mine boundaries. In this case the best approach to the management of the water quality and quantity that will eventually flow into the

watercourse will be to generate an integrated and combined water management and treatment plan for all the mines.

2. The permitted distance from the mine to the watercourse is often determined on the basis of a wetland delineation exercise. It is very obvious in this case that the wetland boundary has no correlation with the extent of the recharge area and catchment. The imposition of a buffer is therefore an exercise in futility as the water impacts will be significant irrespective of the distance of the mine from the wetland.

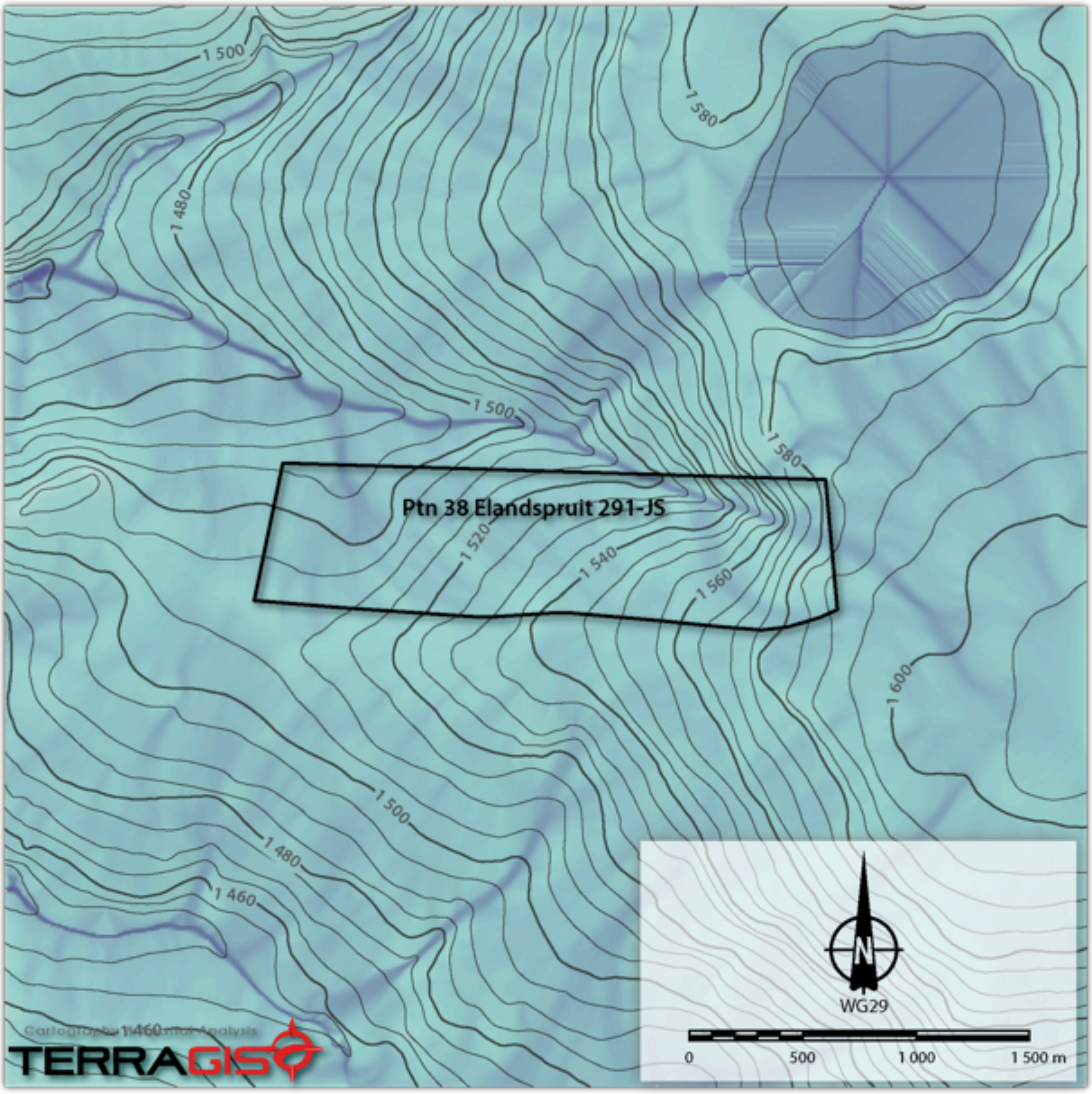

Figure 56 Satellite image of the Elandspruit farm mining site and its drainage feature with the surface water catchment of the watercourse.

7.5 INWARD DRAINING SYSTEM MINED COMPLETELY: MAFUBE

Several examples exist regarding the mining of the complete catchment and wetland on inward draining systems. A distinct example is the pans of Mafube (Ba 19 land type) as discussed in 5.9. The essence of mine planning process in the case of Mafube was to design a completely new landscape with the following characteristics:

1. Alteration of the pre-mining topography, that was inward draining, to a free draining system that would link up with a watercourse to the west and that is situated significantly higher that the decant point for the water that would fill up the voids underground. This was planned specifically for a stability safety purpose.
2. Establishment of a number of depressions on the rehabilitated area that will act as water reservoirs to mimic pan wetland systems. The water flow into and out of these systems is designed to be on the surface as subsoil flow zones would pose stability challenges in the consolidating material. Additionally, the maximum free water level allowed in the "pan" systems was set at 40 cm to prevent large increases in mass on the rehabilitated material. Excess water in the pans would be released through free draining surface structures.
3. The dispersive soils mined from the original pan basins would be used as the bulk of the soil win the new pan systems. Due to the dispersivity of the soils they would 1) yield adequate natural liner material if placed in the depressions and 2) would pose significant stability challenges if used on slopes. The underlying liners had to be engineered to stringent specifications to prevent settlement that could cause breaches in the liner with a subsequent leaking through of dispersive soil material from the basins once they contain water.
4. The ecological parameters of the new "pan" systems would differ significantly from the pre-mining environment due to the drastic change in hydrological functioning. The only parameter that would be relatively easy to manipulate would be the hydro-period of the pan system that could be managed to approximate the hydro-period of the pre-mining system.

7.6 INWARD DRAINING SYSTEM CATCHMENT MINED: SEVERAL

Several examples exist of inward draining systems that have been mined partially or in which the catchment of the systems have been mined within the Ba4 land type. **Figure 57** indicates a pan of which one half has been mined and **Figure 58** indicates a pan of which a large section of the catchment has been mined. In the case of **Figure 57** it is not clear whether a retaining structure has been constructed on the edge of the mine. This structure would be required to ensure that no leaking would take place from the pan into the mine spoil in the void. In the case of both pans the catchments are significantly impacted and smaller than the pre-mining condition. This implies that both these systems will be drier in the future and therefore impacting on the hydrological functioning of the systems. With an impact on the hydrological functioning it is to be expected that the ecological parameters will also change significantly. An open question is what the EMP commitments of these mines are within the context of the wetland assessments and impact determination that have been conducted during the EIA/EMP process.

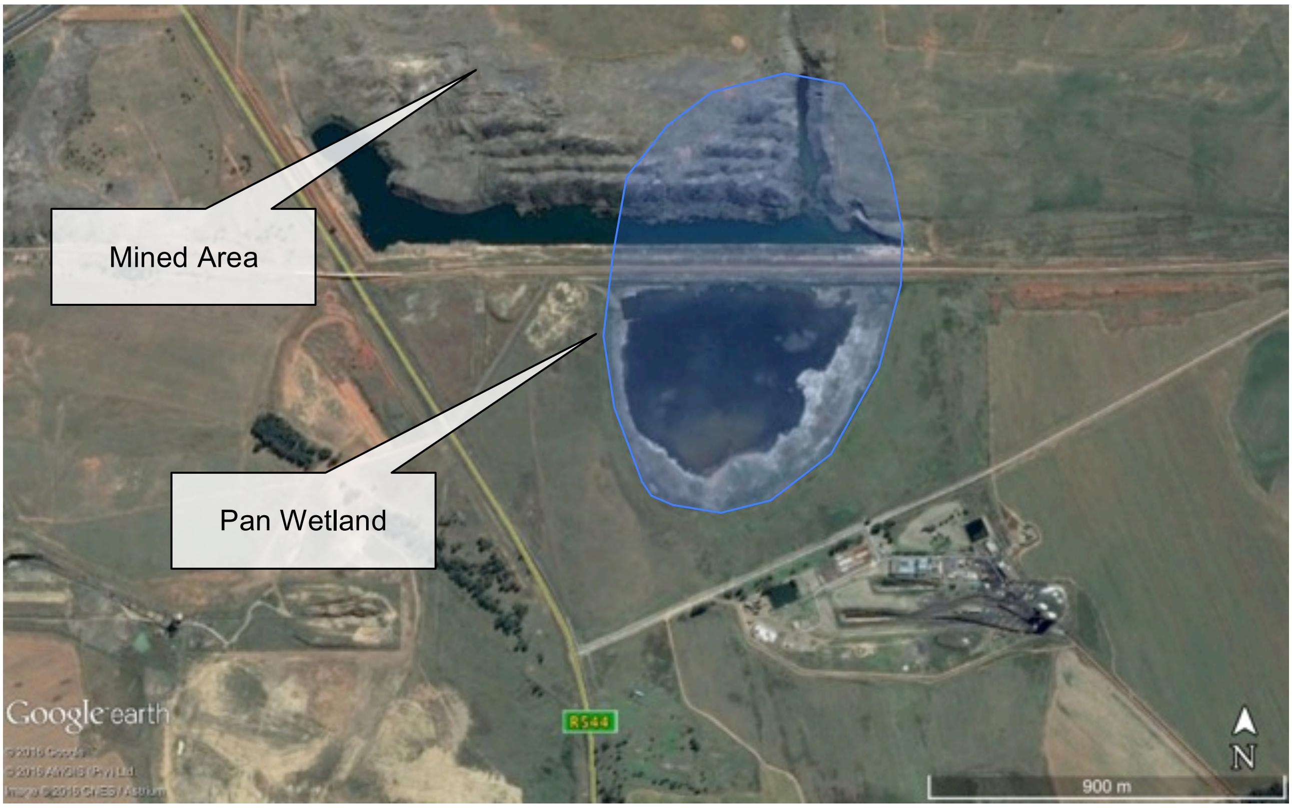

Figure 57 Inward draining pan system that has been cut in half

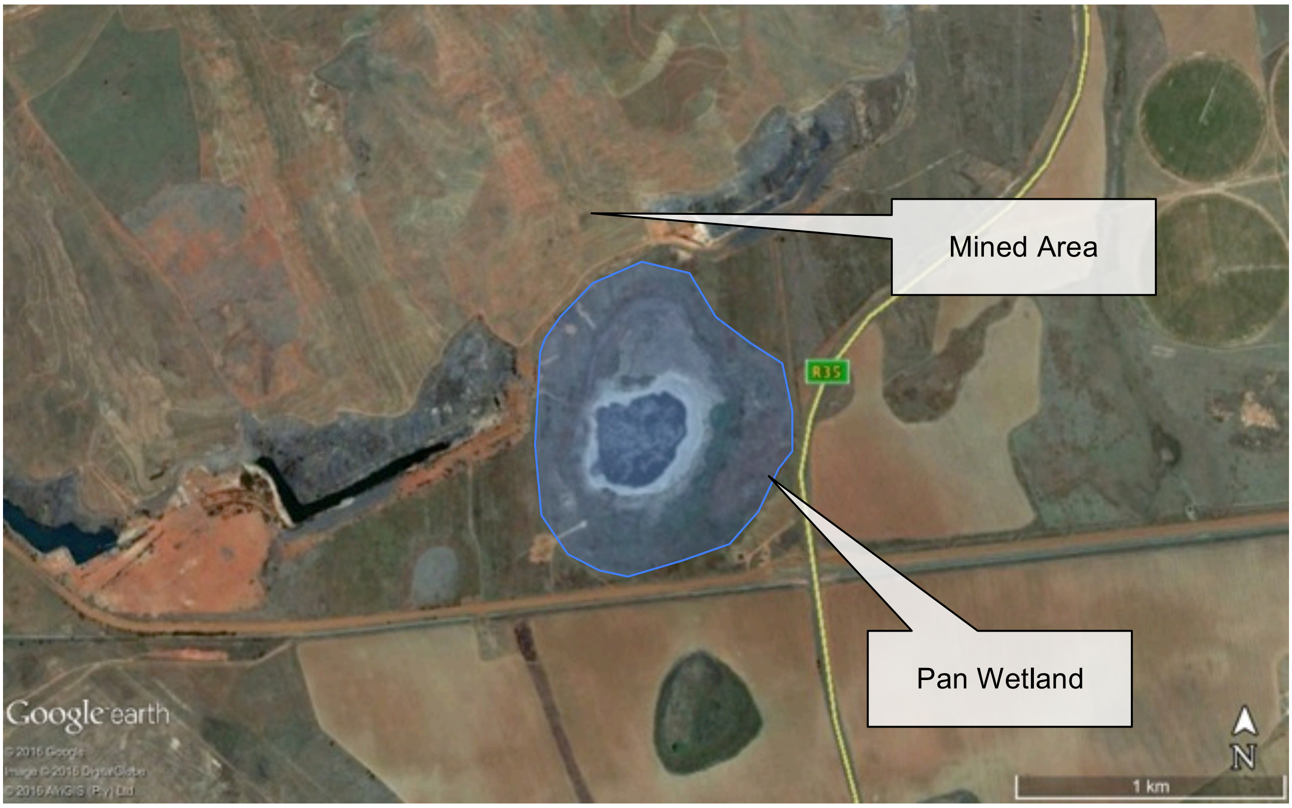

Figure 58 Inward draining pan system of which the catchment has been significantly reduced

7.7 FREE DRAINING SYSTEM WITH MINING IN CATCHMENT AND SIGNIFICANT WATER QUALITY IMPACTS: ELANDSFONTEIN

An example of a mine with significant water generation and quality impacts is Elandsfontein that lies in the Ba5 land type. The overall mine site is indicated in **Figure 59** and this includes:

1. Historical open pit mining area backfilled with carbonaceous spoils the now generate AMD.
2. Coal material handling area and wash plant.
3. Recent open pit mining on the edge of a watercourse.
4. Historical coal stockpile generating AMD effluent.
5. Underground disposal of coal fines generating AMD.

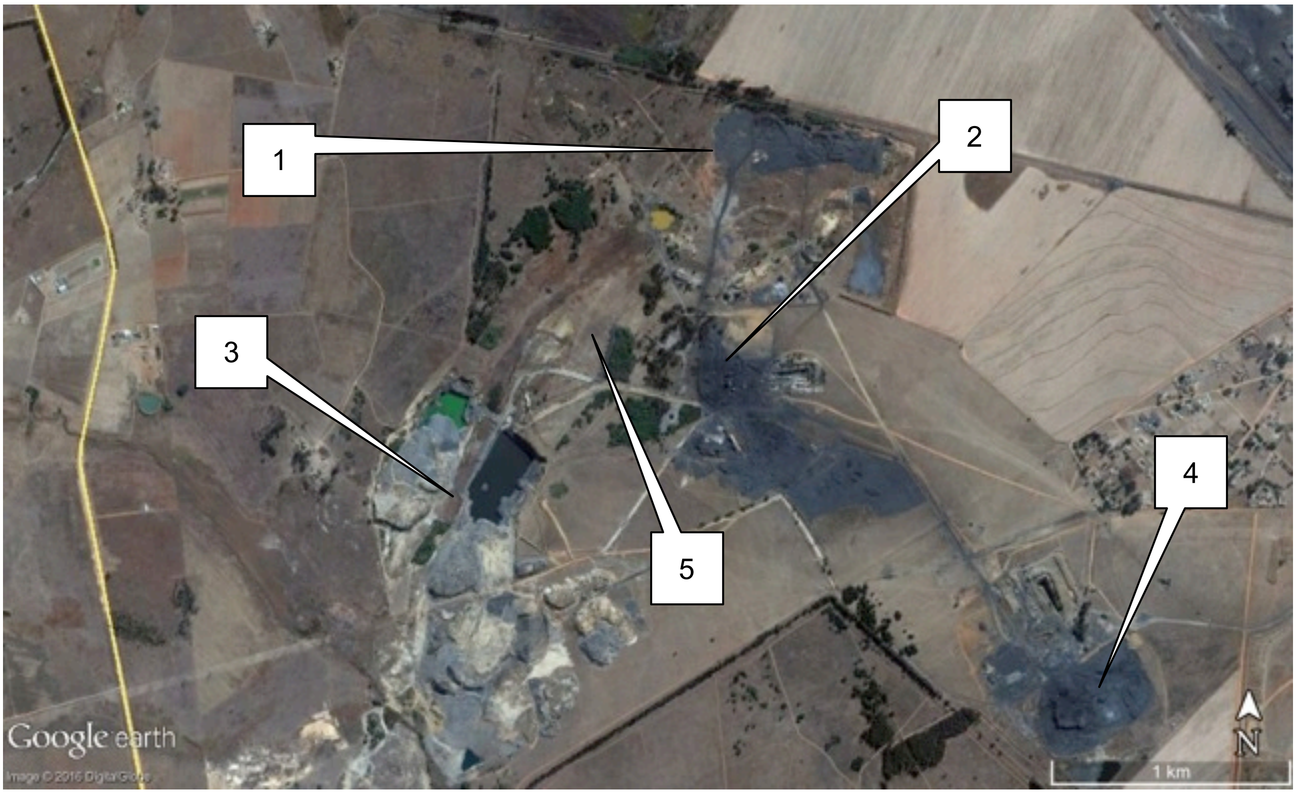

Figure 59 Elandsfontein mine site with various impacts

The main acid mine drainage effluent problems are 1) associated with AMD generated underground in old mine workings filled with coal fines from the wash plant and 2) AMD generated through the oxidation of pyrites in an old coal stockpile. The underground disposal facility is filled with water and the water is flowing out of two boreholes that "punctured" the underground source. (**Figure 60**). The effluent pH is below 3 and the resultant acid water plume is distinctly visible in the image. From the coal stockpile indicated in **Figure 61** AMD runoff accumulates in two unlined containment dams from which the water percolates and leaches underground to daylight in a seep on a different property near surface water bodies (watercourse, wetland and dam). The connectivity of the seepage zone is a function of the landscape's geology and it follows similar patterns to natural seepage areas and wetlands encountered on the Mpumalanga Highveld. The implication of the seep and acid water outflow is that the poor quality water is affecting the water quality and land management options of other landowners and water management authorities.

Figure 60 Acid water outflow zone (with visible plume) through boreholes (red arrows) that "punctured" an underground disposal facility

Figure 61 Coal stockpile (yellow arrow) with containment dam (red arrow) that leaks and leads to acid water seeps downslope (green arrows)

7.8 INWARD DRAINING SYSTEM MINE WATER IMPACTED: LANDAU

An example of water quality impacts in an inward draining system is observed in a pan within the Bb5 and Bb13 land types. **Figure 62** indicates the pan system before impact and after the disposal of sulphate rich water into the pan.

Figure 62 Pan system before mine water impact (top) and after disposal of sulphate rich mine water (bottom)

7.9 REHABILITATION SOIL PROFILES AND SPOIL INTERFACE: MAFUBE

The soil and soil cover characteristics of a rehabilitated landscape is provided in soil profiles from Mafube (**Figures 63** and **64**). The soil profiles vary in thickness and overlie spoil material with a high infiltration/percolation potential due to the lack of significant compaction and sealing. Whereas the soil profiles can hold a significant amount of water (dependent on profile thickness, texture and bulk density parameters) it is inevitable that water will percolate through to the underlying spoil. In this case the water contributes to the mine water management requirements, and depending on the acid/base chemistry of the spoil, with a sulphate and/or rich decant water.

Several investigations are focussing on the water management of the soil capping to minimise water impacts. One such investigation currently under way is assessing the irrigation potential of rehabilitated mine landscapes with neutralised acid mine water. There is currently no coherent and sustainable water management strategy for rehabilitated landscapes and research into this aspect is critical as increasing large areas are being altered into these “new” landscapes.

Figure set 63 Soils of the Witbank form with 170 cm and 60 cm soil depths to spoil respectively

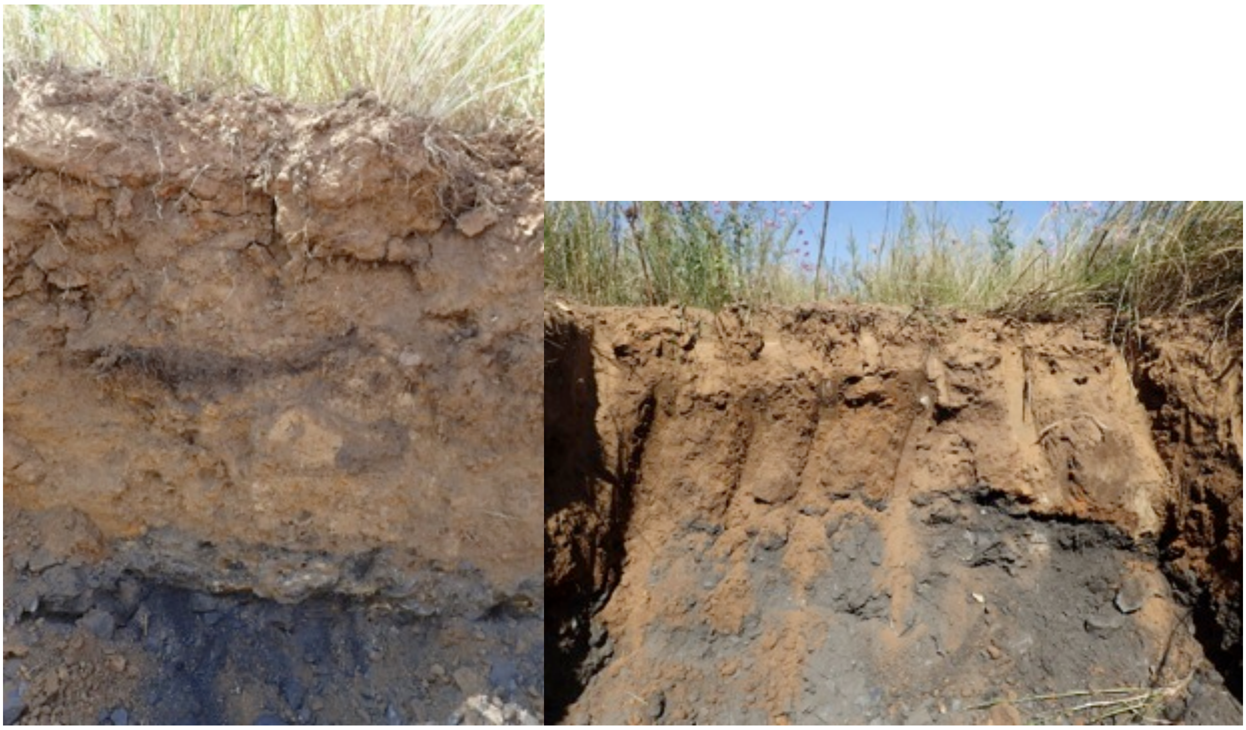

Figure set 63 Soils of the Witbank form with 60 cm and 40 cm soil depths to spoil respectively

8. CONCLUSIONS AND RECOMMENDATIONS

The plinthic landscapes of the Mpumalanga Highveld are characterised by very specific geology, soils and hydrological processes. These processes are the result of the predominantly horizontal orientation of sandstone and coal bearing layers as well as the old and stable landscape in which the soils have formed. Due to the age of the landscape the soils are considered to be very good indicators of landscape hydrology and as such the “hydropedology” is a very useful tool in the understanding, elucidation and conceptual description of water related dynamics and impacts. In this regard the impacts of mining activities on water quality and quantity can be elucidated conceptually through the consideration of the specific mining and landscape context.

Mining impacts have been disaggregated in this manuscript to include most of the various examples that this author has encountered. The impacts are predominantly associated with 1) the alteration of landscape hydrology and 2) the alteration of material properties to increase permeability and specific surface of oxidation sensitive minerals such as pyrite.

Due to the variable nature of the landscape topography and coal bearing layers the impacts very from mine to mine. However, the mines are all situated near to or within hydrologically sensitive areas that also exhibit distinct and extensive wetland distribution. The assessment of these wetlands often rests on the ecological response to the water in the landscape but rarely accommodate the hydrological drivers due to the complexity of elucidating the drivers and flow paths. For an integrated wetland and mining water management solution the only option is to generate suitable information and data to be able to conceptualise meaningful and sustainable water management approaches.

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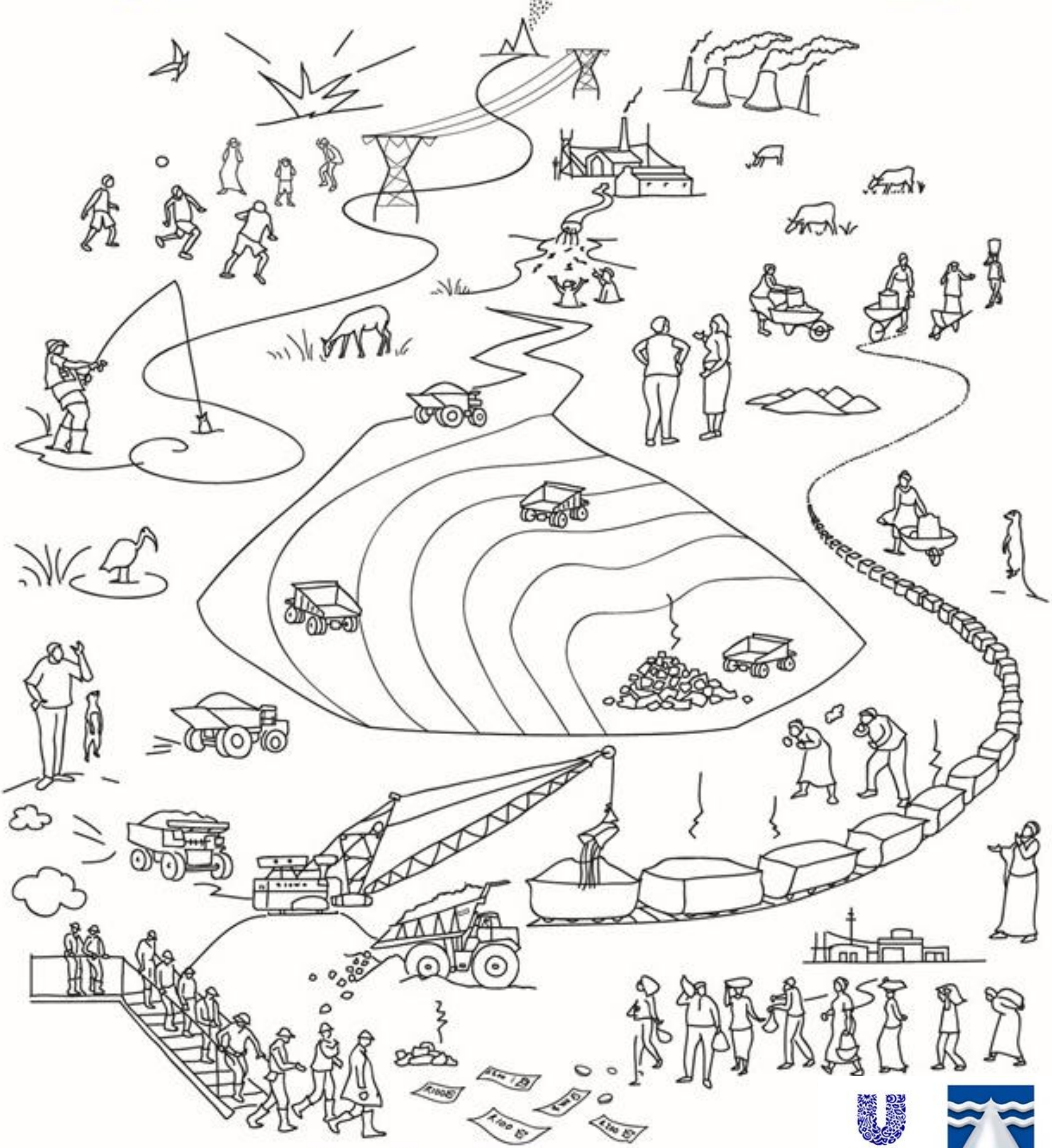
DRAFT

HOW TO...

Engage with coal mines through a Catchment Management Forum

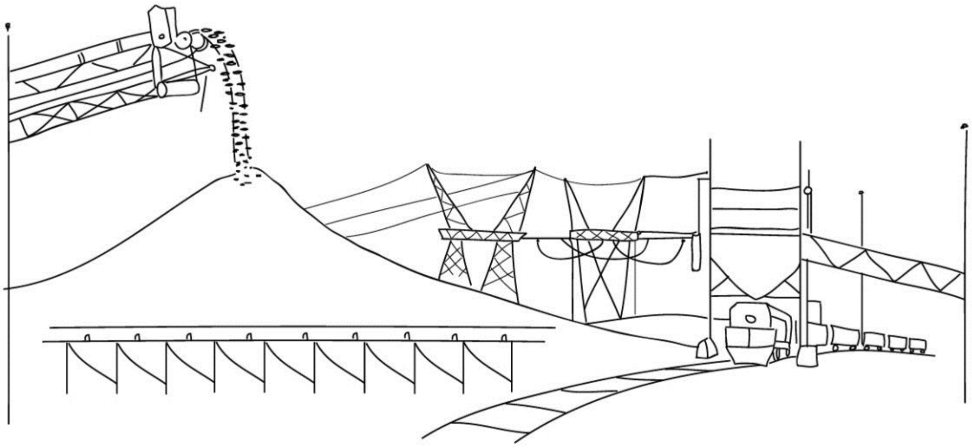


Victor Munnik, Tracy-Lynn Humby, Gareth Thomson, Helen Holleman, Margaret Wolff & Carolyn Palmer

Who is this handbook for?

It's for citizens who want to protect water and biodiversity; for people who are involved in making decisions about coal mining, and people who are concerned about the kinds of decisions being made about coal mining. It's for people who want to know more about the effects of coal mining on the environment and ecological infrastructure*, biodiversity, and on us.

We need coal for electricity, but coal mining damages and destroys our water resources, wetlands and biodiversity*. How can we make good decisions about coal mines and protect our water at the same time?



NOTES:

This book was written for the catchment management forum (CMF) in the Upper Komati Forum (UKF), and they share their experience in order to help other CMFs understand the damage coal mining does to our water resources.

This booklet should be used with *How to Think*… and *How to establish and run a catchment management forum (CMF).*

An * indicates that the word(s) are in the glossary at the end of the handbook.

A true story of a coal mining town

On the morning on 11 January 2012, residents of the small Mpumalanga Highveld town of Carolina woke up to sour water in their taps. The water tasted bad and had a funny colour. Porridge prepared in this water turned blue. A white jelly formed on top when the water was boiled. Residents could not brush their teeth because ‘it felt as if your mouth was on fire’ (Tempelhoff et al, 2012). It turned out the dam was acidic, with a very low pH*.

The Upper Komati Forum was the first catchment forum to be directly affected by acid mine drainage (AMD)* from coal (there are other forums in the Vaal and Limpopo catchments that are affected by AMD from both coal and gold). In 2012, the town of Carolina had no drinking water for seven months as a result of the acidification* of the town dam. The UKF was formed because of this incident. At the same time, the Inkomati Catchment Agency (now the Inkomati Usuthu Catchment Management Agency, or IUCMA) was established. Its purpose is to look after the water resources of the catchment, of which the Upper Komati is a part. One of its functions is to support catchment management forums.

Because of the AMD crisis of 2012 the Minister of Mineral Resources instructed local coal companies to design a common closure strategy – in other words, to plan how water resources will be protected from coal mining pollution <u>during</u> mining operations, and <u>after</u> the mines have closed.

There are a number of medium to small mines in the Carolina area. Some have been abandoned, some are still active above the wetland. From these mines, and the railway siding where coal is heaped, stored, and moved onto trains, acid mine drainage seeped into the mud in the wetland, and collected there over years. Because the rocks in the area are naturally low alkaline*, they could not neutralise* the acidity of the mine water. This acid build-up was unnoticed for decades, because the Boesmanspruit wetland and town dam were used as a channel to transport water from the Jericho Dam into Eskom Nooitgdag Dam, which stores clean water for Eskom’s use. So the acid water was constantly diluted and flushed out. But, in 2012 there was an interruption in this flow.

As a result, the regular stream of clean water for Eskom was no longer diluting the build-up of acidity and heavy metals* from coal mining in the area. Then there was a heavy rainstorm in the upper reaches of the Boesmanspruit catchment (including the Witrandspruit).

After the long, rather dry period, the storm brought 155 mm of rain. The accumulated acid mine water and the heavy metals it contained washed into the town dam, from which the town draws its drinking water. The acid water led to fish deaths, higher levels of sulphates and toxic metals like aluminium, chrome, cobalt, copper, iron, lead and manganese. The town's drinking water purification works failed, because they were not designed for treating acid mine drainage and heavy metals.

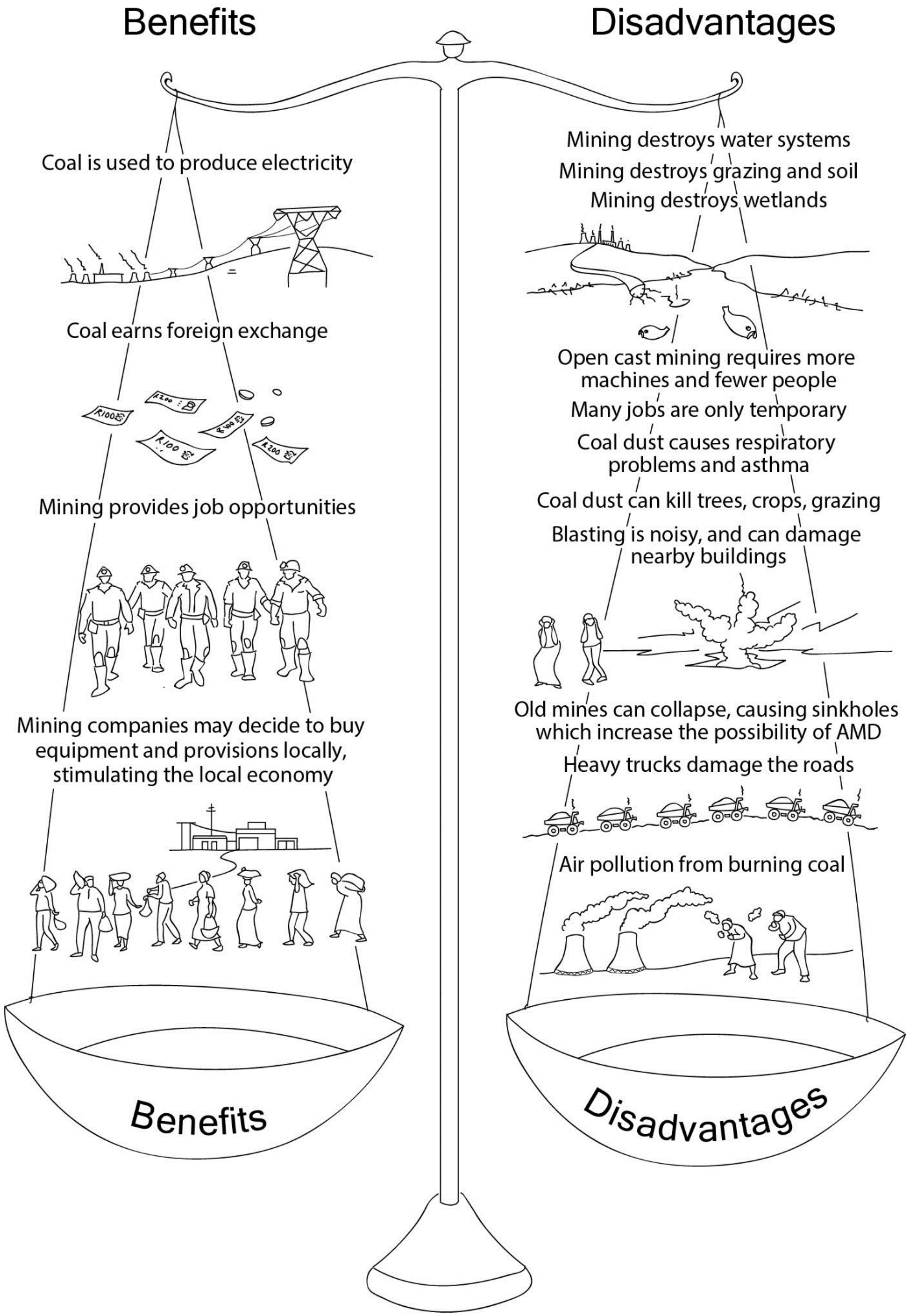
How this handbook was developed

Also in 2012, a mine near Ermelo, which had illegally mined through a river and wetland, agreed in court to rehabilitate* the river. They also agreed to pay money into a WRC research project which would make sure that all damage to the environment or to people (things that that the mines do not usually pay for) would be included in the mine’s cost calculations in future.

The research team worked with volunteers in the UKF and developed a 10-point decision-making process. They also developed a decision support system, which is electronic and publicly available, and they developed this handbook.

Why do we need to balance coal mining with protecting our water resources?

Coal mining has many benefits, but also many disadvantages, as these lists show:

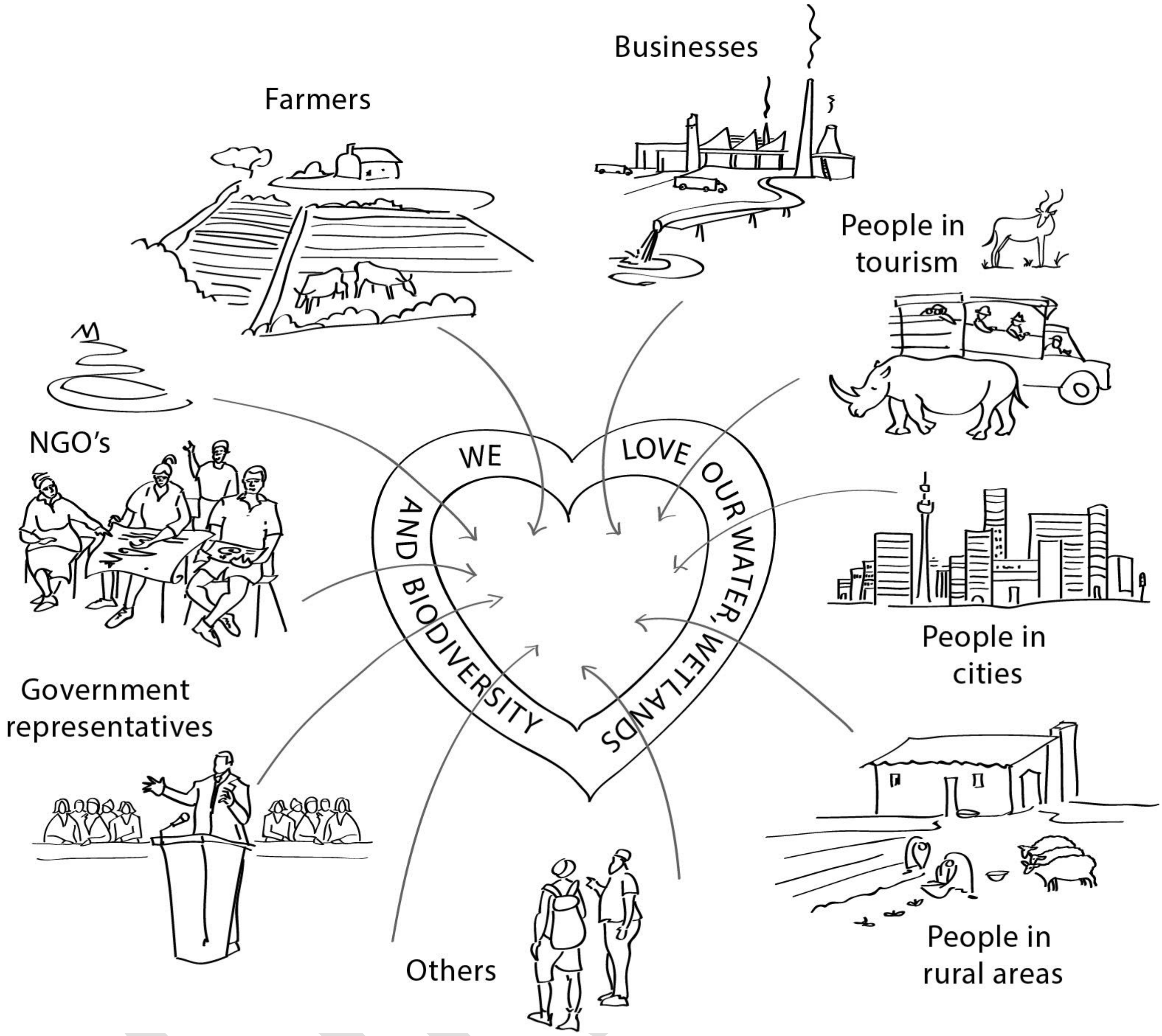


The benefits need to be carefully considered, though. It is true that coal mining can provide job opportunities and local, unskilled labour is often used in the early stages of construction. However, mining companies must explain to the community what the nature of the jobs is and how long they will last. If the companies do not explain, people's expectations are not met, and the community becomes disappointed and angry. As coal mining becomes more mechanised (uses more machines and fewer people), and if it uses the open-cast method of mining, there are fewer jobs and the people who can do them need to be skilled and experienced. It is therefore important to understand the method of mining in order to judge how many jobs it will produce, and for how long.

Mines must develop Social and Labour Plans with the local and/or district municipality as well as with trade unions in order to benefit the community where the mine is. These plans often take the form of the mining company providing a road, or school buildings, or other investments that can benefit the municipality and the local communities.

Coal mining companies can choose whether they buy equipment and provisions locally or not, and they may also choose whether or not to reveal their expenditure locally, provincially and nationally. Most mines can estimate how much coal they will mine, over how many years. These figures can be used to estimate the income from the mine.

The decision to mine, and the decision about where and how to mine, must be carefully considered, and all stakeholders should be involved in the process. Stakeholders include people already living and working in the area; those that are involved in or dependent on land uses that may be threatened by mining, as well as land uses that might be changed or threatened in the future.



Development must be sustainable, which means “meeting the needs of the present without compromising the ability to meet the needs of future generations”, that is, we must use our resources in such a way that there will be resources for our children and their children.

A CMF monitoring the water resources of a catchment should make recommendations to avoid or reduce the damage that coal mining may cause to present and future options for other land uses, such as food security, biodiversity and tourism.

What coal mining does to water resources in the Mpumalanga Grasslands

In the Carolina area, a sandstone* layer a metre or two below the surface keeps water in the soil, enabling plants to grow. Rainwater moves in and along these top two metres, creating springs and wetlands. The coal seams are below the layer of sandstone.

Prospecting holes* can puncture the sandstone layer, and open-cast mining (Figure 2) completely destroys it. No rehabilitation can reconstruct it. Underground mining can cause subsidence*, and cause the sandstone layer to collapse (Figure 4).

Figure 1 shows the relationships between water resources on the surface, water in the soil and the coal below. It also shows the pyrite* (rocks containing iron sulphate*) layer, from which acid mine drainage is released when the rocks are exposed to water and oxygen. The soils and rocks of the Carolina area have a low buffering* capacity, so the area is sensitive to acid mine drainage.

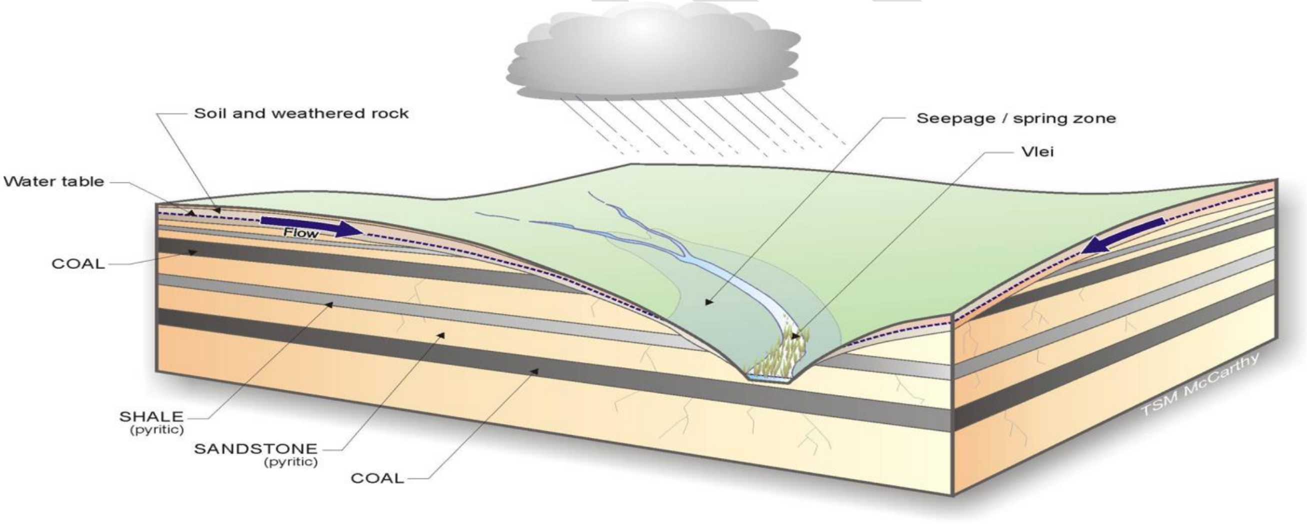


Figure 1. Relationship between surface water sources, soil water and coal seams. (Diagram by Prof T. McCarthy pers comms)

Figure 2 shows how coal is mined using the open-cast method. All the layers of soil, sandstone and shale, including the pyrite which creates acid mine drainage, are removed to expose the coal seams for mining. The 'overburden'* is eventually returned to the mine, if it is rehabilitated (on the right of the diagram). However, because the coal has been removed, there may not be enough rock and soil to fill the hole, leaving a landscape shape that forms a depression where water can accumulate.

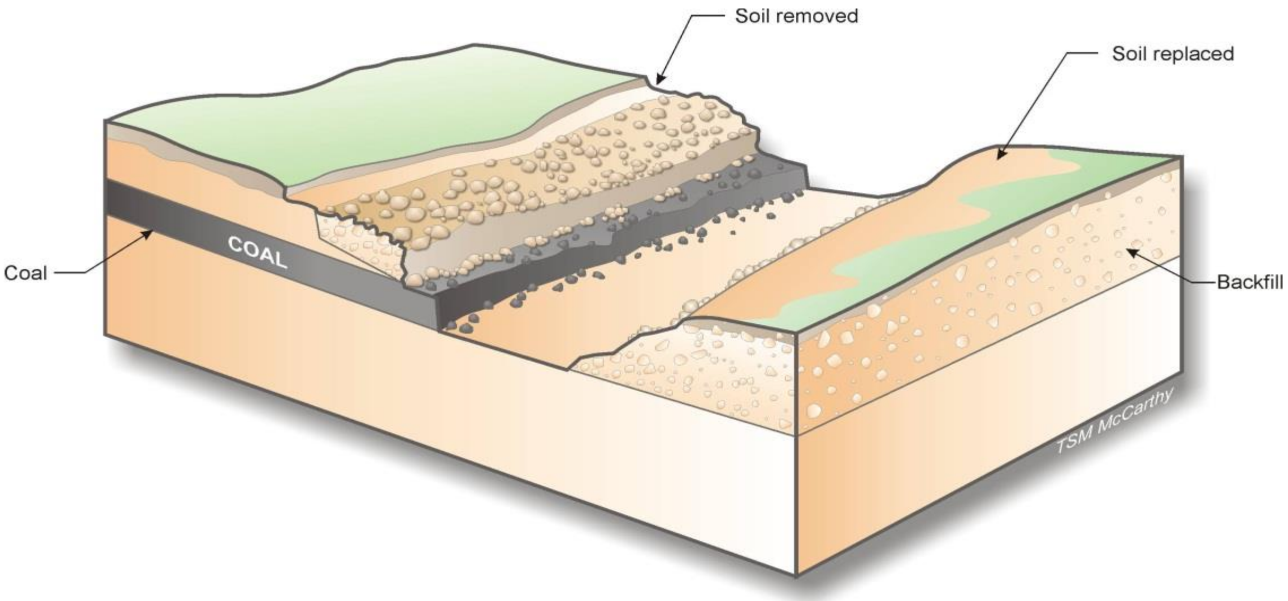


Figure 2. Open-cast mining. (Diagram by Prof T. McCarthy pers comms)

Underground mining uses a method called the pillar and board method (Figure 3). Pillars of coal are left behind in order to hold up the roof which consists of overlying layers of rock and soil.

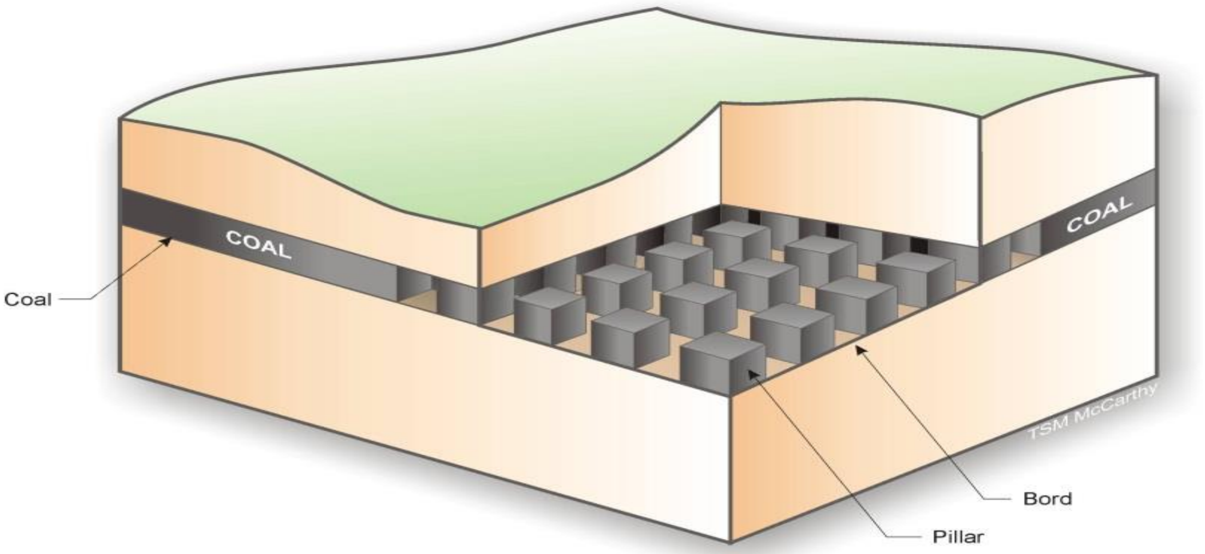


Figure 3. The pillar and board method of underground coal mining. (Diagram by Prof T. McCarthy pers comms)

However, over time, these layers collapse in a typical chequered pattern called 'subsidence' (Figure 4). This happened in mines in Middelburg and Witbank/Emalahleni. Subsidence creates hollows on the surface; clean surface water seeps into the old mine and becomes contaminated (that is, poisoned or polluted) in the form of acid mine drainage. The water also picks up heavy metals.

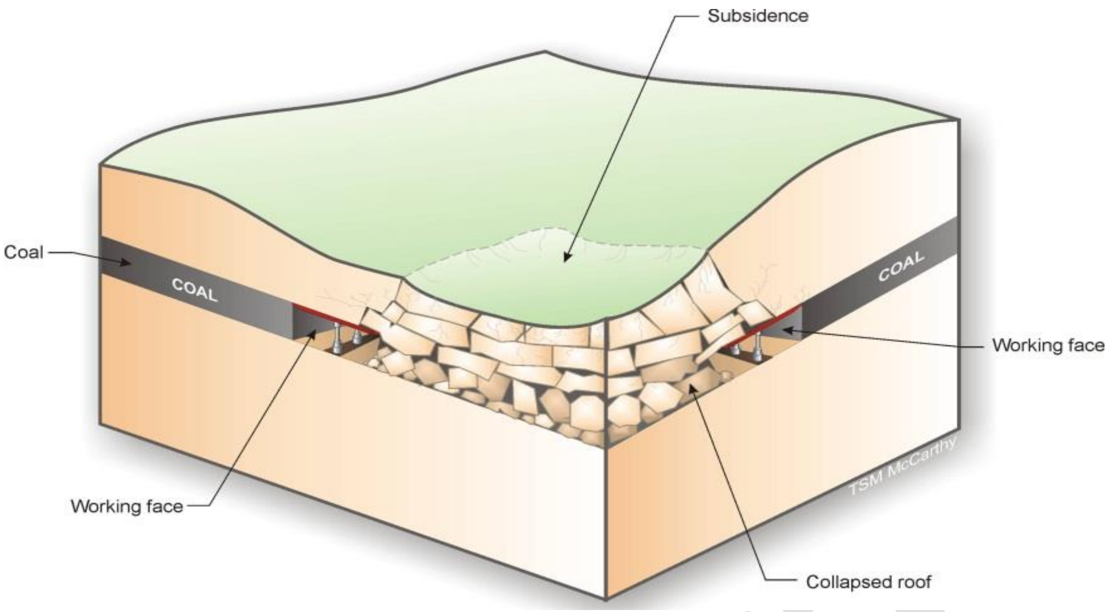


Figure 4: Collapse of rehabilitated pillar and board mine showing subsidence. (Diagram by Prof T. McCarthy pers comms)

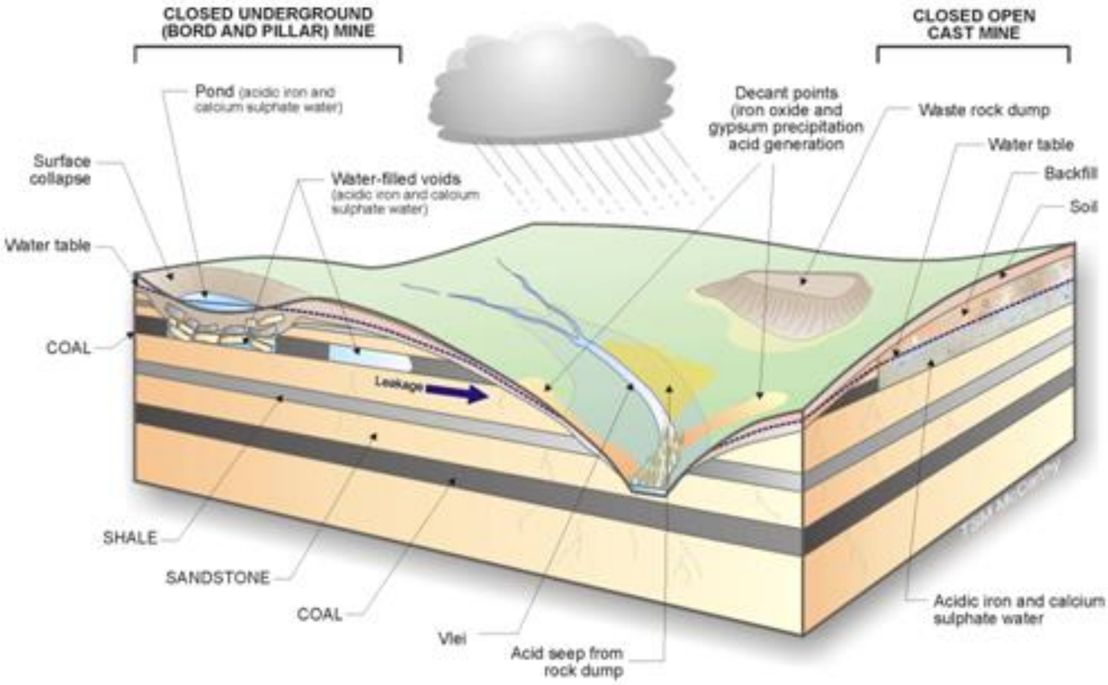


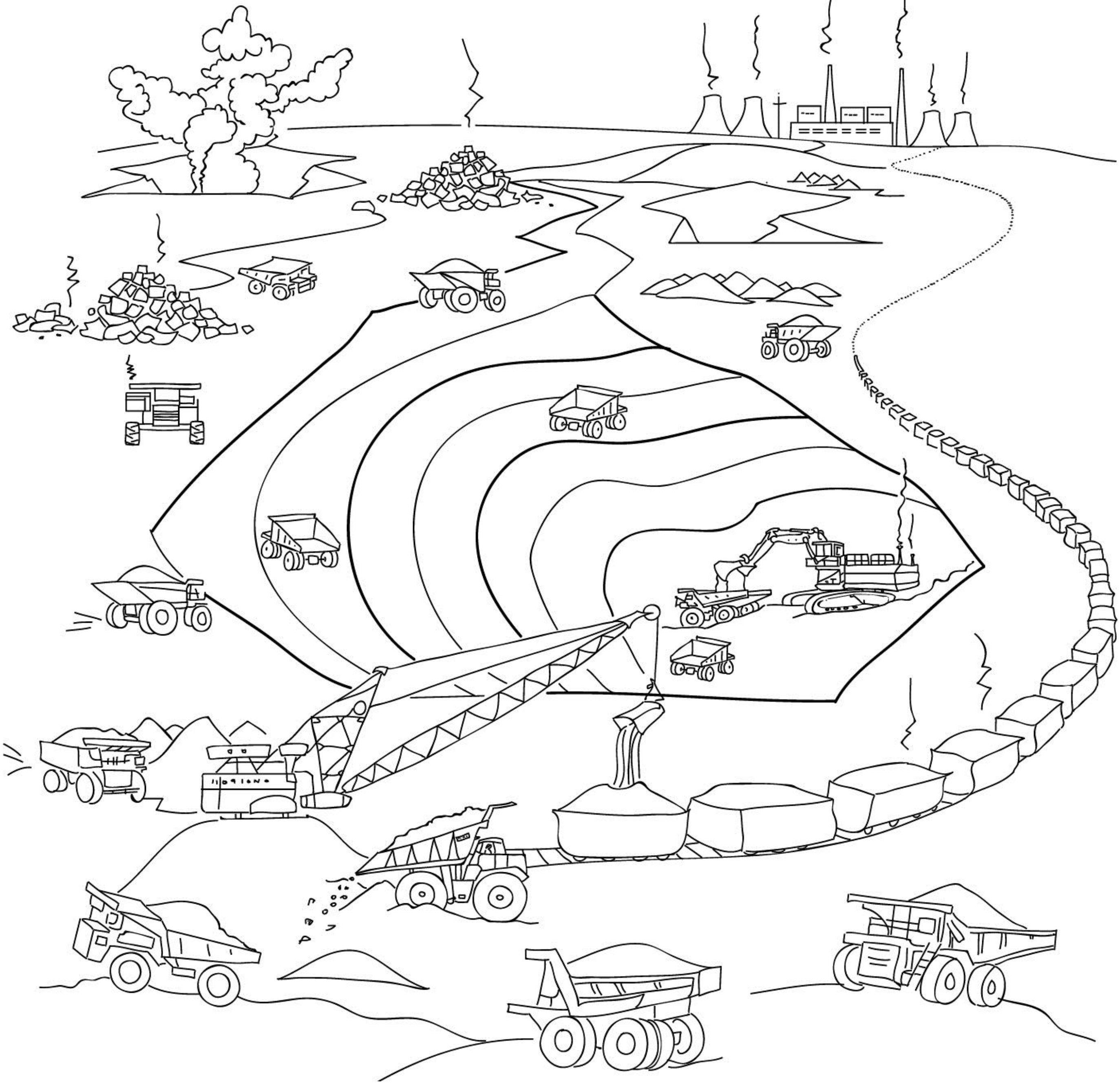
Figure 5. Long-term effects of coal mining. (Diagram by Prof T. McCarthy pers comms)

Figure 5 shows the long-term results of coal mining. The surface of the pillar and board underground mine on the left of the diagram has collapsed, and water is accumulating in it and draining into the mined area. On the right, surface water has also entered the rehabilitated area. From each mined area, a decant point* has developed and is leaking acid mine drainage water into the stream just before the wetland. Contaminated water is also flowing through a rock dump.

The wetland’s functioning is severely compromised, possibly leading to total collapse.

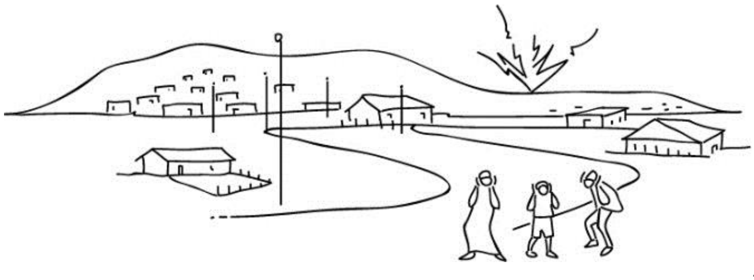
Are there other problems with coal mining?

South Africa has very limited water resources. It is the 30th driest country in the world. Its water resources are fully allocated, so there is none to waste. When coal mining causes AMD, there is even less water for us to use.



Other problems caused by mining include:

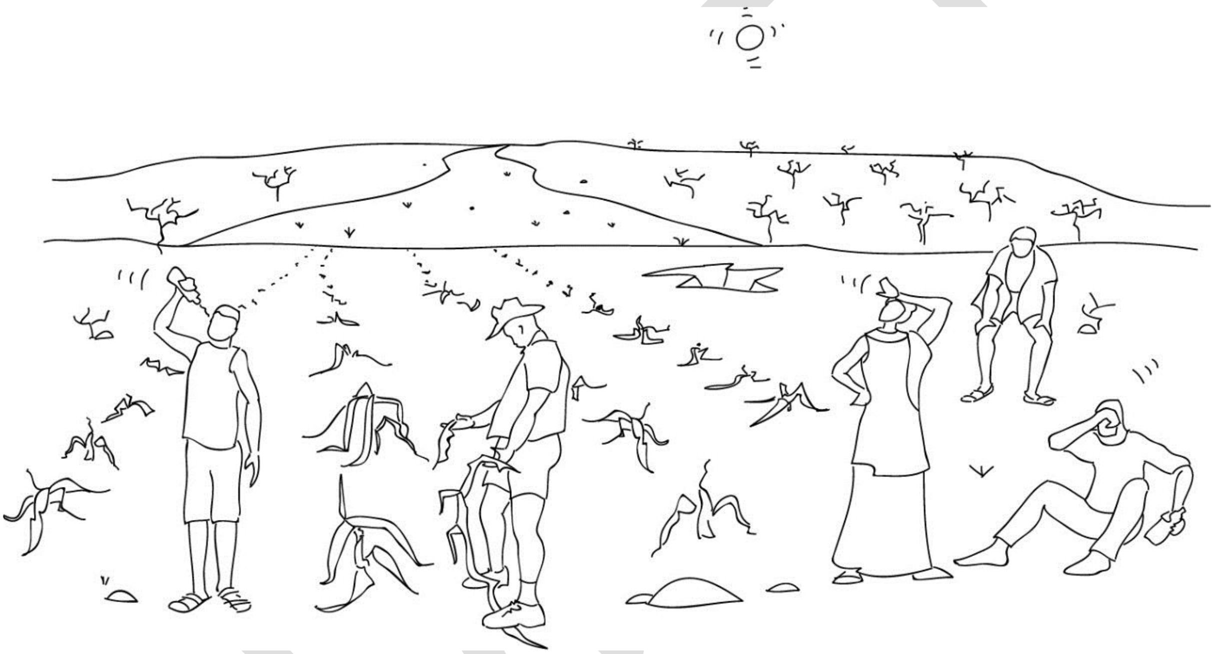
- damage to nearby dwellings from blasting
- disturbing noise from blasting
- dust from mine operations
- heavy trucks on roads not built for them
- air pollution



- dumps of discarded rock and poor-quality coal that burst into flame by themselves (spontaneous combustion)
- abandoned mines where zama-zama (subsistence) miners risk their lives
- interference with farming operations where coal mining has left empty, infertile land, heaps of rock, and other debris.

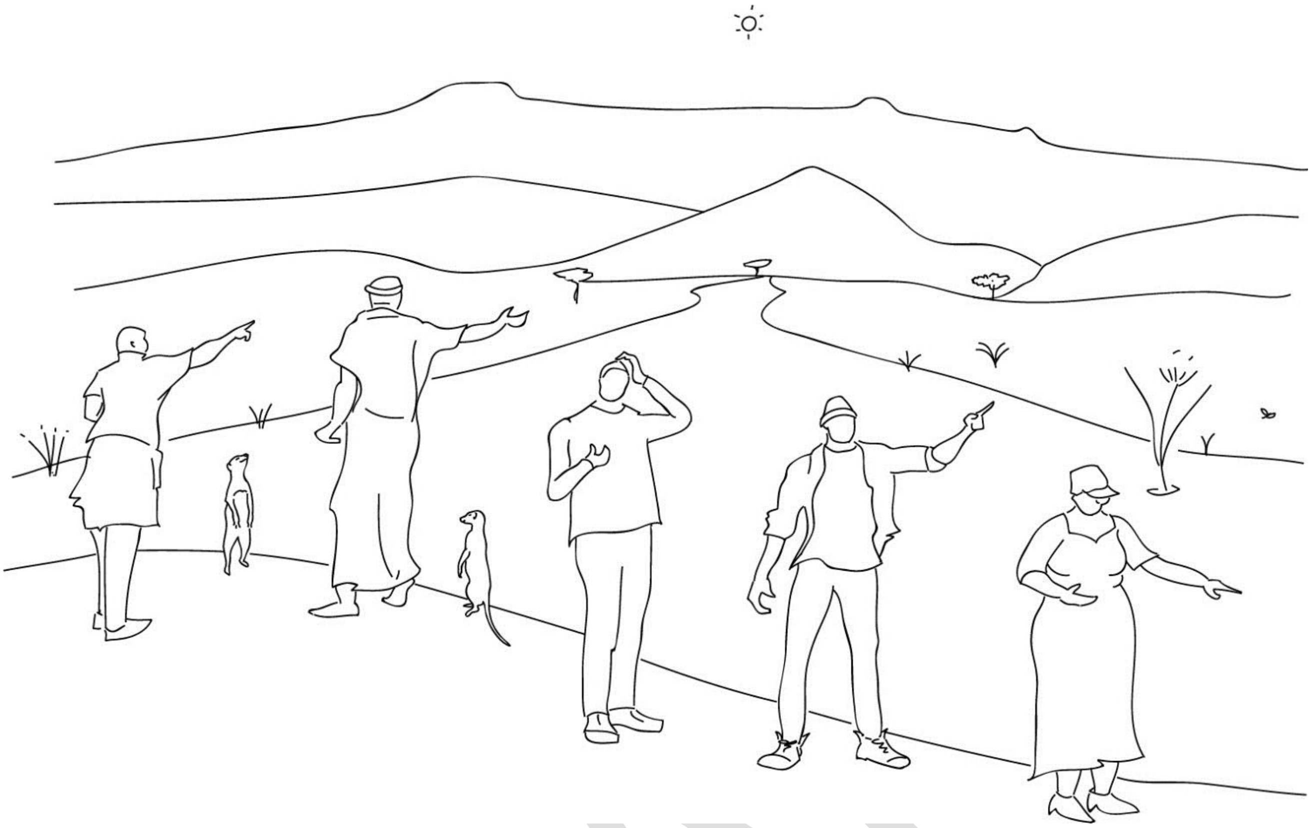
Climate change

Burning coal, especially in coal-fired power stations, is the main factor leading to climate change. Temperatures have already started rising, and a full average 1 °C increase in temperatures is expected by 2020. But the Department of Environmental Affairs (DEA, 2015) reports that in most places in Africa the temperature rises faster (about 1½ to 2 times) than the global average.



For this reason, coal should be used as a little as possible, and we should think very carefully about exporting coal to countries where it will add to climate change. In fact, coal will be used less and less for generating electricity in the future. Many big mining companies (Anglo American, Xstrata and BHP Billiton) are gradually stopping coal mining, or have gone bankrupt (Peabody Coal).

CMFs should think very carefully about which areas should be mined, and which should be left alone.

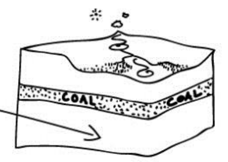


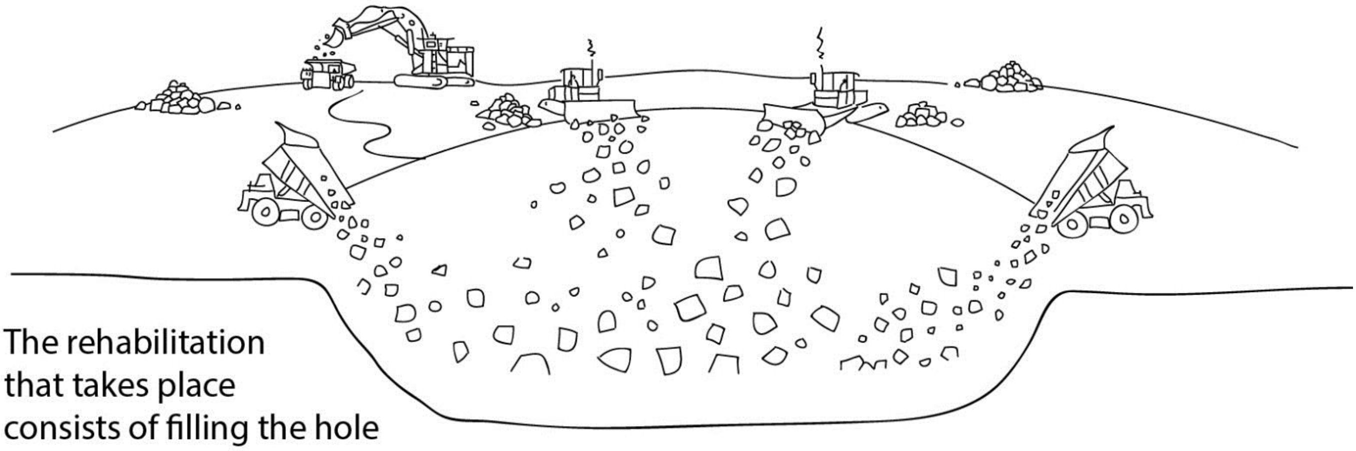
Can coal mines be rehabilitated?

The Carolina district, like most of the Mpumalanga Highveld, has many wetlands and springs. This is because of the layers of rock below the surface. The water lies above a sandstone layer, and a plinthic layer*, which is a layer of clay that stops water penetrating into the ground, and which hardens when it is exposed to the atmosphere.

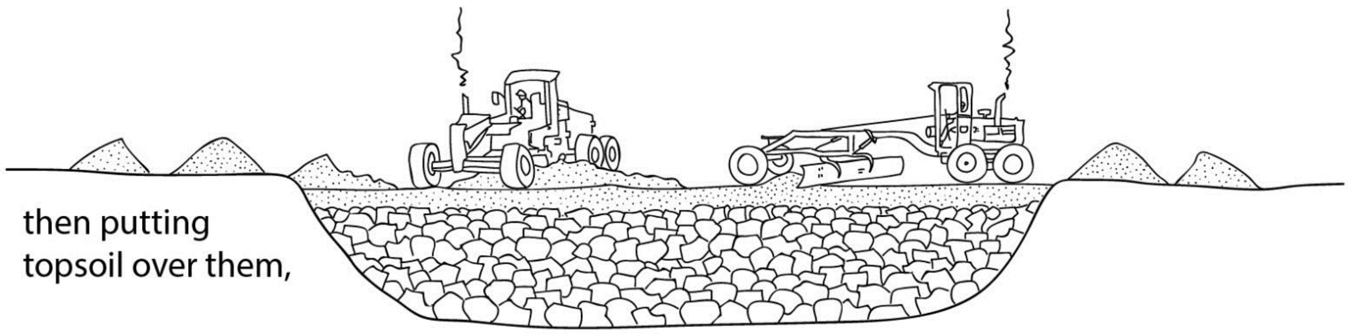
Open-cast mining destroys the sandstone layer, and it is not possible to rehabilitate it. The rehabilitation that takes place consists of filling the hole made by mining with the broken rocks, putting the topsoil over them, and then fertilising and seeding the topsoil to produce a landscaped surface that might be useful for grazing. If the pasture is not good enough, the Chamber of Mines calls it 'wilderness', which is soil that is neither re-established wetland, arable land, nor land suitable for grazing. Rehabilitation does not re-establish the ecosystem*.

Open - cast mining destroys the sandstone layer,
and it is not possible to rehabilitate it.

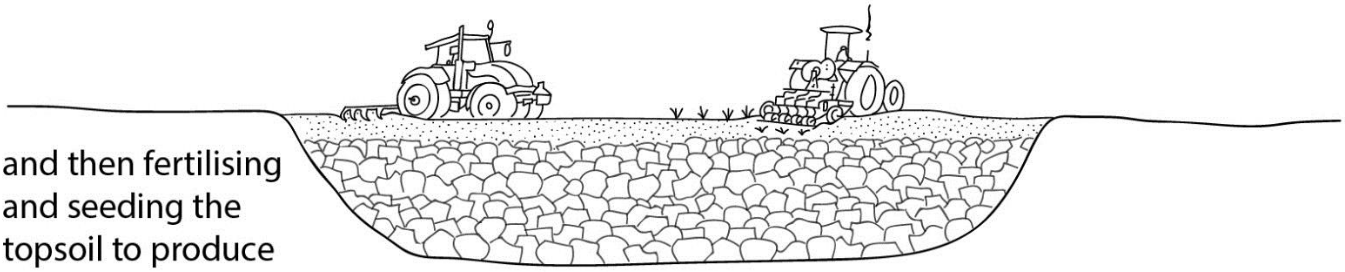




The rehabilitation
that takes place
consists of filling the hole
made by mining with broken rocks,



then putting
topsoil over them,



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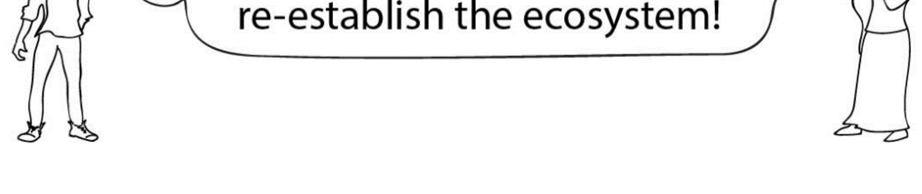


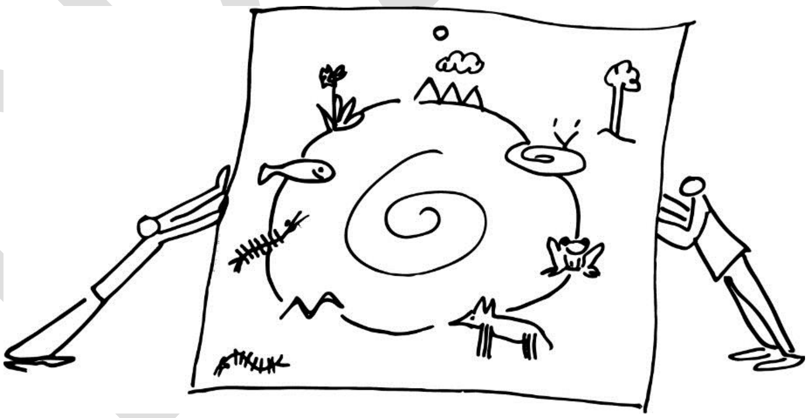
SOLUTIONS

Ecosystems

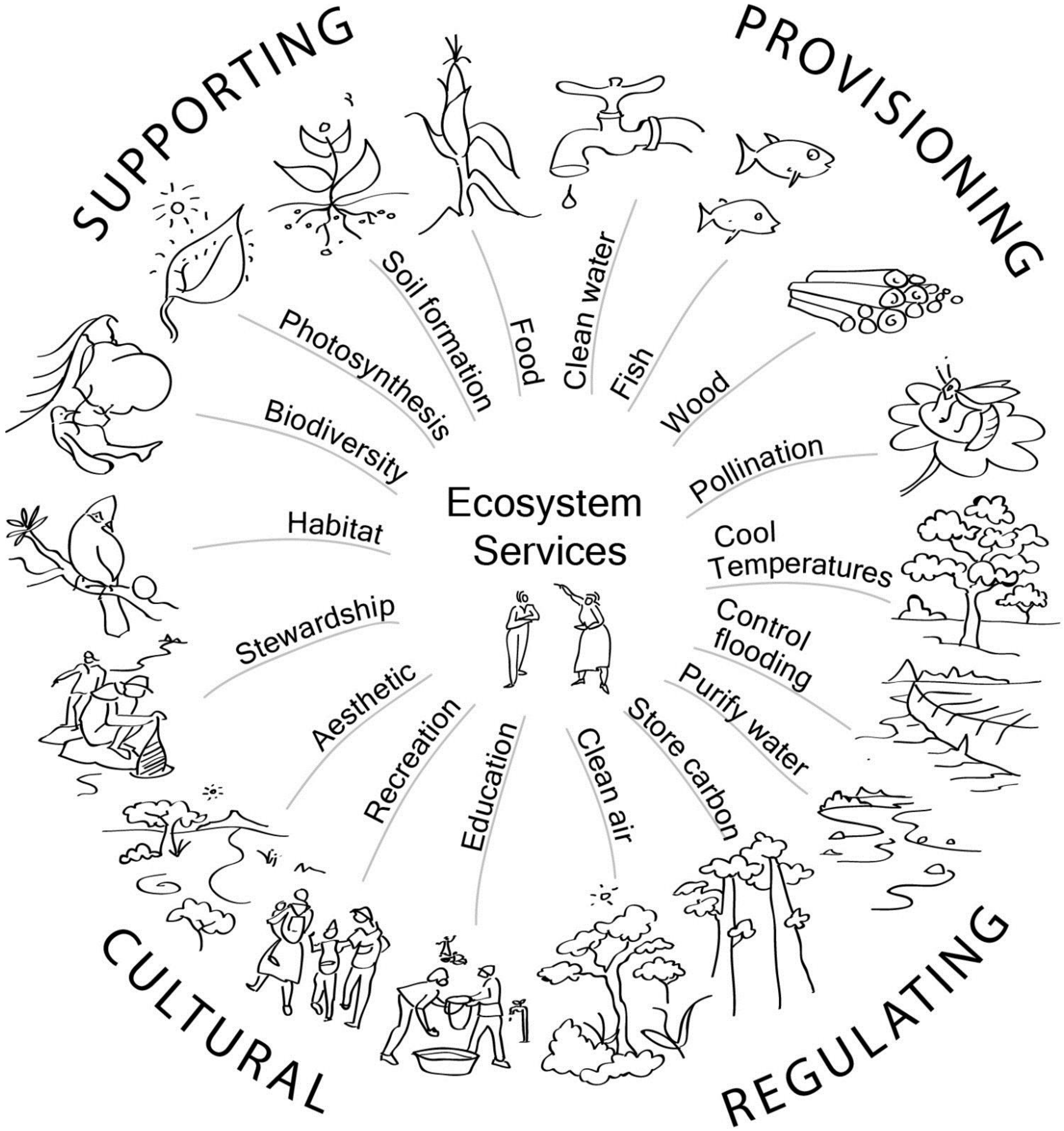
An ecosystem is a complex set of relationships among the living resources, habitats and residents of an area. It includes plants, animals, micro-organisms, water, soil, and people.

Ecosystems vary greatly in size and the elements that make them up, but each is a functioning unit of nature. Everything that lives in an ecosystem depends on the other species and elements that are also part of that ecological community. If one part of an ecosystem is damaged or disappears, it could have an impact on everything else. The ecological processes that happen in it, e.g. functions such as nutrient cycling*, water flows and dispersal keep it functioning as a whole – like the blood in your body keeps your body functioning.

When an ecosystem is healthy, we say it is sustainable. This suggests that the system works, and all the processed that are needed to reproduce the various parts of the system are working.



What do ecosystems provide?



Provisioning services: the harvestable goods or products we obtain from ecosystems such as food, timber, fibre, medicine, and fresh water.
Cultural services: the non-material benefits such as heritage landscapes and seascapes, recreation, ecotourism, spiritual values and aesthetic* enjoyment.

Regulating services: an ecosystem controls natural processes, such as climate, disease, erosion, water flows, pollination, as well as protecting us from natural hazards.
Supporting services: the natural processes such as nutrient recycling, soil formation and primary production that maintain the other services.

When is an ecosystem healthy?
Healthy, natural ecosystems can handle pressures from their environment, moving from one state to another in response to those pressures, but remaining strong. However, certain disturbances, often caused by human beings, move the ecosystem to a state in which change happens too fast, rushes through the system and ruins it.

Signs that an ecosystem is healthy:

a. the system is diverse, and has a variety of plants, animals, insects, etc. in it that live and behave as they used to;
b. the processes that maintain the diversity and complexity of the system are still present.

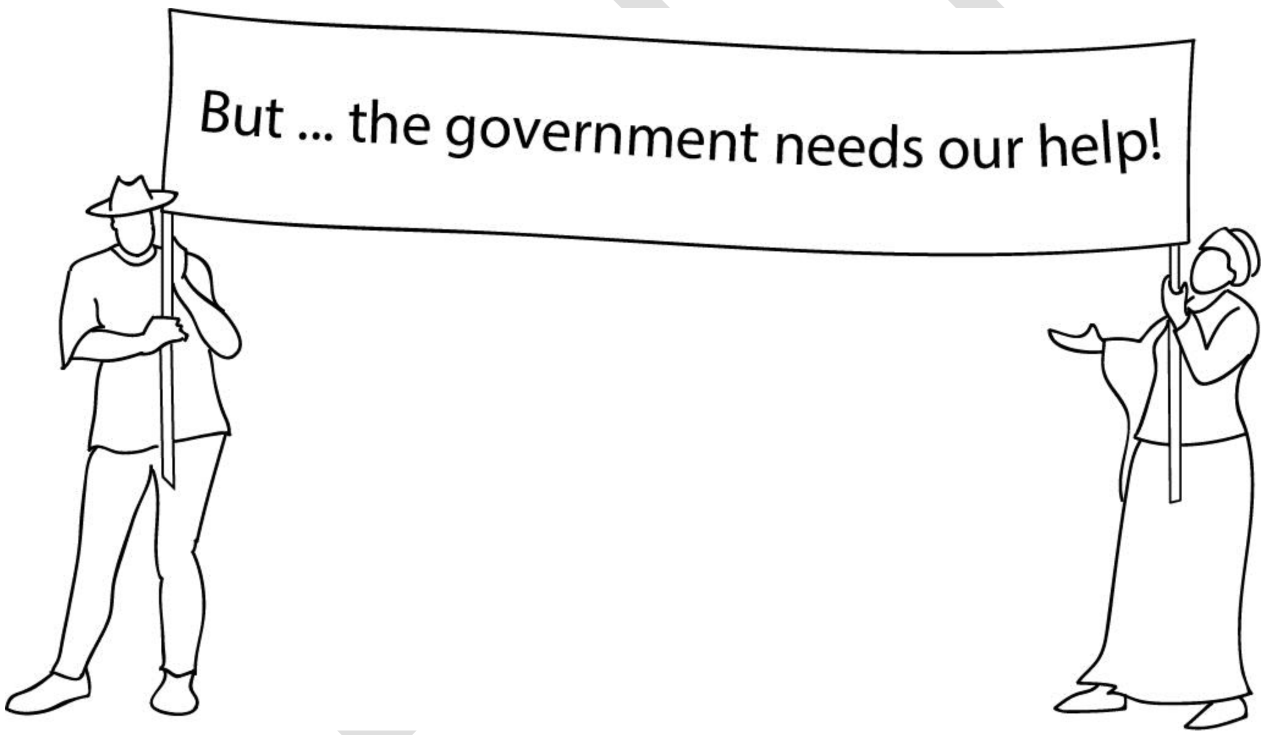
An ecosystem can provide ecosystem services if its self-organising ability is good and strong, and that, in turn, depends on its complexity and biodiversity.

Reasons for protecting the ecosystem are similar to those for protecting biodiversity, with this difference: we value ecosystem because, when we care for it, the ecosystem provides services for humans.

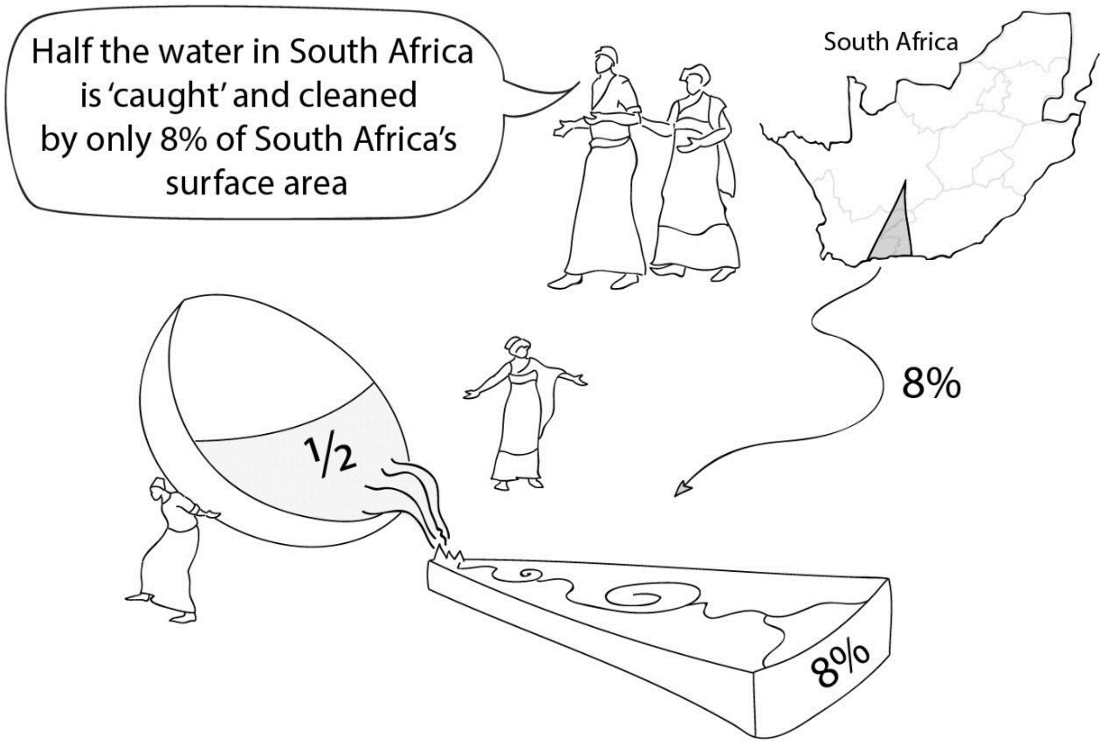
Natural capital and ecological infrastructure

Policy makers and academics often refer to nature as 'natural capital', or 'ecological infrastructure'.

Nature provides many services, so we need to look after it in the same way we look after roads, dams, power lines, etc. However, there are important differences. Natural capital and ecological infrastructure do not belong to anyone – they belong to everyone. We **all** need to look after them.
Legally, water and the mineral resources belong to all South African citizens, and it is the duty of the state (in the form of the Department of Water and Sanitation, Catchment Management Agencies and the Department of Mineral Resources) is to look after these resources on behalf of all South Africans – those alive today, and those who will arrive in the future.



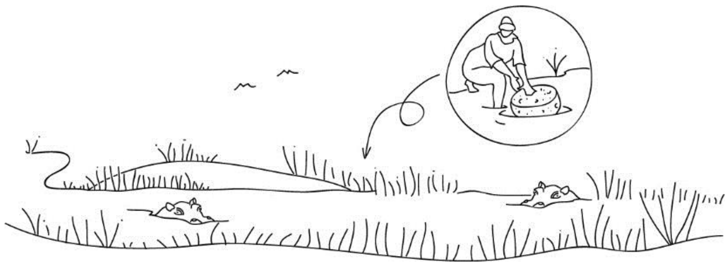
Water resources need your protection
Half the water in South Africa is 'caught' and cleaned by only 8% of South Africa's surface area. So, an area that slightly smaller than KwaZulu Natal and Lesotho captures half the water our country needs.



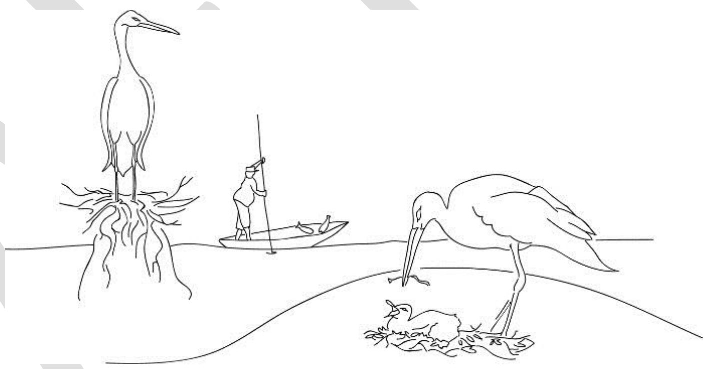
Wetlands*
Grassland areas are important because they filter and store water, and wetlands are especially important for protecting our water resources.

Wetlands are some of the most productive ecosystems in the world. The list below shows only SOME of the benefits they give us:

- They slow down water and create a diverse environment
- They provide a range of ecosystem services:
    - supply fresh water
    - regulate floods (storing water during floods and releasing it later)
    - control erosion (trapping eroded soil and reducing the force of water in the wetland)
    - sustain river flow after the peaks of rainfall (acting as a sponge)
    - recharge groundwater
    - provide food security
    - provide biodiversity refuges and fish nurseries
    - provide places of spiritual, tourism and recreational value



- They are natural filters. They trap pollutants and bacteria that cause disease
- Chemical processes in wetlands can convert potential pollutants like nitrates into atmospheric nitrogen which is released to the air
- Wetland micro-organisms can decompose organic pollutants such as pesticides
- They can trap heavy metals in sediment and absorb excess nutrients. Thus they filter out pollution and clean water
- They spread out the water moving through the catchment and slow it down, thus reducing floods and regulating flow
- They help recharge groundwater
- They control erosion by slowing down water flow and trapping sediments



- They provide diverse habitats to a range of plants, birds, and other animals, some of them endangered
- They trap carbon dioxide, thus reducing climate change
- They may provide grazing for wild animals and livestock (such grazing must be carefully controlled and limited to protect the wetland)

- Many provide fibre for construction and handcrafts, including cultural goods like *amacansi* mats
- Some wetland plants are collected as medicines
- Some wetlands provide fish
- Some are breeding places for waterfowl
- Many provide wonderful places for bird watching

The National Water Act needs your help!
The Act establishes 'suitable institutions and to ensure that they have appropriate community, racial and gender representation'. These are Catchment Management Forums (CMFs) and Catchment Management Agencies (CMAs).

We all need to make sure that the nation's water resources are protected, used, developed, conserved, managed and controlled in ways which take into account things like:

- meeting the basic human needs of present and future generations;
- supporting fair access to water;
- correcting the results of past racial and gender discrimination;
- supporting efficient, sustainable and beneficial use of water in the public interest;
- helping social and economic development;
- finding ways to meet the growing demand for water use;
- protecting aquatic and associated ecosystems and their biological diversity;
- reducing and preventing pollution and degradation of water resources;
- meeting international obligations;
- improving dam safety;
- managing floods and droughts.

How to monitor AMD

Monitoring is an essential part of living with coal mines in a catchment. In the case of Carolina, the AMD event of 2012 led to the installation of a detailed monitoring network in this quaternary catchment (X11B).

Monitoring is important because ... monitoring enabled forum participants to see the consequences of decisions, and use this feedback for current and future decisions. The UKF spends much of its time reviewing data based on water monitoring.

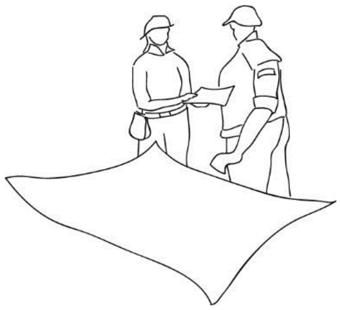
The results from these monitoring points should be presented regularly at the meetings of the CMF, at least every two months. The CMA and CMF should become familiar with the monitoring system, including **what** is monitored and **what it means**. The monitoring takes place within the overall framework of the directive given by the minister of Mineral Resources in 2012, which led to the Golder Report and the recommendations in it.

Monitoring related to coal mine impacts includes:

- Salts, monitored through electrical conductivity. Salts can form when sulphur combines with calcium and magnesium either via treatment, or naturally, as part of the buffering capacity of local soil and rocks. The Carolina catchment has a low natural buffering capacity.
- Sulphur – sulphur that may be released from coal mines and plays a role in AMD.
- pH, or acidity and alkalinity.

How to monitor coal mining

Why do we need to monitor mining? Like most of the rest of the world, South Africa is moving towards more democracy and more sustainability. This road is not easy to follow because it is new. We have to change our thinking about the way we have done things in the past (see How to Think handbook). For example, our economy relied on mining, and we've used coal to generate electricity. But now we are concerned about protecting our water resources and biodiversity, and dealing with climate change. Following this new road leads to a green economy* and democratic ways of making decisions. Catchment Management Agencies (CMAs) and Catchment Management Forums (CMFs) in which citizens protect, monitor and make decisions about our resources, and to which they bring their knowledge and energy are a way of balancing the tasks of making sure our resources meet our present needs, and making sure there will still be resources for our children and grandchildren.



Integrated Monitoring Plan and Decision-Making System (developed in consultation with UKF). These ten steps will take time to implement, but they guide CMAs and CMFs towards integrating and balancing mining development and protecting ecological infrastructure and biodiversity.

ONE

Compile a regional-scale (for example on quaternary catchment scale but nested in bigger scales, such as provincial plans, catchment management strategies) overview of existing ecological infrastructure (water resources, biodiversity, climate and soils for agriculture). This forms part of the Decision Support System. They need to be analysed in terms of ecological infrastructure as they might not be expressed in that form. List authorities and their roles. These plans must be found, brought to the attention of stakeholders and participants in the CMF. The plans are worked through in capacity-building exercises, and then are accessible to all members of the CMA and CMF, both in terms of detail – an URL or on a website – as well as an executive summary for immediate use. All decisions depend on understanding these plans.

TWO

Gather all stakeholders to discuss and establish an overview of land use options and the reasons for choosing those options – cultural resources, needs for historical redress including land claims, options for land use and Integrated Development Plans (IDPs). There may be conflicting agendas among stakeholders, but if the discussions are carried out in an atmosphere of respect and mutual understanding, agreement (if not consensus) can be reached. The advantage of the discussions is that a deeper understanding of a complex situation becomes clearer and trade-offs are possible, or can at least be put into words. All voices should be heard, and options should be considered in the long-term rather than in the immediate or short-term.

THREE

Develop directions for long-term development in terms of the National Development Plan, including options for (and resources needed for) a changeover to the green (low carbon) economy. This involves assessing current economic activities and their impacts, and imagining the change from what is practised now to what the future may be. This discussion should be part of any decisions about coal mining and water.

FOUR

Assess coal mining options in terms of:

4.1 benefits to the national and local economies
4.2 impacts on hydro-ecological-infrastructure (water resources, the ecological infrastructure)
4.3 whether proceeding with coal mining would make competing land uses and other development options impossible in future
4.4 future costs of rehabilitation and restoration of land (eco-infrastructure).

Based on the plans developed in Step 3 above, assess the current and proposed future uses of ecological infrastructure in terms of how those uses relate to current economic activities, and also how they support or eliminate future uses of ecological infrastructure in a green economy. These discussions should happen in an atmosphere of respect for each other and as a result of empowerment and dialogue-type facilitation.

FIVE

Weigh up the options in terms of their sustainable use and impact on eco-infrastructure, future land use and development options, benefits and costs, and need (socio-economic need).

Stakeholders discuss and negotiate, in their own and other forums, such as the local government's Integrated Development Plan processes, departmental processes and in terms of SPLUMA*, how these options contribute to public welfare and the public interest. Stakeholders in the CMFs act as protectors of hydro-ecological-infrastructure. These discussions must happen on a level playing field with empowerment and facilitation for dialogue.

SIX

The knowledge that comes out of these discussions forms the basis of a monitoring system that is supported by legal instruments, for example water-use licences, mining authorisations, social and labour plans, etc.

For the monitoring system to be effective, stakeholders within the catchment area must be able to access, read and comment on these legal instruments, and must be helped to understand and use them. Stakeholders should automatically have access to this information, and actively participate in processing them. Access to the information should be free and straightforward; there should be no legal costs involved. Mines' compliance is made public in a system similar to the Green and Blue Drop incentive schemes.

SEVEN

The decision-making and monitoring system is streamlined in terms of a principled pragmatic approach to IWRM (Integrated Water Resources Management). Documents are concise, accessible and honest.

Decisions and information are written in easily understandable language, are of a reasonable length, and present the relevant conclusions in an understandable way, making it clear, for example, who polluters are, or what the potential for pollution is. Technical data and analysis should be available in appendices, and stakeholder or interest groups have access to publicly-funded technical support to cross-check the conclusions presented and the data and the analysis that these conclusions are based on. Annual reports give information about monitoring results.

EIGHT

Relevant departments participate in and assist this process by offering specialist knowledge, sharing and considering inputs, and supporting participation, especially of historically disadvantaged groups, through capacity building.

All departments understand their duty to invite and support public participation, including through regular capacity building. They have dedicated officials, such as those in CMAs, for this task. These tasks can also be undertaken by civil society organisations or Chapter 9 institutions, with regular monitoring and evaluation by the participants who are supported in this way. These functions are Key Performance Indicators (KPIs) for these departments, according to the principles of *Batho Pele*. The system is underpinned by easy access to information. Media is used extensively and public awareness is built and maintained.

NINE

The CMA co-ordinates the process in terms of water issues. National departments assure alignment and integration with national priorities, through task teams (such as the current AMD task team), with a focus on job creation, to changing to a green economy, etc. Because water is central to most of these land-use options, the Catchment Management system will become stronger through the opportunities for co-operative governance, clear role descriptions and integration of land use plans. Processes to develop, update and extend Catchment Management Strategies are ideal opportunities for this function.

TEN

The Upper Komati Catchment Forum developed a Decision Support System through knowledge of the networking process, as a linked constellation of knowledge resources, including precedents of decision making. Knowledge sources are developed, archived and made accessible, for example, through websites linked to the IUCMA, national, provincial and local governments, as well as civil interest groups. See the section on knowledge resources in this brochure.

STEPS TO GETTING MINING PERMISSON

List of Acronyms:

BAR = Basic Assessment Report
DMR = Department of Mineral Resources
EA = Environmental Authorisation
EIA = Environmental Impact Assessment
EIAR = Environmental Impact Assessment Report
EMPR = Environmental and Management Programme
I&AP = Interested and Affected People
NEMA = National Environmental Management Act

ACTIONS – Mining company	ACTIONS – CMFs and CMAs
A mining company applies to the DMR for the right to prospect/mine right. At the same time, the mining company must apply for environmental authorisation for their proposed mining / prospecting operation.	Register as an Interested and Affected Party (I&AP) which gives you the right to comment on the Mining Application

If the mining company satisfies the preliminary requirements, the DMR will notify the mining company that it accepts the application. *This does not mean that the application is successful.*	
Once the application is accepted, the DMR must (a) instruct the mining company to submit relevant environmental reports (see below); and (b) notify potential interested and affected parties (I&APs) about the proposed mining/prospecting operation. Notices must be put up in various places: DMR offices, Magistrate's Courts, etc., and be published in a local newspaper. Other actions must be taken to make sure that owners and occupiers of the affected land are specifically notified. The notice in (b) should call on Interested and Affected Parties to comment on the application. The mining company must include details of how and to whom to make comments.	If you want to object to or to make comments on a proposed mining/ prospecting operation, you must register as an I&AP. The mining company must keep a list of I&APs. It is important to register as an I&AP because I&APs have an opportunity to make comments on the application process and the various reports and assessments submitted by the mining company to the DMR. Make sure you get notification of the proposed mining/prospecting operation. Make sure you can attend the meeting. Check the notice to see what you have to do in order to submit your comments to the mining company.
In order to obtain a mining /prospecting right, a mining company must submit various documents to the DMR, including: Mining/prospecting right application: Social and labour plan - the role the mining company will play in local	

economic development and job creation during the lifetime of the mine; Draft prospecting/mine works programme: where and how the mining company may mine/prospect; and Environmental Authorisation (EA) application: EAs are issued in terms of the National Environmental Management Act (NEMA). In order to obtain environmental authorisation for mining, a mining company must follow the process for a 'scoping and Environmental Impact Assessment' (EIA). Note: a mining company is only required to submit a scoping report when it is applying for a mining right. When a mining company applies for a prospecting right, a Basic Assessment Report (BAR) is required	
Application for an EA (Environmental Authorisation): the mining company prepares a draft scoping report, showing the broad context of the proposed mining operation. It must explain why the proposed mining operation is necessary and desirable, and explain how the impacts of the proposed mine will be reduced. A copy of the draft scoping report must be made available to all registered I&APS. The mining company must hold a public meeting	Get a copy of the draft scoping report. Read it carefully and attend the public meeting that the mining company arranges. Submit your comments in writing. If an I&AP is given a draft report at a meeting, s/he should not have to comment on that report at the same meeting. That is then an information meeting, which is different from a public consultation, when comments should be submitted.

with I&APs regarding the draft scoping report. I&APs must be given an opportunity to make comments about the draft scoping report at the meeting. Registered I&APs may submit written comments on the draft scoping report.	
Application for an EA: If the DMR accepts the draft scoping report, the mining company will be instructed to prepare two documents: (a) a draft Environmental Management Programme (EMPR) which sets out how the mining company proposes to reduce and manage the impacts of the mine on the environment and how the mining company must rehabilitate the environment after the mining operation is complete; and (b) in the case of a mining right application, an Environmental Impact Assessment Report (EIAR) which is a study which assesses how the mine will impact on the environment. In the case of a prospecting right application, the company prepares a BAR, which sets out the environmental outcomes, impacts and residual risks of the proposed prospecting operation.	
Application for an EA: the mining company must hold another meeting with I&APs about the draft EMPR and EIAR/BAR. The mining company will submit the draft EMPR	I&APs meet with the mining company to discuss the EMPR and EIAR/BAR. I&APs have the opportunity to make comments and the meeting, and to submit written comments.

and EIAR/BAR to the DMR together with the comments from I&APs.	
Application for EA: After considering the draft EMPR and comments from I&APs, the DMR may approve or reject the draft EMPR. If the DMR approves the EMPR, it must consider the EIAR/BAR and the comments from I&APs. After considering the EIAR/BAR and the comments by I&APs, the DMR may grant or refuse an EA to the mining company. All registered I&APs must be notified of the decision by the DMR to grant or refuse an EA.	Make sure you receive notification about whether the DMR has approved or refused an EA to the mining company.
	Anyone may lodge an appeal to the Minister of Environmental Affairs against a decision by the DMR to grant an EA. The EA may not carry on until the appeal is decided. The Minister of Environmental Affairs may uphold or dismiss the appeal.
If the DMR grants an EA, it must decide whether or not to grant a mining/ prospecting right to the mining company in question. In making that decision, the DMR must consider all the information in the Social and Labour plan, the EA application and the prospecting/mining works programme, as well as any comments or objections from I&APs.	All registered I&APs must be notified of the DMR's decision to grant or refuse a mining/prospecting right application.

	Anyone may lodge an appeal with the Minister of Mineral Resources against a decision of the DMR to grant a mining/prospecting right to a mining company. On request from the appellant, the Minister of Mineral Resources may decide whether or not to suspend a mining right pending the outcome of the appeal. The Minister of Mineral Resources may uphold or dismiss the appeal.

Checklist of documents for a mining operation:

1	Copy of application to DMR for i) a mining right and ii) an environmental authorisation
2	Notification from DMR that the application was accepted.
3	Reports: - Social and labour plan. - Draft mine works programme. - Environmental Authorisation (EA) application including the draft scoping report.
4	Copy of meeting notice to interested and affected parties (that should include an invitation to comment on the application, and lists of places where these notices were posted). Evidence that the draft scoping report was available. List of affected landowners who were notified individually.
5	List of registered I&APs; confirmation they were sent the draft scoping report in advance of the meeting.
6	Evidence that the draft scoping report was sent to DMR with all comments received.
7	Acceptance of DMR of draft scoping report.
8	Reports: - Draft Environmental Management Programme (EMPR). - Environmental Impact Assessment Report (IEAR).
9	Copy of meeting notice to interested and affected parties (it should include an invitation to comment on the application, lists of places where the notices were posted). Evidence the draft scoping report was available. List of affected landowners who were notified individually.
10	List of registered I&APs; confirmation they were sent the EMPR and EIAR in advance of the meeting.
11	Evidence that IAPs were alerted to the chance to appeal.

Glossary

acid mine drainage (AMD) – the acidic water that is created when sulphide minerals are exposed to air and water through mining, and produce sulphuric acid. The water is dangerous for people who use the water, and plants and animals that live in it.

acidification – to make or become acid. Something that is acid has a pH value lower than 7 (see pH below).

alkaline – the opposite of acid. Something that is alkaline has a pH value greater than 7 (see pH below). Alkaline solutions can be used to reduce acid solutions.

biodiversity – The variability among living organisms from all sources including, land, marine and other aquatic ecosystems and the ecological complexes of which they are part and also includes diversity within species, between species and of ecosystems. Biodiversity is important for healthy ecosystems.

buffering – the ability of soil to reduce or neutralise acid.

decant point – the place where water that has separated from sludge and mud flows from.

ecosystem – different communities of living things and their environments, as well as their many interactions.

ecological infrastructure – naturally functioning ecosystems that produce and deliver valuable services to people, such as water and climate regulation, soil formation and flood reduction.

green economy – an economy that aims to reduce environmental risks and develop sustainably without damaging the environment.

heavy metals – these are metals like aluminium, chrome, cobalt, copper, lead, iron and manganese. They can poison fish, animals and people.

iron sulphate – a salty-tasting mineral that dissolves in water. It is used to make other salts, to purify water, make fertilizer, and for medicine to treat anaemia.

neutralise – to stop something having an effect, e.g. alkaline solutions can neutralise acidic water.

nutrient recycling – the movement and exchange of organic and inorganic matter into producing living matter, e.g. animals eat plants and then excrete them as manure. Microorganisms break the manure down so that the plants can use it to grow and produce food for animals once again. Ecosystems use biodiversity to recycle the nutrients that sustain all human societies.

overburden – (also called waste or spoil) the material above the coal seam, for example, the rock, soil and ecosystem.

pH – a measurement of how acid or alkaline water is. The scale of measurement goes from 1–14. Low pH values are acid; high pH values are alkaline (or basic).

plinthic layer – a type of soil that becomes very hard when it is repeatedly wetted and dried.

prospecting holes – holes that are drilled or dug as experiments to see whether it is economically possible to mine an area.

rehabilitate – to restore a place to its previous condition.

sandstone – sedimentary rock composed mainly of sand-sized minerals or rock grains.

SPLUMA – Spatial Planning and Land Use Management Act 16 of 2013.

subsidence – the collapse of the rocks and earth above a mine.

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Useful contacts
Coaltech, www.coaltech.co.za
Centre for Environmental Rights, www.cer.org.za
Inkomati-Usuthu Catchment Management Agency, www.inkomaticma.org.za
Department of Mineral Resources, www.dmr.gov.za
Department of Water and Sanitation, www.dws.gov.za
Foundation for Sustainable Environments, www.fse.org.za

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We thank all the participants from the Upper Komati Forum Working Group on coal mining, participants in the Forum, Prof Terence McCarthy for the permission to use his diagrams on coal mining and water, the Water Research Commission for supporting this project, and our colleagues and students in the Institute of Water Research at Rhodes University. Special thanks to Centre for Environmental Rights for making available their training material *"The prospecting/mining right application process: environmental authorisation"* used in this handbook.

APPENDIX E

RECORD OF UPPER KOMATI CATCHMENT MANAGEMENT FORUM (UKCMF) DIALOGUES

This Appendix contains minutes of the following meetings: 21 October 2015; 24 November 2015; 19 January 2016; 9 June 2016; 1 Sept 2016. Attendance registers appear at the end of this report. Report backs at regular UKCMF meetings during this period are not recorded as they are captured in the IUCMA minutes.

TABLE OF CONTENTS

1 PROCEEDINGS OF 21 OCTOBER 2015

Minutes of short workshop on Water Research Commission Project K5/2355: "Aligning and integrating biodiversity and environmental water quality into the mining development life cycle" as part of Upper Komati forum

No separate attendance register was taken for this meeting, as the attendance is reflected in the IUCMA minutes of the UKCMF meeting of 21 Oct 2015.

Question 1: Comments on the current mining decision making process

1. It's made to protect the resource, when you get license you show how you will do that. But there is no follow up, no man power, to check "are they still complying to the license?" Only review it once in a while, do have some measures to protect the resource, only problem is you don't get to follow up.
2. Gap (offset) in middle, DWS doesn't want any impact, mines know there will be impact, so needs to be area in middle as in don't mine here, but mine there.
3. During course of decision making, no integration of all facets of government's responsibilities, eg social, environmental, etc. I believe decisions are made for economic gain only.
4. Mine licenses still go through when applications have lots of complaints. Mining is short term, farming is for life
5. Coal mining is a business, so mining companies want to mine where it is most profitable for them. The sweet areas are next to streams and wetlands. There is no integration between departments. DMR approves all applications and DWS comes in too late. Mines are granted EMPs etc before DWS even gets involved. They can be mining for 8 years, but still trying to get water licenses, because DMR approved it. There is an issue of political influence, because some shareholders are big politicians. The Department may say no it won't approve the license, but in the end it gets approved as it NEEDS to be approved.
6. If you are working on the mining side, if you don't deliver on key performance indicators, you get fired. Of the various departments that are involved in process, each has own mandate, DWS – protect the resource. DMR – Promote mining (responsible). If no mining happens, minister gets fired. So all parties have to compromise, no one will get what they want.
7. Different mandates have to be looked at, else mining applications without consultation results in mining with degradation.
8. Integration of decision making process under way: NEMA and MPRDA.

Question 2: What is or can be the role of a Catchment Forum in the decision making process?

1. We want to see catchment management strategy to include consultation in areas, where as a result, certain areas are automatically excluded from mining possibilities.
2. No better decision making without all stakeholders on board. To do that, forum needs to encourage all key stakeholders. It would need memorandum of understanding with them, so certain departments can send decision making members to forums so that they can change things, not just normal.

3. Forum members need to be empowered, consultant shows technical report to everybody, but farmers, for example, may not understand what it says. We need to empower members, need to enforce something.
4. Forums can borrow power from other institutions.
5. Mine manager challenge: I am not of the view that forum should have powers. We have enough bodies that are taking such positions. Participants come to forum meetings with different agendas and viewpoints. Members are not as interested in as area 200km away, but because the neighbour is producing issues for them, they want it to be dealt with. I don't see the forum being able to move to decisions. The forum would not be accountable, and would not be able to sign off on anything.

2 PROCEEDINGS OF 24 NOV 2015.

Water Research Commission workshop in Carolina, on 24 November 2015, from 09:00 to 14:00.

1. Background and agenda

The meeting was held by the Water Research Commission Project K5/2355: "Aligning and integrating biodiversity and environmental water quality into the mining development life cycle" invites you to a workshop on 24 November, to explore the development of an "Integrated monitoring plan able to align biodiversity and mining development, accompanied by an appropriate Decision Support System" for the Carolina quaternary catchment.

This research was introduced to the Upper Komati Forum during its meeting on 21 October 2015. The Carolina area was chosen for the research for the following two reasons: (1) the 2012 Acid Mine Drainage event that left the town without water for seven months, and subsequent responses; and (2) the existence of the Upper Komati Catchment Management Forum supported by the Inkomati Usuthu Catchment Management Agency.

This is the first of three dedicated workshops and an economics research project planned for this research project. The workshops will look at:

1. Current decision making, balancing coal mining and the protection of water resources (starting from where we left off on 21 October).
2. Exploring the possibilities of supporting regional decision making about coal mining and alternative development (land use) options, from within the emerging catchment management system.
3. Exploring what bodies of knowledge – including local knowledge – would be needed to enable such monitoring and participation in decision making.
4. Participation in an ecological economics case study into the value of coal mining compared with other land uses.

This research is based on local knowledge and experience, and the interests and agendas of people who live and work in the quaternary catchment.

2. Proceedings:

During preliminary discussions, prof Kevin Rogers of Wits University warned against putting a value on wetlands, arguing that they are already protected by law, and that some wetlands may be assigned such small values that they will not be protected. Others argued that the project should give equal attention to mining and agriculture, which is also destructive of wetlands and other water resources. Dr Munnik argued that valuing wetlands will not necessarily be in financial terms.

The meeting then dealt with the following questions:

1. Current decision making balancing coal mining and the protection of water resources (starting where we left off on 21 October).

2. Exploring the possibilities of supporting regional decision making about coal mining and alternative development (land use) options from within the emerging catchment management system.

3. Exploring what bodies of knowledge – including local knowledge – would be needed to enable such monitoring and participation in decision making.

4. Participation in this study, including an ecological economics case study into the valuation of coal mining compared to other land uses.

Question 1: What do you think of current decision making balancing coal mining and protection of water resources?

Group 1

1. The current decision making process is ill informed. Communication is lacking within the department of Mineral Resources and within the ranks of stakeholders. Decisions taken should be reported back to the community that will be affected by the activity.
2. There are imbalances in the results of coal mining decisions, in terms of value and economics. These issues are not clearly explained to the community (during EIAs and other decision making processes). The proponents come and only tell them how many people will be employed, and how much they can make, but don’t speak about wetlands and water and enviro issues, and how these will be negatively affected.
3. Political influence distorts compliance. Non-compliance is due to a political person who is a shareholder in that company and makes sure that the company is protected from compliance pressures. Qualification of EAP is swept under the table. Even though it will negatively impact. Most political leaders are involved with industry that makes money
4. There is concern about assessing wetlands integrity. It is difficult to assess impacts of mining on wetlands, especially water quality. In order to show what impact a mine has had on a wetland, it is necessary to do tests to show what the initial condition of the wetland is.
5. More attention is needed on illegal and non performing mines. Illegal miners are really impacting on economy, wetlands, and other water resources. Many mines do comply, but difficult companies need to be combated. They don’t have environmental assessments. Non performance goes back to political connection.
6. Kevin: in 99% of cases of wetlands mine will impact on wetlands, but the

individual value of the wetland may be miniscule. By valuing wetlands, it devalues the wetland as mine can pay their worth easily. We need to be careful of valuing it. Victor: certain decisions cannot be done in monitoring terms.

Group 2

7. DMR Dominates the scene. It dominates decision making, and the inputs of other departments don't make a difference.
8. Mines do need water licenses, but in practice this never means that DWS can stop the mine. DWS can only impose conditions on the water use.
9. The impacts of mining are cumulative. We need to look at more than 20 years of the mine's life, and then need to look at 80 years after and what happens then.
10. There is an inflexibility of decision makers in water. There may be a wetland in a maize field was already destroyed by farm, now mine wants to build mine there, decision maker says they need to rehabilitate it even though its already destroyed.
11. Acknowledge the multiplier effect mine has on a town. For example, when miners in Rustenburg went on strike, business in town went down.
12. DMR is not releasing guarantee, the rehabilitation money isn't released by DMR as they don't issue mine closure certificates. DMR just refuses to give the money. The closure approach has failed. What is the next best thing? Once mines are finished mining in area, they need the rehabilitation work to be done, then move on. We need an annual mining audit. Identify what needs to measured. Mines that prove themselves and do what needs to be done should be acknowledged, but illegal or bad mines that are not adhering need to be focussed on.

Question 2: supporting regional decision making about coal mining and alternative land uses within catchment management.

Group 1

13. There is poor communication among decision makers. Officials in one section in one department can't come to the same decision as their colleagues in the same department, so how can we get different government departments to come to a decision.? It is very difficult to come to conclusions.
14. DMR dominates. Eg water affairs says bad idea to grant mining right to DMR, DMR still grants mining right
15. Requisite simplicity: we need to simplify licensing requirements to get users to comply. We need to make it easier (simpler) to comply, no one reads the (excessive) documentation at regulator level in any case. We don't talk enough. Officials and others involved need to talk nonsense for an hour before a meeting, so I can get to know you better and how you think. This is not about decision making, informal talk. The future system does need requisite simplicity. We need to get past the paranoia of omission, so submit excessive amounts of documents just in case.

Group 2

16. We need something like the Green Drop scheme, which would be a public acknowledgement of companies doing well.
17. We need regional solutions, such as protected areas. We need to identify water producing areas and keep coal mines out of them.
18. We need integrated legislation. In terms of NEMA, MPRDA and NWA, the DWS should define no-go areas based on water producing areas. They should submit (the maps of these areas) all to one place and one department, and land use planning, including permissions to mine coal, should be based on that..
19. Regional people should be involved in decision making, and monitoring and managing impacts.
20. A word of doubt: we already have proclaimed protected areas, based on scientific proof, but will that stop mining?
21. We need national campaigns/forums/seminars, to build awareness of wetlands and their value.
22. Empower people, so that there are numbers of people able to influence political decisions using media (world Wetlands day etc)

Question 4: participation in this study, including an ecological economics case study into the valuation of coal mining compared to other land uses.

23. What is the mandate of forums? There are just a couple of people here today, what impact can we actually make? The answer was that forums are evolving, as the institutional rearrangement through the roll-out of Catchment Management Agencies and Catchment Management Forums revitalisation is happening. Those who are active in forums now can shape the future.
24. One thing isn't happening here, is that some forums invite local media. They struggle to retain attendance. When appropriate there should be press releases. Start with things that are topical, eg drought. Level of dams etc. restrictions etc. Expand this, because different meetings have different focus, for example water quality and wetlands. Give the journalists a few paragraphs. They can reach out to a larger audience, and get a better feedback from them.
25. These are important things to look at, comparing alternative land uses. Break the comparison down into money, and then into local, national, international benefits. Another priority is job creation. However, people underestimate job creation by farms, and the family members that are taken care of on farms, including schooling etc. Local Carolina newspaper will be interested in publishing.
26. Knowledge is mostly invisible to the user. The current tone of info on the Upper Komati which is available, is hard to understand. We need to make it easy to access information, such as a website for the forum. The first thing we would want to see is a map, then populating information on it. Mapping key wetlands. We are living in a new age of information technology. It is even possible to develop an app that notifies people of meetings, events and forum activities. But be careful with the quality of the information, which must be accessible to people. Put information, not data, in other words, present the

information in such a way that we EMPOWER people with information that is relevant for Carolina people, including basic information. We can use Google Earth as a basis.

The final question was about planning, and the proposal was to meet again on 19th January 2016, a Tuesday.

3 PROCEEDINGS 19 JANUARY 2016

AGENDA

09h00	Welcome, language and introductions
09h30	Exercise: How am I connected to Water in Carolina?
10h00	Group discussion on decision-making system
11h30	Reportback and discussion
12h30	Next steps
13h00	Lunch

WELCOME AND BACKGROUND

Victor welcomed all participants to the Workshop and offered that discussions could take place in languages other than English, with help from a translator.
Participants introduced themselves, gave their affiliations and explained their interests in participating in the Workshop.
Victor explained the background to this project (the Golfview legal case) and explained that these Workshops abide by the Chatham House rule (i.e. all discussions are treated as confidential and all documents are anonymous) to encourage open and honest participation.

This workshop mirrors back the findings of a number of discussions in the forum (24 Nov, 18 Oct), as well as a series of interviews with mine managers etc, including some work that we reported back on before. On the basis of research into legal provisions and experiences with them, the current process of streamlining legislation, the research team has designed the outlines of an alternative decision making process to balance the future of coal mining in the area with the protection of water resources, specifically wetlands.

We are inviting you to work through and comment on this design. The design works on two levels. In terms of the overall decision making process, we are aware that it may take time, further discussions, contestations etc, to arrive at this decision making process with agreement from everybody involved. So therefore we see this as research that indicates what may be possible.

On the level of the Upper Komati Catchment Forum, the research looks at what role the forum can play in improving the decision making process – by playing its own role better, with more resources, information and social capital. This is also research – action research that improves the ability of the Forum to play its role. We hope that we can repeat this work in other forums dealing with coal mining.

The proposed decision making process responds to issues raised:
- that decision making is not inclusive enough at present, not of government departments other than DMR, and not of affected people

- that decision making is not transparent, that it is unnecessarily complicated and demanding (e.g. in terms of paper work, including very thick reports)
- that decision making does not take into account and protect wetlands and water resources, and that this may limit future economic and land use options in the area
- that mining impacts are unfairly singled out, while agriculture and local government are not so strongly regulated
- that the current decision making process does not protect people from water quality threats.

But first there is an exercise social hydro-connectivity in Carolina.

1. EXERCISE: Communicating by means of a picture, please answer these three questions:

1. How are you connected to water in Carolina?
2. Does water in Carolina divide or unite us?
3. How did you experience the 2012 AMD event?

REPORT BACK

1. DWs said it is the custodian of all water and is concerned if there is any pollution, anywhere.
2. IUCMA explained that they are concerned about all the water users, that they should have clean water and should not pollute.
3. The Community reported brown water from taps this week. They think it is contaminated by sewage coming from ground water into their boreholes.
4. New mines are trying to be greener, more environmentally friendly. As consultants we can advise but mine management decides. This was echoed by an Environmental Manager with a mine in the area: they too can advise but not take decisions.
5. General discussion remarked on the absence of the DMR and which mines are abandoned.
   Problems are brought to us, as private practitioners, to test boreholes, test water, every month
   Do you have power to make decisions?
   As consultants and environmental managers within the mines, we continuously advise management, they can take it or leave it
   We submitted the information in annual reports, how to pick up the pollution.Reports on all mines go to DWS.
   When is it advice, when is it action, and who has authority?
   Monitoring starts only just before mining operations begin. We use data only for a certain period. But impact on water quality cannot be seen because there are no records for the ten years previous. All our stuff goes to DWS.
6. We want to see a reversal of this into process, to address leaking AMD. The problem is that upstream there is already pollution. Another problem is that some mines do not have ownership.
   Where is the policy document that defines when a mine is ownerless or abandoned?
   It exists within the DMR.

But they won't give it to us.
Abandoned is usually defined by how long it has not been operating.
How hard do we look for an owner; how much we invest in looking for owner.
Its a complex legal process, case by case, to deal with abandoned or ownerless. There are all kinds of agreements, prior to 1956, another date is the Fanie Botha Accord of 1975?, which is due for a revamp.

7. A local resident who is a geologist explained that water connects all the activities and if the water is polluted it affects all the activities, whether from rivers or underground water. Overflow from mine water gets into the streams then the rivers, and is carried further down.

John There are four areas: conservation, agriculture, mining and forestry. They are all integrated and connected by water, through rivers and streams. How does the DMR know which areas to exclude from mining., or which hold high grade quality coal?

Victor There is water connectivity and social connectivity. It is very difficult for DMR to make decisions from the outside. What if decisions were made by local citizens with local knowledge?

John Local knowledge will need some sort of authority to be effective.

Lourens We will also need the ability to check the mines, who operate without any supervision.

Victor We hope that the system of Catchment Management Agencies will provide the knowledge and authority, and support, to local communities.

8. Participant explained his image. I have lots of questions and it feels as if I am flying over the landscape in a helicopter.
9. Participant explained his image (1 small yellow), balanced, crystal ball, interested in the future.
10. Participant (1 small yellow) identify pollution, consumer, dirty water from municipality, have a borehold and does monthly test of the water. Knows what is in it. Municipality and Mines are looking down on we who use they water they are contaminating. Mine managers don't care, they just give an order. We need to change that. Need an example.
    Q: What does the test of your borehole water show?
    That things are normal. We once found ecoli in it and informed the medical personnel.
    We have found heavy metals also, which is not good for your system.
    Q: What do you mean by 'normal'?
    Complying with the SABS standard. The borehole is at my home, and I work at Droogvallei, where we have found ecoli at the siding, in the tap drinking water.
    Q: So you are saying that Municipal water is dirty?
    At the time the test was done.
    The water for the community is dirty. The ground and tap water.

INVITATION TO COMMENT ON A PROPOSED FUTURE DECISION MAKING SYSTEM BALANCING COAL AND PROTECTION OF WETLANDS

Facilitator: We look at this proposed decision making process from two points of view. The first one is long-term, towards a Green Economy due to climate change. Such an economy will be light on resources and dense on information. The change is coming. Fossil fuels and coal will be seen as part of an older economy. CC will push the coal market back.
The second view is more immediate. How can forums like this (and there are many others) influence decisions? We are responding to a number of issues. In general, to complaints that after AMD crisis in 2012 there was no decisive change. Decisions are dominated by DMR, other land uses like agriculture complain they are ignored.
Mining interests complain they are unfairly singled out – why is all attention on mining and not, say, agriculture. Need to have balance. Authorisations demanding complicated. Because red tape some things are hidden in voluminous, complicated documentation. A way of withholding info. The current system does not allow for proper arguments, discussion and decisions. Leads to conflict.

Poster: What do you think of this Future Decision making?

TEN PRINCIPLES:

It is arranged in ten principles, which are:

1. The decision making process should leave the future open – so that there are ample choices of how the natural capital of the area is used (mining should not damage the natural capital, like wetlands, rivers and underground water)

2. The future should be decided on the basis of, and with knowledge of what Carolina's natural capital is and what it can be used, including it water resources and biodiversity (based on information from all relevant government departments and other information holders)

3. Decisions about coal mining should be made in full knowledge of current and future land use options, including IDPs, land reform plans and national development plans

4. Against this background, coal mining decisions should be made in terms of benefits to national and local economies, its impacts on water resources, preserving other land use options into the future, and the costs of restoring any damage.

5. Coal mining decisions should be the outcome of a fully informed process of dialogue that take all these factors into account.

6. These decisions form the basis of a monitoring system that is fully informed by open access to all legal instruments, such as water use licences, mining authorisations, social and labour plans.

7. Documents and discussions are streamlined, in accessible language, reasonable length, honest and sincere, with publicly funded support for participants to check data.

8. Relevant departments support this process through specialist knowledge, which is part of the Key Performance Indicators in their jobs.

9. The process is co-ordinated by Catchment Management Agencies as custodians of water resources.

10. The Catchment Management Forum develops a knowledge network of information at hand, local knowledge and experts to call on, to support making decisions, monitoring and acting on compliance.

Facilitator invited participants to divide into groups to discuss these questions. The ten points for the future system are on the printed hand-out, and was e-mailed to participants before the meeting.

There was some negotiation about how to form the groups, but agreement in that interests and voices from each group would be different. The division was:
community group (4)
consultants group (4)
regulators group (9) – including IUCMA, DWS, DAFF Mpumalanga and Human Rights Lawyers.

Questions for small group discussion:

What do you think of this system in terms of:
1. Is it desirable? What do you like about it and what do you dislike?
2. Can it work? What can work and what can't? What may take a long time to work?
3. What would you change about the proposed decision making system?
4. What would need to change in the present system for this decision making system to work?

Report back from Community:
Q1: Desirability No question the new system is desirable.
Q2 Went some distance but not far enough re community involvement.
Q3. Not far enough should go even further.
Q4. We are not sure that it is not strongly enough enforceable. Still open to abuse. Any system could be open to abuse if the wrong people run it.
From community point of view involvement is costly. Others are sent here by emplyers, but community participants pay for their participation (time and transport) themselves.
Workability: Yes its workable, but it will depend on the commitment of those involved, their serousness and honesty. The track records are not positive.
Timing: People’s attitudes and mind sets must change, will take long.
Process should be dynamic, we should review and change it whenever necessary (in the light of experience).

Comment: To be included in system. Feedback about community concerns is not taken seriously enough. These are minuted but no action follows. Would like to see a real Action Plan with a Timeline and the Names of responsible people. Report back in the next meeting. If no action, what next – Plan B?

Report back from Consultants:

Q1. Yes, desirable.

Like: The fact that there will be local input from local communities, people close to home. But conflict of interests. Important that it is driven by local knowledge. But capacity building and explanations for local participants will be needed.

Work: Yes, with some difficulty. What will work: Implementation of these principles in one environmental system, with adequate support and education of local community, and support.

Could be too complex. Takes time for a paradigm shift, change the mindsets of all involved, needs a variety of economic benefits per sector.

Change: One decision-maker, deal with one department. Can have sub-sets, but basically one body that decides so no conflict of interest.

Change the present system. Ditto – implementation of one enviro system.

Facilitator: Adequate support & capacity building. What does the community think, what does the IUCMA think?

What will adequate support look like?

Local body is local people, not researchers, but local and important knowledge. But supported by people with appropriate expertise, inc. financial expertise. But wh will pay for this?

Get the community to make informed decisions, they do understand simple things like impacts from mining, but how to rectify it.

What support will work best?

Workshops to train community.

IUCMA:` It is sometimes difficult for us to identify leadership in communities. We need people with whom we can work to build leadership in the long term, and who can can report back to communities. We identify HDIs, women, youth, but next time it is completely different people. No consistency. The custodians of info are not there.

Facilitator: Yes this is a challenge but there is a solution to it. VEJA created a Water Task Team. They go to the training, to the CM Forums, to build continuity and to develop knowledge. But of course this assumes the existence of organisations of activists in the community.

Departments currently trying to streamline into one decision/authorisation system. Maybe not one department but one decision making Co-ordinating role.

Report back from Regulators:

1. Regional overview of existing eco infrastructure
    - Good to start off with situation assessment, good to have knowledge of point of departure. Problem with details – different groups/areas. Need to make that available to everyone (licence issues, confidentiality). Need a baseline.
    - Region to region level – discrepancies between different areas. Oversight of regional bodies for complying with standards for baseline study.
    - Some people interested in different levels (scope). Can't have info for every borehole. What is minimum scale that we need?
    - Would like to see it expanded: also land use info as well, infrastructure, org/people that deal with it. Different district/local boundaries. Info needed about the people.
        - Who represents each group – is forum representative of stakeholders?
        - Who will speak on behalf of the environment?
    - Accountability and completeness.

2. Overview of LU options
    - Fully ventilate different ideas, not just mines drowning out other voices. Mines tend to dominate these discussions (economic interest).
    - No sustainability – social issues, benefits, other issues, water resources
    - Need to put people first. Industry being given water security over people.
    - Need to look at long term options – mining is short term. Necessary and need to know this.

3. Long term trajectory – green, low-carbon economy (the future)
    - Not letting one role dominate conversation. Idea of green economy as a goal that we all work towards.
    - Lack of political will to curtail mining (seen as economic saviour). Other stakeholders (municipality, community) not working together.
    - Need to commit to reducing carbon emissions – this will have impact on coal mining.
    - Green economy is very vast topic.
    - Need to be aware of the future. E.g., river may not be here in 10 years.

4. and 5. Coal mining – benefits to economy, eco-infrastructure etc.

- Alternative uses of the land
- Don't agree with what is said here – would work later on. But need to fully ventilate on point 3 before that.
- What if point 3 was fully discussed? Have conversations going on – then point 4 could, work. Need to elevate other stakeholders to the same level. Financial interests can't be the only interests. Those who are not decision-makers should not be disregarded. Who will give these people power? Role of ISA (?)
- **There should be a step where there is an empowering stage early on** – stakeholders need to make informed decisions. Should occur before Point 4.
- Noted in pt. 8 – empowerment. The steps don't have to be taken in the order that they appear (not linear)??
- Issues here are to do with trust. The mines will say anything. How to build trust? Mines will put forward a very strong case.

5. (above)

6. Forum is basis of a monitoring system enabled by legal instruments
- Mines are claiming that SLPs are private documents. PAIA requests – mine have no reason to withhold information. Need better legal infrastructure to get access to info. Delineate what's in the public interest (define it quite narrowly) and put this info on a website. Asking for it doesn't mean that you get it. Some officials are completely refusing.
- General public – don't give them data, but knowledge. Simplify to: resources quality, narrative reports, graphs, status of impacts, compliance. Certain info is not relevant. Write this out in plain language.
- Green drop and blue drop system. Individual waste water systems?
- Issues of access vs. dissemination. Should be more easily accessible. How do you channel information? Municipalities do not want to give out information.
- SLPs – communities affected by mine should form part of SLP. Difficulty with who picks that person (does the mine, community?).

7. Decision making and monitoring is streamlined. Docs are concise, accessible and honest.
- Regulators: can decide what is/isn't relevant, but this should be very liberal.
- Corrective action – creating a summary/annual report that indicates the status and what's being done, what's happened in previous years.
- Two-way stream? Report from regulators and also one to regulators. Difficulties would be: complexity/things are too technical (financial constraints). Could have an executive summary that helps laypeople understand as part of the report. E.g., colour coded maps (red = bad, blue/green = good) – don't have to understand how it's done, just that they get the info.
- Need community empowerment. They are resourceful, enable them to create forums and allow them to communicate and produce a report that accesses performance (what they were promised vs. what is

happening on the ground).

8. Capacity building
    - Should be done earlier on. DMR should have a chat and engage with concerns of other stakeholders.
    - Need more details – what does this mean. E.g., outreach to schools, for communities to enable them to make decisions.
    - Who to identify in community? Hard to just go to community and give training. Challenge is choosing people? Asking community to nominate? Self-identification? Try to ID leadership (e.g., in NGOs). Trouble relaying/disseminating information back to community.
    - Forum needs to continue to reach communities and have community members attend forums. E.g., put things in the paper, radio, soapy. National exercise to reach grassroots. Multi-layered approach.
    - Tried in past to invite newspapers? Why doesn't forum do a write-up to summarize – write about AMD, dam levels, status of water restrictions other topics, etc. Problem is newspapers want a scoop. Write a press statement?

9. Catchment Management Agency
    - Need cooperative governance with dialogue and strong accountability. Need to know who is doing what in each role.

10. Decision Support System – knowledge network process
    - Internal source of knowledge – would require a lot of resources.
    - Good idea! Doesn't have to be developed over night. Centralized system populated by different inputs.

Could the CMA and Forums act as the driver of this process?

IUCMA: Try to involve all, which is going well. So, yes.

Facilitator: Point 10 is a deliverable of this project to develop knowledge network process and system.

NEXT STEPS

Facilitator: Results of this Workshop will be handed in to WRC as Deliverable No. 6, by the end of this month. We are planning economic case studies comparing coal mining and cattle rearing, and a return to the Golfview, assess restoration and its cost. Looking at how we value natural capital. This group was cautioned by Prof Kevin Rogers not to assign monetary values.

Future Workshops. Next Forum meeting is on 17 February. Another two workshops, put together a booklet for capacity building and reference, about the Carolina catchment, specifically.

4 PROCEEDINGS OF 9 JUNE 2016.

Victor introduction gives an overview (powerpoint presentation)

Remark: It is great that the importance of the sandstone layer is recognised, we have been trying to tell you about this.
Question: Were you able to the costs of rehabilitation per hectare?
Answer: Unfortunately not yet.

Prof Palmer introduction:
Real value of having a product that is embedded in actions. That is work that we are co-producing today.

To take an example, in your body, you have vital systems and you don't die until one of those systems fail completely. If one fails completely, its over… When we talk about vital systems, it's nice but not necessary to get a knee replacement. The vital organ of this catchment is that water and rock and sediment are layered, and the way in which water behaves in that connected system, in relation to the surface water at the top – so those of you who need surface water – if you puncture this layer, if you interrupt that flow, you seriously interrupt the life supporting system of this catchment. We need to protect the hydrological connectivity of the system.

The second level driver, is the water quality. So what we are talking about here, is a complex set of interactions, we need to think about primary drivers what we need to keep the catchment healthy.

You produced a framework for decision making and monitoring on coal mining and protection of water resources. I made an analysis of it, looking at how it could be used in the forum as a "decision support system", in other words, a system that provides the knowledge that is needed to make decisions and monitor as a forum.

These are 6 points that are embedded in this framework. I am suggesting, I have done as a first draft, what if you turned this framework into a template, that you added info to at regular interval you decide. Lets say you do a state of the catchment report every year. Or when a WUL application, or discharge license, or EIA comes for the development of a new mine, that you can evaluate it with the knowledge you need, and you can hold those responsible for the decision, to account. One of purposes of the forum as people who live in the catchment, is to be able to judge "this is a really good idea" or "hang on, this development will poke a hole in my cup".

You might form working groups to maintain and use this framework.

1. You are comfortable working at this scale, in this space, in the quarternary catchment, Carolina, or in the municipality, Gert Sibande.
2. How often, we would like to keep this contextual assessment, check how often you want to keep this up to date?
3. You will need, on one side, a lot of information coming from the IUCMA, we are lucky to have well developed and able CMA. They provide information on flow, quality, even looking at habitat and biota. You might want to look at what are the main social drivers in your system. You may find that in you forum, community members, miners, government officials, people

who live in this catchment. And if you think people are missing…For example, the Droogvalley wetland (which we assessed), did not seem well connected to people living there. In our short exchange with the mines, they have more knowledge that many of us… keep track in your forum on what kind of local knowledge you have. I understand you have issues with your WWTWs – it's a systemic problem that we work on throughout the country. It is a very important process, you will be interested in municipal procurement processes. The municipality often takes most of the shots in a forum, and mining also takes most of the shots. The huge shift in social environment is where we say, we actually all live here, and have different roles and knowledges, and when we can put them on the table and talk, we can look at alternatives. The blame game: "we know we are bad but they are worse". To get out of apartheid, we had to get better ourselves. We need to understand that it can be tremendously frustrating to be in the municipality, to get a MIG grant… So this conceptual assessment is "where are we".

One of the things we need to know, is about land ownership and land use. Who owns which land, in which way, for which purpose.

You want to be able to assess options. What if… then I have contingency plans. (E.g finding a projector this morning). You need to do that in a much more complex space. Your knowledge bank, that we have three months to intensively help you build, underpinning each framework option. What do you have to do, in all of the phases of coal mining, and if there is a co-operative spirit, Greg will be able to talk honestly and frankly about what his realities are.

Principled pragmatism. If your principle for this catchment is to return it to pristine condition, I am sorry, but this is not practical, not reasonable. I am an ecologist, I deeply believe we cannot live on this planet if we don't look after it. Our generation's primary challenge is to deal with a planet that is struggling. But I live in South Africa with a history of unfairness, so redress is a primary goal. Principled pragmatism only works when we talk – what if your principles conflict with my principles. How do we assess what sustainable infrastructure is?

Greenies like myself too often say "if you do that it will be destroyed", we should say "if you destroy so many of this, you will take away something that is really important".

What are the coming changes in land use?

Hold people accountable for giving you documentation that you can understand – or go to a specialist who can translate. So that documents you receive and produce, need to be understandable, well illustrated documents.

You can develop in the forum the capacity for oversight. You do not need to make it happen, you know enough to make sure that it is happening. You can check about enforcement, which directives are given and how they are enforced. We can say "its difficult to speak to the DMR", that "they are never there", but you can find out who is talking to who, how to build these connections.

You need an economic future, and coal will be part of it for some time. Agriculture has potential to be part of that future indefinitely, you need to know whether you want tourism, or wind energy etc. Are these options aligned to what you see as your sustainable economic future.

You will find all these points in your framework. What we are suggesting is that you relook what we are suggesting, and talk about the practicalities, as a group, of building up a knowledge base, and capturing this in a framework… a framework to support forum action, in ensuring accountability in their catchment governance.

Develop a knowledge framework, so that when applications come up for licensing, you have a good enough understanding, good relationship with a CMA, you can go to your knowledge base and principles, so you can evaluate these proposals. And then you can challenge them. This is not a book on a shelf, that we can just say "deliverable 8", this is us asking you if you are prepared to be a guinea pig, Geert, we are hoping that other forums dealing with coal mining, might take this up and practice it, in the form of a dialogic training with the Acid Mine Drainage Task Team.

Its principled, but is it pragmatic? Can we do it?

Then the guidelines that we produce, would be how does a person who comes into this forum, how do they participate, how do they use the knowledge base, how to work with agencies, how to hold each other mutually accountable?

Group discussion followed on what would be their requirements for the Decision Support System

The meeting decided not to break into small groups as planned, but to do this in one group. The following approach was agreed upon for the knowledge support system:

There should be guidelines for each group of land users, and the forum is where everything comes together.

Do it at an appropriate scale, let's not focus just on Carolina, although our info must be for Carolina, but report should be at a bigger scale…

We need to look at other things that are happening in forum area; but how do these things fit into the structure of existing protection, how does it fit into an agenda. When forum gets together they have an agenda. Talk about resource quality. About waste water treatment compliance. So we would like to get an integrated framework for reporting. This framework is about integrated water resource.

The short document about Carolina and coal (the booklet) is a different knowledge network, a sort of an introduction.

Language needs to accessible, on the level where this information is needed.

A vehicle to take us through the points faster, e.g. "now there is a new application"…

point 2 is where the start… what is the existing situation. This needs to be put together.

Point 4, is what are your alternatives, if you say no to mining, what are the alternatives? What are the positives or negatives of mining, or not, including after mining, what are the positives or negatives after mining has stopped?

Point 1 (referring to the poster) Where am I in the landscape… where is my area, what is my mandate?

The question of scale, is which boundaries must you be careful of. This is an active forum, this remains the relevant forum.

Municipality is important, we have Albert Luthuli and Emakhazeni, they have different IDPs, part of different district muniicpalities.

You must think in a GIS method, what are the different maps you may need. The forum includes the municipalities.

What else do we need to add?
Land ownership is important, because you start with the farm portions – 3 must become number 2.

Land use is available in each municipality's Spatial Development Framework. Local municipality SDF has to comply with district SDF, and comply with the provincial SDF. All the levels must work together… IDPs are in place.

You need to keep your information to the essential minimum. We need to distinguish what is easy to get from what is difficult.

3. Contextual assessment: The biophysical, social and technical infrastructure. Already we know, at Upper Komati, there is regular reporting on the information. There is info on water quality reports, but reports focusing on coal mining, we don't have yet. We know where mines are, its easy to identify where the relevant monitoring points are.

IUCMA can provide the history since 2012 – when around 30 monitoring stations were set up.

If you have a classification, and have RQOs, those will be what (DWS? IUCMA?) are reporting against.

Relevance goes by risk assessments. What do you want to be informed about? We don't want 106 results, in the meeting have very specific reporting.

Red flags can be quality change, for example.

4. Assessment of options

How do we do this? : Assess options – development project, coal mining, sustainable; sustainable ecological infrastructure, changing land use?

Risk is combination of hazard (how dangerous it is) how likely is it to happen.

This is where the knowledge is most difficult to access. Primary risk factors are "how does mining interrupt the hydrology" and "how does this affect the water quality"?

There is mitigation possible. There is a big difference between a mine that mines responsibly, vs. one that mines, declares bankruptcy and then runs away.

If there is a need for coal, it will be mined. E.g. Eskom runs our electricity on coal. There is a need to expert coal. But then, the question is, should that mine happen at this place, at this time? Should we be mining high potential soil, or where biodiversity is high. Is coal mining desirable (in this place)?

We have roughly 200 years of coal, we will need it for 10 or 20 years. Then question is which 10% are we going to extract, and which 90% to leave. Accurate mapping becomes a really important tool.

Hydrology is a specialist layer that applies in this area. If you look at conservation maps, what they are saying about critical biodiversity areas, if you want to encroach on that, the onus is on you to show that you will not cause damage.

We are going to cut off hydro-connectivity somewhere if we mine in this area. But the problem is, the mining company holds a right in a specific area, and wants to mine specifically there.

It is now easier to access documents than it used to be. But the problem remains: We look at documents, we report, but then nothing happens.

Number 6: oversight, (checking on)

Maybe booklet is not the way to go, everything is there, in new NEMA regulations, how you must do your EIA, there is a need and desirability. The big thing is enforcement.
Wietsche said yesterday they are expanding monitoring and compliance capacity.
You must do planning and action, but then it is checking compliance. It is essential.

Agency. The power to act and change. We are not going to have huge influence in cabinet, but we can raise issues in our catchment. Section 6 draws on all the other sections, this is quite hard work. People should understand what should be assessed, and what is really assessed. It is important that people understand what the real requirements are.

The problem is, for example, as in this case where there is mining within a wetland. We have satellite pictures, IUCMA goes out and submit it. Then they send it to to DWS, but IUCMA does not have access to state attorney's office. If it takes anybody on, this action will be for its own legal account. (At the time of the meeting the delegations from DWS to IUCMA had not yet been completed.) DWS goes to state attorney, they act for them. IUCMA has its own legal account, so the mines sue them for directives, and these things run into millions of Rands. The regulator is DWS, and they act if there is a violation of any sort. Our part as the forum, is an issue, we are here to say, whoever must act on something, please must act on it. Minister has withdrawn delegations from CMA, and significantly reduced its powers to act. So there is an institutional relation, so there is a difficulty in the power relations.

A ground rule of complexity is that you don't stop because there is a difficulty, you find a way to go around.

Nobody has the capacity to drive this activity. My question, do we really need a set of guidelines? The forum has a problem, somebody has to spend time and effort to drive a forum, or do you create a structure to facilitate this…

Resourcing CMF questions come up everywhere. Our WMA has put money aside for forum organisation…

Would you go to other coal forums, and say Upper Komati has started an interesting approach? This is one of most active forums, some are not active at all. What do we need to do, we are not going to get the Rolls Royce, but if we can start off with a model T4.

We know have a more formal structure, some good work has been done. But we can always unpack the others a bit more.

You need somebody that can spend two days a week, to keep this going… to keep track of the applications. What if CMA is connecting this for their annual report?

This info should be somewhere already…

So, is this a sensible reinterpretation of this document: how do we now take it forward?

Step 1: We need to get the following people, CMA as lead agent, how will they start unpacking this. We have Acid Mine Drainage technical task team. They can at least say what is the current status quo. Those are the people who produce the status quo on the mining… Who will do the social, where will they get the information…

Currently IUCMA supports the forum, the work is done by forum committee. It can work when you have a very active CEO.

If local government (Gumede) becomes the resource, we could run it like the IDP. It is IUCMA responsibility to support participation. There are contradictions in resourcing of CMFs. CMFs are independent, where IUCMA is not seen as big brother, you also have to sustain the CMF. At some point there will be decisions against the IUCMA officials. The reason why we give chairperson etc powers, the implementation of those decisions have to be seen to be independent. CMFs are not the fundamental KPI for performance assessment. And then it comes to the issue for CMFs, we were told not to budget for CMFs. We then said to stakeholders, assist us to support CMFs. 60% of costs are supported by stakeholders.

In DWS there is still a debate about the importance of CMFs. It may be government should be funding the independent participatory body.

The quickest way to raise that level, is a crisis.

If we can show, there is something that has emerged, confirmed as useful, it is possible generally, but there are specific barriers.

Can you create a basic map, and get it consolidated?

Yes, it does not sound impossible to do some of the actual maps. An active framework starter pack is a product we can do.

And we do have to do some training – maybe going to other forums. Here is an implementation starter pack. A DWS official reported that he plotted a map of Carolina. It clarified the situation immediately. Not everybody can access info easily. It does not mean that because the info is there, somebody needs to put all of that together.

Do we need a private consultant? We can ask DWS for maps… ask municipality to “bring us what you have”.

This starter pack may be a clear example of what is possible. So that people can see what is possible. A “proof of concept”.

So there will be 2 products…
(1) starter pack knowledge system
(2) 30 pages booklet that is an introduction for a person in a catchment forum that is dealing with coal mines
(3) why wetlands are important is well known and not necessary now.

Koos: I started working on these issues in 2001. There have been massive changes in policy and government over that period of time. Dept of Agric is now refusing mines on basis of food security and high potential soils. There has been a significant change in the regulatory process. I am not sure that there is willingness to address it immediately, but the movement is in the right direction…

Geert: a summarised 4 A4 pages. We have produced newsletters in our projects, e.g. on water quality. We should have a website for the project.

Thank you to all the participants. This is what co-learning is, this is the contribution of everybody.

5 MINUTES OF 1 SEPTEMBER 2016.

Minutes of the Upper Komati Catchment Management Forum Meeting Featherbed Lodge, Carolina.

Draft Agenda

1. Introduction and welcome.
2. Presentation of booklet "HOW TO balance coal mining and water protection in a CMF"
3. Presentation of Decision Support and Knowledge System.
4. Using the Decision Support and Knowledge System to analyse the Verkeerdepan mine.
5. Evaluating the training materials.

The workshop was presented by the developers of the training materials, namely prof Tally Palmer and Dr Victor Munnik of the Institute for Water Research at Rhodes University, and Mr Ben Cobbing of Conservation Support Services Geographical Information Systems (CSSGIS). (Please see chapter 6, 6.4 for detail on the Decision Support or Knowledge System).
Discussion:
I would like to see a layer which gives the location of mines.
I would like to see where all the prospecting applications are.
The strategicy water partnership, appointed a person to plot the location of excisting mines, including Carolina, as well as prospecting. There is nearly nothing in the Mpumalanga area that is not put up for prospecting.
Jo Burgess is busy with WRC to create a mine water atlas. We should get hold of that. It superimposes the mines and the water.
Create on GIS buffer zones around water resources, what areas are not available for mining.
I have been busting my head against data sets on where the mines are… Geosciences I tell them data is incomplete, the mines do not add up.
You could find out from IUCMA staff where that layer is.
What is the possibility of developing an app. for google earth? The problem is that it is very data intense. Oryx map is free application.
Hugo Retief and AWARD – are introducing different monitoring tools (for Upper Olifants).
Oxpecker has developed a tool called "Mine Alert". We could inivite Oxpeckers to join us in a UKF meeting.
Koos Pretorius has a list of mines "this along".
This project can alert this group to the possibilities.
It takes the energy of a group in a catchment, possibly the dividing up of task, to scan the environment and see what is going on. Our job in this project is to alert people to the existence of data.
If we could use tools to empower people, we can move into the right direction, like Oxpecker would complement the current work. We could synergise our efforts to maximise the resources we have.
How does DMR decide when there are enough coal mines in an area?
It is not how much water mines use, but what their impact is.
We don't have a national plan, and not an abstraction licence related to water quality data.
Voice of outrage has to come from people… so you can be as much of an informed voice as you can be. We live in a developmental state, we have to be able to motivate looking after resources in terms of long term jobs and opportunities.. who is going to have which jobs and incomes in 10 or 30 years,
Then you must go to all landowners ... on my farm they have taken my water. If you compile a list, mines have already taken away this and this much water… these must be no go mining areas.
That will be big job.

Yes one of our research jobs could be to look at NDP, motivate we have best first steps to put a locally developed future plan on the table… maybe turn that into a job creation project… (maybe working with IDP?)
DWS is updating record of water uses. They are running regional workshops, if that happens here, it could be a vehicle here… then you have a way of attracting water users to come in… validation and verification, mainly looking at quantity (its opportunity for people to walk into a room, questionnaire based on this).
Prof Palmer: What we want to know is what training would you need for other people to be able to use these maps? How can we make it real for people to be able to participate and understand?
Mervyn Lotter has drawn up a Mpumalanga biodiversity plan – not yet legal but not gazetted. There is a handbook on the biodiversity sector plan.
Verkeerdepan example – follow 11 steps (Tally)
Our first student went through steps… what a mine has to do to get permission to mine… Then I made a summary, and related it to what Ben was doing, so this is my guess of what you could do..
Step 1, also contains privileged information, its on a system, and it won't be available (there is a list of things that you must put on the system)
Step 2, notification from DMR that application was accepted. (you should receive acceptance letter)
Step 3, Social and Labour plan, draft mine works programme, environmental authorisation (SLP is not part of public scrutiny).
Mine works programme is initial programme, what you want to do, how, for how long. You are making a business case for the mine. It is handed in as part of step 1(on the system)
NEMA law does not tell you have definitions for consultation… I&Aps register, must declare their registration, who will be sent out the scoping report (look at 2012 DEA participation guidelines,
https://www.environment.gov.za/sites/default/files/legislations/nema107of1998_publicparticipationguideline.pdf)
Method of consultation is dependent on nature of impacts, nature of affected parties etc.
In checklist, differentiate between what is happening behind the scenes (confidential) and when people can act – and what information is publically available.
Oral submissions are treated as less important than written submissions. Most of oral submissions are not properly picked up. (is it necessary to exit the system and have a parallel civil society process of recording objections etc)
Can you set a limit for blasts?
"Every blast gets recorded by a seismograph" and must be within legal limits.
In an EMP if blast modeller picks up there are … they must take pictures of all the possible impacted structures, depending on how close you are to the mine.
There are ways of blasting that can limit the amount of dust. There could be a discussion with our modeller about the ins and outs of blasting.
There are serious impacts on people living close to mining area, we have problems with blasting. The mining company finds farmer, they identify a box they want to cut, they remove the people to a 2 km. Explosion amount is so excessive it reaches other people. Too much space taken to discard the coal.
Water gets contaminated, it gets into the springs. In terms of jobs, monitoring mining activities, forums might establish a funded project to do monitoring… because people who are living there, they know the area, and they know what the impacts are. They know how much the dust is affecting the vegetation around the mine. This could employ people, to check wetlands etc, houses that are affected etc. Those reports will help the companies and the forums.
Answer: yes this is complicated. We will record that this project has uncovered that there are many more questions than we originally imagined, and we will write them down (and think of ways to deal with them). WE have given you a record of points at which you can comment… those are the reports that are pushed out…

In rural areas, the impacts in rural and urban areas are not the same. It should not be a once off process, it should be one of the tools (the knowledge system) that we use routinely, the tool should complement the other work. The maps are very important to understand

1. Maps are useful to know exactly where the mine is going to be.
2. In an operational mine, we would like to understand the area around the mine, for example what are the wetlands around Kusile (we could have used maps before ground truthing).

This information is useful to us, without a map you can't go anywhere. Its just that these maps need to be supported.
IUCMA = I would recommend that we keep in contact, so IUCMA can review document and make contributions.
It is potentially sueful, but I am not sure about way forward, people I am working with have access to data systems, we can do that on our own. WRC should send reports of this project to the working group, and these should be distributed further and wide.
There is a possiblitiy of a training and capacity building, for example to take a new mine to consider how will you apply this. Different groups have different needs, in a forum there are too many diverse interests.
These products are very good for I&AP, to comment on water and biodiversity, but not necessary for mining managers and consultants When I start a project, I will also start with all those maps.
Will it help for monitoring? I am not sure. Maybe in broader in IUCMA way, but for a specific mine, that is much more local. As a consultant, that will be determined in my EIA process. Different environmental specialists will tell me where I must monitor what.
Farmer: it is very good, that we know this. But my problem comes at the end. If you have a problem with the mine, you discuss it, but you cannot resolve it. I am very pleased that you are here etc… but in the end, to solve the question, there must be someone responsible, first the mine, and who else is on top of them? Often one needs a name of a specific person in the department.
Each mine is supposed to have a complaints register in their office. They must have someone who looks at the complaint register. It must be reported to DMR (what the complaints are). Sometimes we can't agree, and I don't want to go to court. Sometimes issue is not so big. So in the end, you just ignore it, you suffer, but not that much, but it poisons the relationship.
One thing we are lacking, is an arbitration process before you go to court.
The materials were given to the Omgewingsgroep and the IUCMA for local safekeeping.

6 PARTICIPATION LISTS, REGISTERS

PARTICIPANTS 19 January 2016

1.	Nomvuso Mjadu	DAFF
2.	Edwin Manibu	DAFF
3.	Adele Delport	DRSC
4.	Geert Grobler	DWS – Planner
5.	Derrick Cholo	DWS – Usutu River regulator
6.	Lourens Greyling	Geo Consulting Company
7.	Riana Bate	Geovicon Consulting
8.	Leon Dormehl	Hebron GeoServe, local enviro group, churches,
9.	Diketso Khaile	IUCMA
10.	Gugu Motha	IUCMA

11. Tony Sibiya	IUCMA – Upper Komati
12. John Geary	Jaco K Consulting
13. Kelly Kropman	Legal Resources Centre (LRC)
14. Claire Yick	Legal Resources Centre (LRC
15. Joan Cameron	Rhodes University and Munnik Research
16. Victor Munnik	Rhodes University and the WRC
17. Hendriena Sibanyoni	Silobela Community
18. Maria Mkathswa	Silobela Community
19. David Masito	South32

PARTICIPANTS 9 June 2016

1. Tally Palmer	Rhodes University
2. Riana Bate	Geovicon Environmental
3. Leon Dormehl	Carolina Omgewingsgroep
4. Koos Pretorius	FSE
5. Geert Grobler	DWS, WRSP
6. Ramabulana Ndwamato	DAFF
7. Granny Mahlare	DWS
8. Bethuel Khosa	DWS
9. John Geary	Jaco-K Consulting
10. Greg Middup	Northern Coal
11. David Mosito	South32
12. Mxolisi Gumede	Albert Luthuli LM
13. Gugu Motha	IUCMA
14. Liketso Khaile	IUCMA
15. Tony Sibiya	IUCMA
16. Victor Munnik	Rhodes University

PARTICIPANTS 24 November 2016

1. Annalise van Zyl	Shanduka
2. Lucky Mashuta	Shanduka
3. Riana Bate	Geovicon Environmental
4. Kevin Rogers	Wits/ Farmer
5. Gareth Thomson	Rhodes University
6. Victor Munnik	Rhodes University
7. Tia Keighley	Rhodes University
8. Granny Mahlare	DWS, Vygeboom
9. Geert Grobler	DWS, WRSP
10. Subiso Mhlanga	Gert Sibande Municipality
11. Maria Mkathswa	HEJN
12. Thwala Thwala	HEJN
13. N. Ncongwane	HEJN

Social hydro-connectivity in Carolina and a new decision-making framework. UKCMF workshop 19 January 2016

7 SOCIAL HYDRO-CONNECTIVITY IN CAROLINA: PARTICIPANTS' VIEW

The 19 January workshop started with an exercise in social hydro-connectivity.
Hydro-connectivity recognises that water resources are connected on the surface, through wetland systems that encompass surface and underground water. The term has been defined by the United State Environmental Protection Agency as follows: *"Watersheds are integrated at multiple spatial and temporal scales by flows of surface water and ground water, transport and transformation of physical and chemical materials, and movements of organisms. Although all parts of a watershed are connected to some degree — by the hydrologic cycle or dispersal of organisms, for example — the degree, and downstream effects, of these connections vary spatially and temporally, and are determined by characteristics of the physical, chemical, and biological environments and by human activities*" (US EPA, 2015).

Social hydro-connectivity emphasises that the social and hydrological sides are closely integrated."

In this WRC project, we reached for a workable understanding of social-ecological hydro-connectivity, to develop a decision-making support system specifically for Carolina, but also as an input to a broader understanding of the relationships between host communities and the "social license" to mine (see Morrison, 2014). This work proceeds as part of social action research, based on a self-understanding of participants in the UKF. As a first step in this direction, the social connectivity in the group was explored by means of asking the following questions:

1. How are you connected to water in Carolina?
2. Does water in Carolina unite us or divide us?
3. How did you experience the 2012 AMD event?

Participants drew pictures, in groups of two or more, to express their answers to these questions. The pictures were displayed on a wall, and participants invited to explain, and then engage with each other.

Apart from serving as an ice-breaker (accessing non-verbal expression and creating entry points for discussion between participants and starting to build familiarity), the exercise also revealed interesting aspects of social hydro-connectivity in Carolina. One resident, a trained geologist, saw the landscape as composed of geological layers, which physically determined hydro-connectivity, and graphically explained why contamination from coal mines threatened Carolina's water resources.

Others focused on their role of taking care of water resources and water users (IUCMA). Their picture featured the Komati river, streams, a dam and trees, Community members from Silobela reported that, in the week of the workshop, tap water that they received from a borehole, had a brown colour. They explained the cause as Wastewater Works (WWTW) pollution of the stream that they see as connected to the aquifer that feeds the borehole, thus illustrating that people spontaneously look for connectivity among water resources, or assume it.

Display 2: Small group discussions

Regulators, consultants, researchers and lawyers are in some sense outsiders who are, from a national/professional perspective, involved in the water issues of Carolina. They showed a more schematic view of the situation, and included specific activities, like water sampling and analysis. However, since many live in the area, they also shared concerns about water quality.

The animated discussions, which ranged from intentions of immediate follow-up on water quality issues to discussions of systemic relationships, showed an interest in, and existing understanding of, social hydro-connectivity, which this project intends to build on as the UKF-centred knowledge system is further developed. For the purposes of discussion, the participants self-divided into three groups, related to the roles that participants played, as discussed in the previous social connectivity exercise. The result was three composite voice, described below.

The **community group** included two participants from Silobela, connected to the Highveld Environmental Justice Network, who are involved in coal-related issues because of local pollution impacts. This is a Mpumalanga wide network and part of the broader South African Environmental Justice movement (for more on this see Deliverable 4, on contestation). Another two members came from the previously-mentioned Carolina *Omgewingsgroep*, an environmental study and action group centred on the Dutch Reformed Church, which had been a prime actor in the response to the 2012 Acid Mine Drainage event.

It should be noted that other participants also regarded themselves as community members, including some working for mines as environmental managers and/or consultants.

Consultants formed the second group. Members explained that, during the social hydro-connectivity exercise that consultants and environmental managers within mining companies played the role of advisors rather than decision makers, i.e. they did not have the decision-making power that other participants thought they did. The consultant group had a view of the system as a whole, were serious about environmental sustainability (based on their professional background) and had close experience of current decision-making processes by DRM, DWS and mining companies. They lived in Carolina, or nearby, and were arguably geographically closer to the community than the next group, loosely called regulators.

Regulators formed the biggest grouping – IUCMA, DWS (Acid mine water task team), Mpumalanga Department of Agriculture, Forestry and Fisheries (DAFF) – whose members shared their concern about AMD impacts on agriculture and forestry. Civil society appeared at the meeting as a regulator, in the form of staff of the Legal Resources Centre, who are pursuing the outcomes from 2012 court cases.

Other participants in the UKCMF organised farmers with serious concerns about coal mining impacts and often in direct conflicts (including court cases) with coal mines. Previous discussions included participation from local government representatives. DMR, as noted above, has consistently been absent. Participants viewed a PowerPoint presentation, which summarised the proposed IMP and DSS, as well as a more detailed DSS and IMP in hard copy. The presentation outlined a number of important issues, outlined below.

1. The decision-making process which should leave the future open. Mining should not, therefore, damage the natural capital, like wetlands, rivers and underground water.
2. The future should be decided on the basis of, and with knowledge of what Carolina's natural capital is and what it can be used for water resources and biodiversity.
3. Decisions about coal mining should be made in full knowledge of current and future land use options, including IDPs, land reform plans and national development plans.
4. Against this background, coal mining decisions should be made in terms of benefits to national and local economies, its impacts on water resources, preserving other land use options into the future, and the costs of restoring any damage.
5. Coal mining decisions should be the outcome of a fully informed process of dialogue that take all these factors into account.
6. These decisions form the basis of a monitoring system that is fully informed by open access to all legal instruments, such as water use licences, mining authorisations, social and labour plans.
7. Documents and discussions are streamlined, in accessible language, reasonable length, honest and sincere, with publicly-funded support for those who checked data.
8. Relevant departments support this process through specialist knowledge (part of the Key Performance Indicators in their jobs).
9. The process is co-ordinated by Catchment Management Agencies as custodians of water resources.
10. The Catchment Management Forum develops a knowledge network of information at hand, local knowledge and experts to call on, to support making decisions, monitoring and acting on compliance.

After the presentation, participants were asked to respond to the following questions, as outlined below.

Explain what you think of this system, in terms of the following questions.

1. Is it desirable? What do you like about it and what do you dislike?
2. Can it work? What can work and what can't? What may take a long time to work?

3. What would you change about the proposed decision-making system?
4. What would need to change in the present system for this decision-making system to work?

The first two groups responded to the questions in general, while the regulators gave point-by-point responses. The detailed responses from all three groups are recorded in Appendix E, the minutes of the meeting.

All three groups agreed that the new system was desirable and necessary, although many doubted how long it would take to achieve. Some were clear that power struggles would block the way. In particular, people's mind-sets, attitudes, and ways of doing things would have to change. In summary, a big and broad transformation would be needed. The analysis below draws together the various inputs into the ten themes that attracted most comment. (These 10 points are not directly related to the 10 points in the IMP and DSS).

7.1 Comments and concerns about a new decision-making system

7.1.1 Community participation

Participants commented that there is not enough community involvement foreseen in the plan. Community involvement became a serious discussion, including the following issues: who in the community should participate; achieving continuity through organised civil society; the costs to community in money and time lost; bridging knowledge gaps where these exist, and relationships with government officials.

During the discussions, it emerged that the group saw the community as ‘the broader public’, that can be reached through media, website, newsletter, and that can influence decision-making about coal mines and water resources.

From the community point of view, some commented that their involvement (participation) was costly, while participants were sent to the meetings by employers, but many paid for their participation (in terms of time and transport) themselves. As a result, the catchment management system needed to be simple and sincere. It must not be time-consuming and confusing because people's time is a scarce resource. That very morning, only two out of four confirmed Silobela participants could attend, because the other two were looking for work, i.e. income. Another community participant was in and out of the meeting as he had to meet people for work.

Community concerns are currently not taken seriously, argued community participants. There is little feedback, concerns are minuted, but no action follows. An interesting aspect, coming from the community voice, is that the decision-making process should be dynamic, should be constantly reviewed, and changed when necessary. This is an explicit expression of support for adaptive management, to avoid a situation where mining companies achieve a “once-off for ever” permission through a process that may misrepresent or miscalculate both benefits and risks.

The issue of how community participation can have continuity is also a serious one. The IUCMA reported that continuity can be a challenge. The answer seems to lie in (1) organised structures in civil society who commit to participation; and (2) are then supported with information, capacity building workshops; and (3) logistical and financial support, e.g. for travel. The discussion came around to the conclusion that capacity should be built and supported by officials from various departments, as part of their work as public servants. This requirement goes beyond transparency into the realm of “putting people first” (Batho Pele) and serving the people. Thus, the requirement is not just that the community must be included and consulted, but that the right circumstances should be created for this scarce volunteered resource.

The consultant group said they “like the fact that there will be local input from local communities, from people close to home.” It is important that this process is driven by local knowledge, but capacity building and explanations for local participants will be needed.

The consultants however expressed concern that there may be a conflict of interests between different participants. How would this be resolved? (This important issue is pursued further, below.)

7.1.2 Dialogue and conflicts of interest

An important concern was the **nature of the dialogue** that is foreseen. Participants argued that all voices should be heard in a balanced way. The information about land use planning, different options, benefits, costs and risks should be openly and fairly shared. To the analyst's ear this resonates with the idea of a dialogue aiming at cognitive justice, a “parliament of different but equal knowledges” (Visvanathan, 2009). This links back to a question underlying community participation – and in general catchment forum participation: Who speaks for who? How do we achieve cognitive justice in these spaces?

A particular concern was with mines “selling” their projects in such a process. There was a nagging concern about **conflicts of interest** – how and by whom are decisions made? There is a potentially difficult question of conflicting agendas. However, one may remember that the main point of this system is seeing that coal mining permissions do not undermine ecological infrastructure. It is therefore not a total decision-making system; rather one that protects water resources, and future options, within the catchment management framework. However, the point of a fair and inclusive dialogue is very important. This brings us to questions about the nature of the dialogue: it should be inclusive, well informed, in the public interest, and how it should be facilitated. (Forums project works with similar concerns and questions.)

7.1.3 Knowledge and power

These considerations link closely to the theme of knowledge and power: how decision making and monitoring is enabled or disabled by keeping away knowledge. There were many discussions in the meeting of 19 January about knowledge. One discussion focused on how data needs to be refined into information and then knowledge, that there is a specific function of publicly paid officials to refine this data and make it available. There is great power in this process, so this process needs to be undertaken in a principled, transparent way, in the public interest.

There was a strong suspicion in the discussions that the inscrutability and unaccountability of decisions about coal mining and their impact on water resources serve some interests well. This question needs further research.

7.1.4 Plain language, capacity building and communication

There is strong support for clear, sincere communication, plain language, access to information etc. as part of a monitoring system. With less paper work (there were strong objections to lengthy technical submissions “that never get read”) there are better chances for participants familiarising themselves with the content (as argued above, volunteer time is limited). With a plain-language approach, proposers and regulators are forced to explain themselves clearly. Moreover, capacity building should aim at levelling the playing field and giving participants the ability to really participate in discussions.

7.1.5 What does the transition to green economy mean?

The proposed decision-making process is ultimately **framed in a transition** from a fossil fuel to a low carbon or **green economy**, which gives rise to the underlying concern of protecting

the “ecological infrastructure” on which this new economy will depend. Currently, some land uses other than mining already rely on this eco-infrastructure.
During discussions on 19 January, concerns were expressed that the “green economy” framing is “vast” and difficult. It also does not command support from everybody. There are many who believe in traditional growth economy and coal mining as a driver of it.

The framing itself needs to be debated to build up understanding. In particular, how is South Africa positioned in this worldwide contested transition? The pressures for an economy with a lower carbon budget seem huge and unavoidable. Also, there is clear support for it in national policy, including the National Development Plan.

7.1.6 Is this a decision-making process?

There remains a clear concern with the decision-making process, including what the actual arenas of decision making are. It is this aspect that cautions us to look at two levels of ambition:

(1) It intends to catalyse awareness and set directions of, and mechanisms to support, change
(2) more immediately, it is aimed at developing the capacity and demonstrating the potential of the UKF, and similar catchment management forums, to meaningfully participate in decision making involving coal mining, wetlands, water resources and ecological infrastructure in the area. The development of the monitoring and decision support systems contemplated in this project therefore needs to be seen as initial steps in a long-term process that may provide some immediate relief, and will work to strengthen the emergent catchment management system It also explores pathways in the transition to a green, sustainable, low carbon economy.

What power would this process have? How would it negotiate with DRM? Would it be trying to reform DMR? Is it looking for dialogue with DMR? It seems that it would be limited by a catchment management perspective – but that still involves the fundamental forum constellation question:

1. Who should be participating in the forum?
2. What powers should they lend the forum,
3. What obligations do they have, e.g. as government departments, to include participants in decisions, to provide or share knowledge, to build capacity?

7.1.7 Catchment Management Agency co-ordinates the process

The leading role of the Catchment Management Agency (CMA) has been an assumption in this project from the start. The participants in the meeting of 19 January agreed with this, viewing it as basically unremarkable. However, there were two preconditions: this leadership role would need cooperative governance with dialogue and strong accountability. And it would need to know who is doing what in each role.

This, in fact, <u>is</u> the role of the CMA: taking responsibility for water resources, authorising, monitoring and regulating their use. The UKCMF fits within this process. However, it is an emerging one that is slowly receiving mandates, budgets, and staff to do this. For example, the process in South Africa has been delayed by at least ten years, and at times – e.g. West Coast – a nearly complete process was demobilised. Thus, it is not a straightforward assumption but would be an achievement. Important here is the assumption of a supportive relationship between the CMA (IUCMA is a good example) and the forums.

7.1.8 The need for a single, streamlined system

The need for a single, streamlined environmental system has been continually expressed. The one argument is to overcome a process that is currently fragmented and riddled with duplication, making it difficult for many actors to follow the decision-making process. The other argument is the need for integration of all considerations and inputs. The fear is that the latter system may be captured by a single, dominant player and not lead to any substantial improvements, instead of being characterised by true co-operative governance and participation. [See Chapter 3 discussion on the history and current features of a single, streamlined system for coal mining decision making.]

7.1.9 Develop a Decision Support System in the form of a knowledge network

Participants supported the idea of an internal (to the forum), localised source of knowledge, but cautioned that it may need a lot of resources to create and update. They cautioned that this step, like capacity building, should not wait until the end of the project, but be an early activity.

APPENDIX F

ECOLOGICAL INFRASTRUCTURE, MINING LICENSING AND CONTESTATION

(Please note: references in this appendix can be found in the references in the main report.)

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1 ECOLOGICAL INFRASTRUCTURE, MINING LICENSING AND CONTESTATION

This appendix further develops the analysis by asking how the law frames resistance and contestation in the arena of mining and the protection of wetlands, biodiversity and ecological infrastructure.

1.1.1 Legal framing of contestation and resistance

It is worth mentioning that the shortcomings outlined above come into focus from the perspective of protecting wetlands, biodiversity and ecological infrastructure, i.e. that the legal framing of mining licensing processes undergirds the strength and continued dominance of the Minerals Energy Complex. As a result, mining is frequently authorised in a manner that overrides other interests of national, regional and local importance. What options does the law establish – both within, and outside of, the mining licensing process – to resist and contend against this state of affairs? How does law channel contestation and resistance? What is the basis for, and scope of resistance? Where are the loci of dispute resolution and why have they not functioned effectively to establish a more proportional relationship between coal mining and ecological protection? What are the trade-offs? How do resistance and contestation feed back into decision-making, if at all?

In this section, we pursue these questions by drawing a broad distinction between (a) broad-scale forms of resistance and contention that challenge the frame; i.e. the law and conduct establishing the legal parameters in which mining licensing occurs; (b) resistance and contention associated with the mining licensing process. In this regard, we pay more attention to forms of resistance and contention that can be exercised prior to the authorisation of mining; and (c) forms of resistance and contention that are not necessarily linked to a licensing process. The case discussions in the section that follow draw upon the researcher's work for the Mining and Environment Litigation Review undertaken for the Centre for Environmental Rights, and available on their website (http://cer.org.za/programmes/mining/mining-and-environment-litigation-inventory).

The forms of contestation and resistance discussed in this section are necessarily formal in nature, as a result of their framing in law. It must be borne in mind that there are many avenues of informal resistance and contestation that may be pursued instead of, or alongside, these formal paths. In the case of informal resistance and contestation, law may nevertheless also play a framing role in terms of law relating to gatherings, trespass and its definition of various other forms of 'criminal' conduct.

1.1.2 Contesting the frame

Can one resist the manner in which wetlands, biodiversity and ecological infrastructure are backgrounded in current mining licensing processes by challenging the law itself? Can one challenge legislative or executive *conduct* that determines how effectively such laws function? Law in this sense can refer to any one of the statutory enactments discussed in this chapter, as well as the bylaws and local town-planning schemes of local authorities. Conduct refers to legislative or, more commonly executive, action that can be differentiated from administrative action; i.e. the kind of action involved in deciding when legislation commences, making regulations, or developing strategy.

Since South Africa became a constitutional democracy, it has been possible to contest law and conduct on the basis of unconstitutionality (s 2, Constitution). The South African Constitution articulates rights, obligations and values, with which all law and conduct must conform. The legal basis for doing so can be either one of the rights set out in the Bill of Rights (the right to environment or possibly the socio-economic rights set out in ss 26 and 27), or the constitutional principle of legality. The principle of legality is associated with constitutional

supremacy and the rule of law as articulated in s 1(c) of the Constitution, which states that South Africa is founded on the values of supremacy of the Constitution and the rule of law. The principle of legality has been used much more frequently than any of the human rights to contend against laws applicable to mining.
A selection of landmark cases (listed below) are relevant to this discussion. Details of the pertinent legal issues as well as the outcome are provided in Appendix XX1.

Case 1: *Aquarius Platinum SA (Pty) Ltd v Minister of Water and Sanitation & others* (unreported, Case No. 75622/2014, Gauteng North High Court, 27 May 2015)
In this case, the fifth-largest platinum miner in the world challenged the President's publication of the National Environmental Laws Amendment Act 25 of 2014, which had the effect of bringing this piece of amendment legislation into force and the knock-on effect of setting the SES in motion. See Appendix XX1 for further details.

The High Court distinguished the President's action of publishing the legislation as lying closer to legislative than administrative action (thus situating it within the realm of the principle of legality, see para 23). Referencing ss 79 and 81 of the Constitution, Aquarius argued that this power had to be exercised in a responsible and considered manner, having assessed the progress that had been made to promulgate the supporting regulations (in this instance, the *Draft Regulations on Mine Residue Stockpiles and Deposits*) (para 19). To this the court added that the exercise of the power had to be rational (para 23). After analysing how the President's action affected the SES, and the application of waste legislation in particular to mine residue stockpiles and deposits, the court found that the President's conduct had created a legislative vacuum and a number of other absurdities (para 26). It had also placed the holders of environmental management programmes in a state of uncertainty (para 27). As a result, the President's conduct was found to be irrational and his proclamation bringing the NEMLA was held to be invalid and set aside (para 29) pending confirmation by the Constitutional Court (s 172(2)(a) Constitution). Soon after this judgment, however, the regulations on mine residue stockpiles and deposits were in fact published (on 24 July 2015). (See Appendix B for further details).

The *case of Exxaro Coal (Mpumalanga) (Pty) Ltd & another v Minister of Water Affairs & another* 2012 JDR 2502 (GNP) illustrates how using the principle of legality can be used in conjunction with constitutional rights to challenge executive conduct.
In this case Exxaro challenged the Minister of Water Affairs' decision to suspend the Water Tribunal in 2012 on the basis that the contract of the chairperson and members of the Tribunal had expired and legislative changes relating to the Water Tribunal were pending. Exxaro had wished to appeal to the Water Tribunal against a directive issued against it in terms of s 22 of the NWA. However, following the Minister's decision all persons with matters lodged at the Tribunal were instructed to have their matters set down for a process of mediation and negotiation. The court had little difficulty in finding that the Minister had no power under the NWA to disband the Water Tribunal, or to exercise discretion to appoint its members or chairperson. Item 3, Schedule 6 of the NWA specifically provides that the Minister is obliged to take steps to fill vacancies on the Water Tribunal as they occur (para 24) and because she had failed to do this the Minister had failed in both her statutory duties, but also her constitutional duties (because s 237 of the Constitution provides that all 'constitutional obligations' must be performed diligently and without delay (para 41). The judge, however, also went on to find that in deciding not to appoint a chairperson and members of the Water Tribunal, the Minister thus also infringed the applicants' constitutional rights under s 34 of the Constitution (right of access to the courts) (paras 21, 27).

Apart from contesting law or executive action (where the remedy would be setting aside the law or conduct complained of), the higher courts can also be approached to provide an authoritative interpretation of laws, as in the case of *Maccsand (Pty) Ltd v City of Cape Town & Others* 2012 (4) SA 181 (CC). In the *Maccsand* matter the higher courts were asked to decide whether the meaning of 'relevant law' in s 23(6) of the MPRDA referred to mining-related laws strictly speaking (such as laws dealing with mine health and safety) or also to laws dealing with land-use planning and the environment. The significance of this interpretation was that it determined whether the MPRDA, and decisions taken on its terms, 'trumped' other laws or not. The Constitutional Court decided that the term 'relevant' should be interpreted widely, thus not allowing the exclusion of land use planning laws to land upon which prospecting or mining has been authorised – one of the most significant judicial decisions in the field of mining and environment in recent years.

In the field of environmental law more generally, there are examples of civil society groups using the principle of legality or the Bill of Rights provisions of the Constitution to compel the State to properly implement environmental laws. Examples include *Wildlife Society of Southern Africa & others v Minister of Environmental Affairs and Tourism of the Republic of South Africa & others* 1996 (3) SA 1095 (Tks) in which the Wildlife Society of Southern Africa was successful in a court application to compel the Minister of Environmental Affairs to enforce the provisions of s 39(2) of Decree No. 9 (Environment Conservation), 1992 of the former government of the Transkei to ensure the ecological integrity of the Eastern Cape coastline. This challenge succeeded notwithstanding that a Task Group had been set up by the government to tackle illegal developments on this coastline. And in *Kloof Conservancy v Government of the Republic of South Africa* 2015 JDR 0078 (KZD) the applicant sought a mandamus against the government for failing to publish a list of invasive alien species (IAS) as required by s 70(1)(a) of the National Biodiversity Act 10 of 2004. In a ground-breaking judgment Vahed J linked the meaning of 'health and well-being' in s 24 of the Constitution to biodiversity and the ecosystem services that biodiversity provides. He held further that effective conservation and sustainable use of biodiversity at all levels was a precondition for sustainable development. Development would accordingly not be sustainable if it resulted in loss and degradation of habitat in threatened ecosystems and critical biodiversity areas; further introduction or spread of IAS; or over-abstraction of water beyond the limits of the ecological reserve (para 109). On the basis of this rights-based reasoning, the court found that the Department of Environment's failure to publish the list of IASs within the statutorily delimited times was unlawful and unconstitutional, and further instructed a variety of national and provincial authorities to 'do all such things and take all such steps' necessary and within their legal authority to ensure that all organs of State in every sphere of government complied with the IAS regulatory framework.

These cases illustrate the potential to use the principle of legality or various rights in the Bill of Rights to challenge the framework for calibrating mining authorisation against the need to protect wetlands, biodiversity and infrastructure. Types of cases that could be brought include a challenge to the standards that must be used for the issue of environmental authorisations or water use licenses; the current institutional arrangements for valuing ecological infrastructure in mining licensing processes in the context of the State's duty as a custodian of various natural resources; the exceptionalism still afforded mining as regards consent; the need for the Minister of Environmental Affairs to exercise her power to declare certain specified geographical areas off limits for purposes of issuing environmental authorisations or waste use management licences. The remedy in such cases will either be the setting aside of law or conduct, the reading in of provisions into the law, interpretation of the law, or the compulsion of state action. As is apparent from the *Kloof Conservancy* case, the courts will not necessarily shy away from orders having resource implications. Nevertheless, it is important to acknowledge that launching and sustaining a test case challenging the frame is resource intensive and may involve a commitment of many years if the case is taken on appeal. Given the precedent-setting value of such decisions, the stakes of losing are also high.

1.1.3 Contestations associated with mining licensing processes 31 MAY 21.45

One can broadly distinguish between formal forms of resistance that may occur (a) before a decision to authorise mining is taken or before mining commences; (b) those that may occur within a relatively short period of time after the licensing decision and that essentially challenge the licensing decision; and (c) forms of resistance and contestation that are essentially concerned with the proper enforcement of the licensing conditions. In the case of pre-licensing resistance and contestation this report examines s 10 objections, contestations around land access, and contestations around land-use planning. In the case of immediate post-licensing resistance and contestation, ministerial appeals, appeals to the Water Tribunal and judicial review are considered. For forms of resistance and contestation associated with the enforcement of licence requests for access to information, licence amendments, complaints relating to law enforcement, directives, environmental audits, suspensions and withdrawals, public participation around closure, and criminal proceedings are considered. In each case, the emphasis falls on the capacity of each form of resistance and contestation to protect wetlands, biodiversity and ecological infrastructure.

1.1.3.1 Contestation and resistance prior to mining licensing

(a) Section 10 objections

Under the SES, an opportunity to 'object' to the granting of a prospecting or mining right still exists. This stands alongside the opportunity to engage in public participation relating to the environmental authorisation granted in terms of the NEMA. The rules set out in chapter 6 of the 2014 EIA Regulations now govern the latter process. While these rules set out better notice requirements, and require that comments submitted by interested and affected parties be recorded in reports and plans submitted to the authorities, it is our opinion that the public participation processes offer minimal opportunity for meaningful contestation and resistance. This is because comments from other state authorities and civil society are heavily mediated by the persons compiling the public participation and environmental reports; and because it is clear from the articulated purpose of public participation as set out in the EIA regulations, that participants have little more than a right to comment and have access to information, i.e. the purpose is not more broadly framed to improve decision-making pertaining to wetlands, biodiversity and ecological infrastructure. This offers little hope of comments submitted during the public participation process having any substantive impact.

At the moment, the bare legal framing of s 10 objections is still limited to s 10(2) of the MPRDA, which provides that if a person objects to the granting of a prospecting or mining right or mining permit, the Regional Manager must refer the objection to the Regional Mining and Environment Development Committee (RMDEC) to consider the objections and advise the Minister of Minerals thereon. An objection could relate to any procedural or substantive issue and theoretically could therefore serve as a means of contesting the impact of prospecting or mining on significant ecological infrastructure. Following the entry into force of Act 49 of 2008, however, there is currently no longer a requirement for the Minister to even consider the advice of the RMDECs (a requirement that used to be found in the now repealed s 39(4)(b)(i) of the MPRDA). The MPRDA Amendment Bill, which has been before Parliament for some time, contains provisions aimed at strengthening the functioning of the RMDECs including new rules on its composition, membership requirements, the filling of vacancies and reporting. Significantly, these provisions say nothing about the need for the RMDECs to function transparently. Furthermore, the prescribed composition of the forum is heavily skewed toward mining interests (proposed s 10C of the Mining Bill states that the 14 members nominated to the committee must have experience in mineral and mining development, mine environmental management, petroleum exploration and production). The capacity of such a forum to fairly and objectively assess the impact of an extractive project on wetlands, biodiversity and ecological infrastructure may already therefore be suspect. Additionally, the proposed amendments define a new procedure whereby the Regional Manager, upon receiving an objection, may refer such to the applicant to consult with the person objecting with a view to formulating an agreement. If an agreement is reached it must be reduced to writing and forwarded to the RMDEC. This procedure is likely to function to de-escalate the objector's concerns, raising a barrier to the consideration and resolution of the objection by an impartial forum.

A review of pending cases compiled for the Centre for Environmental Rights additionally found that the DMR failed to notify objectors that their concerns had been forwarded to the relevant RMDEC, or to alert them to the meeting at which their objection would be considered (Centre for Environmental Rights, 2011: 125). In the case of the COAL of Africa project located close to the Mapungubwe Heritage site, it was found that:

'[A] number of objections to the project were submitted in terms of s. 10 of the MPRDA. By law the RMDEC was obliged to consider these and submit recommendations to the Minister. Although the Endangered Wildlife Trust was granted an opportunity to address the RMDEC of its concerns, the RMDEC meeting at which this was to occur was postponed. No further notice of a RMDEC meeting at which objections to the Vele colliery were considered was received by the appellants and to the best of their knowledge none took place prior to the approval of the EMP' (at 125).
These considerations point to both public participation and s 10 objections as being weak avenues for contestation and resistance.

(b) Access to land (section 5(4)(c), MPRDA)

In the past landowners have used the (now repealed) notification and consultation requirement in s 5(4)(c) of the MPRDA to force some level of negotiation with the holders of prospecting or mining rights. This provision prohibited any person from prospecting or mining without 'notifying and consulting with the land owner or lawful occupier of the land in question.' In *Bengwenyama Minerals (Pty) Ltd v Genorah Resources (Pty) Ltd* 2010 JDR 1446 (CC) the Constitutional Court affirmed that the entitlements associated with a prospecting or mining right may not be exercised without the holder undertaking such notification and consultation (para 38). If the landowner or lawful occupier impeded the entry of the prospecting or mining rights holder onto the land, or if an owner or occupier believed they would suffer loss as a result of the operation, either party could notify the Regional Manager and initiate the mediation and arbitration process envisaged in s 54. The envisaged outcome of a s 54 process would either be a written agreement regarding compensation for loss, or determination of the level of compensation by arbitration.

Section 5(4(c) consultations could protect wetlands, biodiversity and ecological infrastructure if it was in the interest of the landowner to bring these issues into the consultation process with the landowner. Frequently, however, land owners and occupiers resist granting prospecting or mining proponents not because they wish to protect nature, but because they themselves wish to mine on the land. This was the case, for instance, in the two decided cases dealing with s 5(4)(c): *Meepo v Kotze* 2008 (1) SA 104 (NC) and *Aquila Steel (Pty) Ltd v South African Steel Company (Pty) Ltd* (unreported, Case No. 14612/2013, Gauteng North High Court, 14 March 2014). Alternately, in another decided case, *Coal of Africa Ltd v Akkerland Boerdery* (unreported, Case No. 38528/2012, North Gauteng High Court, 5 March 2014) it was clear that the landowner had other strategic interests – not the protection of ecological infrastructure – that weighed against him. In this case Coal of Africa had been granted a prospecting right to a farm owned by Akkerland Boerdery. One of the grounds upon which Akkerland refused to grant Coal of Africa access to the farm was that it's Environmental Management Programme (EMP) had not been validly approved, which suggests that ecological concerns also motivated resistance. However, in dealing with the question whether Akkerland had another suitable remedy (other than refusing Coal of Africa access to the land) it was noted that the respondent was lining up 'grandiose schemes of operating hospitality business and other activities" while the legal proceedings dragged on' (para 119).

Using s 5(4)(c) as a source of resistance to prospecting and mining operations for purposes of protecting wetlands, biodiversity and infrastructure has however largely dissipated for two reasons: Firstly, there has been a narrowing of the consultative burden the courts were willing to place on the rights holder under the banner of s 5(4)(c). In the *Meepo* case, for instance, the court had held that consultation under this provision entails more than giving notice. Instead, the prospecting rights holder must attempt to obtain the consent of the landowner as regards entry upon the land for the purposes of prospecting. In *Akkerland Boerdery*, by contrast, the judge held that the purpose of the consultative process envisaged in s 5(4)(c) was to afford the landowner the opportunity to 'minimise damages' inevitably suffered as a consequence of the granting of a prospecting right. This process did not require consensus as a pre-requisite for the holder to access the land (para 36). Secondly, Amendment Act 49 of 2008 repealed s 5(4)(c) and replaced it with a new s 5A(c) which simply requires that the holder of a prospecting or mining right provide the landowner with 21 days written notice of the intent to conduct prospecting or mining operations; i.e. removing the consultation requirement all together.

One can thus conclude that contestation between landowners and occupiers and rights holders over the issue of being granted access to the land to mine or prospect is not an effective channel of resistance for purposes of protecting wetlands, biodiversity and ecological infrastructure.

(c) Land use planning

The Constitutional Court's decision in *Maccsand (Pty) Ltd v City of Cape Town & Others* 2012 (4) SA 181 (CC) established that the granting of a prospecting or mining authorisation does not obviate the need to obtain the requisite land use planning authorisations which would in almost all instances be a rezoning application. The Court said that it was permissible for different spheres of government to exercise powers in respect of the same object and for their powers to overlap at times. In these circumstances, the spheres concerned would need to attempt to resolve their differences in line with the principles of cooperative government set out in the Constitution or, alternately, bring the matter on review before a court.

Following the decision, it was thought that land use planning regulations could at least protect uses of land other than and in opposition to mining, if not to protect wetlands, biodiversity and ecological infrastructure *per se*. *Maccsand* had the effect of re-empowering landowners because in terms of land-use planning laws (which are different in different provinces) it is usually the landowner who is required to submit a rezoning application. However, the manner in which this application of *Maccsand* has played out in formal contestations has been uneven in different provinces, a direct incidence of different land use planning frameworks.

In the Western Cape, where the Land Use Planning Ordinance, 1985 (LUPO, the framework in contention in the *Maccsand* case) governs land use planning, it appears that the provincial authorities are enforcing the zoning requirement. For example, in *Jacobs & another v Transand (Pty) Ltd & another* (unreported, Case No. 11554/2014, Western Cape High Court, 14 November 2014) it was not contentious that mining required proper authorisation in terms of the LUPO before it could proceed. This case, however, reveals other difficulties with the use of zoning requirements (and contestations relating thereto) for purposes of protecting wetlands, biodiversity and ecological infrastructure. The dispute between the applicants and Transand was essentially whether and how the farm had been zoned 'Agricultural 1' in terms of s 14 of the LUPO, a zoning which did not permit mining activities to occur. Much of the case accordingly turned on the *standard* necessary to prove the zoning of a particular property, as well as the *factual evidence* in support of the particular zoning of Agricultural 1 in the case. It was contended, for instance, that it was not enough to show that a zoning certificate was insufficient proof of the zoning of property and that evidence of a decision by the relevant council in respect of the property concerned was required (based on an unreported judgment of the Western Cape High Court (*Frenvest cc v Smith* unreported, Case No. A476/96 of 20 February 1997). Further, in one of the affidavits submitted in the case, it was noted that in the late 1990s it was general practice not to make a zoning determination of a farm property until there was an application either for a relaxation, departure or consent use in relation to that property (para 29). In using zoning requirements as a base for contestation and resistance, therefore, parties contending for the protection of wetlands, biodiversity and ecological infrastructure may come up against the fact that the property in question may not in fact have been zoned. Alternately, they may struggle to find the evidence establishing the zoning. The extent to which wetlands, biodiversity and ecological infrastructure are in fact protected by a particular zoning or not will also be mediated by the forms of land use allowed and restricted in terms of the categories of the relevant town planning scheme.

In provinces, other than the Western Cape, however, contending parties have not been successful in their reliance on the *Maccsand* principle to prevent or delay mining from occurring in their localities. In the case of *Mtunzini Conservancy v Tronox KZN Sands (Pty) Ltd* 2013 JDR 0026 (KZD) it was evidently in the interests of the applicant to protect not only the socio-economic character of the town of Mtunzini, but also the ecological integrity of the pristine dunes on the Zululand coastline. They also argued that eco-tourism was a more long-term sustainable development scenario for the region. If the mining of the dunes for minerals used in the production of titanium dioxide had to occur, due process had to be followed and authorisations in terms of applicable environmental and planning legislation had to be obtained. Although the Mtunzini Conservancy relied on *Maccsand*, and highlighted the distinction between 'mine' as a noun (falling within the land use function) and 'mine' as a verb (falling within the mining function), these arguments did not convince the judge. He distinguished the case from *Maccsand*: A different land use regulatory framework was in place and this had been amended over the years, only making it clear in 2008 that development authorisations were required when land was developed for mining purposes. The mining rights to the area had also been granted in terms of the Minerals Act 50 of 1991, not the MPRDA – this Act together with the constitutional framework relevant to provincial powers made it clear, according to the judge, that a mining authorisation was the only permission required to commence mining.

In two cases – *Coal of Africa* and *Aquila Steel*, both concerning land in areas governed by the Town Planning and Townships Ordinance, 1986 (Transvaal) – the courts affirmed that prospecting and mining must comply with relevant zoning requirements as per *Maccsand*. Their judgments confirm, however, that much hinges upon the interpretation of the actual land use planning instrument in question. In *Coal of Africa*, the court found that the Makhado Land Use Planning Scheme created a 'permanent exemption' in favour of allowing mining to occur without the need to apply for a special consent use in areas that fell within the jurisdiction of a local municipality but outside the area of a proclaimed township. In *Aquila Steel* the judge found that the Town Planning Ordinance obviated the need for rezoning on at least two grounds: It was clear that the authority of a local authority was limited, and that only those portions of land within the jurisdiction of the local authority that fell within a town planning scheme were affected by zoning requirements. Land falling outside of a town planning scheme would accordingly fall outside a zoning scheme and the approval of the local authority would not be required. The judge then linked this finding to the controversial s 21(1) of the Ordinance, which provides that a local authority shall not prepare a town planning scheme in respect of land which is proclaimed land or land on which prospecting, digging or mining operations are being carried out, unless such land is situated within an approved township (para 60). The effect of this judgment is therefore that in areas governed by the Transvaal Provincial Ordinance local authorities cannot prepare a town-planning scheme in respect of land on which prospecting or mining is being carried out, thus conclusively excluding the need for local authorising approval for rezoning.

The cases discussed above illustrate that relying on land-use planning frameworks as a basis for contention and resistance in the context of mining, wetlands, biodiversity and ecological infrastructure is, at best, tenuous. Much depends firstly, on how town planning schemes define particular land uses and the impact of those uses on the natural landscape (for example, it is not clear that a zoning of 'Agriculture 1' would necessarily provide superior protection for wetlands and biodiversity than any other zoning). Secondly, one cannot assume that areas of undeveloped land necessarily have a zoned use, and finally there are provisions in land use planning laws that block local authorities from preparing town planning schemes in respect of land on which prospecting or mining is being carried out.

1.1.3.2 Post-licensing contestations aimed at setting the license aside

The second set of formal contestations relating to the licensing relationship may occur in the immediate aftermath of a decision to authorise prospecting or mining in a particular area. The objective of these forms of contestation is essentially to set the licence aside. Any concern relating to the protection of wetlands, biodiversity and ecological infrastructure may ground the launch of the appeals described in this section, and may form the substantive basis of the ground for judicial review.

Ministerial appeals

Since the establishment of the SES there are now two broad avenues of appeal:

- Section 96 of the MPRDA allows any person 'whose rights or legitimate expectations have been materially or adversely affected' or who is 'aggrieved' by a decision to authorise prospecting or mining to appeal to the Minister of Mineral Resources. The lodging of such an appeal does not suspend the operation of the prospecting or mining right concerned, which means that operations may commence while the appeal is being decided (s 96(2)(a). MPRDA).
- Section 43(1A) of the NEMA allows any person to appeal to the Minister of Environment against a decision taken by the Minister of Mineral Resources of any person acting under his or her delegated authority (i) in terms of the NEMA; or (ii) in terms of any 'specific environmental management Act' (i.e. waste authorisations under the NEMWA). The Minister of Environment may consider the appeal herself or appoint an appeal panel to consider and advise here thereon (s 43(5) NEMA). After considering the appeal, she may confirm, set aside or vary the original decision or any provision, condition or directive associated with the decision or make any other appropriate decision (s 43(6) NEMA). Lodging an appeal under the NEMA has the effect of suspending the initial decision.

Either of these avenues of appeal could be used to argue that a prospecting or mining right should not have been granted on ecological grounds. Since the consolidation of the SES, it seems more appropriate that appeals relating to wetlands, biodiversity or ecological infrastructure would follow the NEMA route, because they relate to the project's environmental authorisation. In parliamentary portfolio committee meeting discussions preceding the establishment of the SES, however, the need to curtail the potential for appeals was expressly discussed. The committee's concerns now find expression in s 47CA of the NEMA, which provides that in respect of a decision that relates to prospecting or mining under the NEMA or a specific environmental management Act (i.e. the NEMWA), the Minister of Minerals may only condone a failure to comply with time periods relating to appeals in 'exceptional circumstances'. This must be read with new regulations on EIA appeals, which shorten the periods for the time in which appeals may be lodged.

At the moment, an appeal to the Minister of the Environment under the NEMA is essentially an untested route. It remains to be seen whether actors interested in the protection of wetlands, biodiversity and ecological infrastructure will be able to use the appeal process to advance their concerns.

Prior to the establishment of the SES, some civil society and community-based groups attempted to use s 96 appeals to protect wetlands, biodiversity and ecological infrastructure (see the discussion of the Limpopo Coal-Mapungubwe case and the TEM-Xolobeni case in the CER's Mining and Environment Litigation Review, 118). Both cases illustrate one of the key structural deficiencies of s 96, which is that the time within which the Minister is required to decide the appeal is not prescribed. Because the lodging of the appeal does not suspend the application, it is in the interest of the mining proponents to delay decision-making – for example, in the TEM-Xolobeni case the Minister decided the appeal nearly three years after it had been submitted. There is also no guarantee that the appeal will set the license aside and the appeal, like in the TEM-Xolobeni case, may simply result in the rights holder being instructed to remedy some defect in its application process.

Ministerial appeals, particularly under the NEMA, may prove to be an important formal basis for contending against the ecologically inappropriate granting of prospecting or mining rights. Nevertheless, the experience of relying on s 96 of MPRDA has not yielded positive results.

Appeals to the Water Tribunal

The NWA establishes the Water Tribunal as an independent body with national jurisdiction (s 146, NWA). The jurisdiction of the Water Tribunal extends to the decisions of a responsible authority on an application for a water use licence in terms of s 41. An appeal to the Water Tribunal may be submitted by the licence applicant 'or any other person who has timeously lodged a written objection against the application (s 148(1)(f), NWA). Lodgement of the appeal has the effect of suspending the water use licence contended against, unless the Minister decides otherwise (s 148(2), NWA).

It is reasonable to expect that the Water Tribunal would have played a key role in developing a substantive set of principles pertaining to the impacts of mining on wetlands, biodiversity and ecological infrastructure. Civil society actors have attempted to use the Water Tribunal as a means of resistance and contestation. Between 2009 and 2010, for instance, the Escarpment Environment Protection Group and other civil society actors lodged a number of appeals with the Tribunal contending against the granting of water use licences for coal mining operations (see *Escarpment Environment Protection Group & Wonderfontein Environmental Committee v Department of Water Affairs & Exxaro Coal (Pty) Ltd* (unreported, WT 03/08/2010); *Escarpment Environment Protection Group & Langkloof Environmental Committee v Department of Water Affairs & WER Mining* (unreported, WT 25/11/2009); *Escarpment Environment Protection Group & Wonderfontein Environmental Committee v Department of Water Affairs & Xstrata Mining* (unreported, WT 24/11/2009); and *Gideon Anderson T/A Zonnebloem Boerdery v Department of Water and Environmental Affairs and another* (unreported, WT 24/02/2010). None of these cases was considered on the merits, however, because the Water Tribunal adopted the ludicrous position that the applicants had no locus standi. This was based on their interpretation of s 148(1)(f) read together with s 41(4) of the NWA, which provides in turn that the responsible authority may require the applicant for a water use licence to publish a notice in newspapers and 'other media' stating that written objections may be lodged against the application within a specific time. If the responsible authority had not exercised its discretion to require the applicant to call for written objections, it followed that no person other than the applicant would have locus standi to lodge an appeal before the Water Tribunal, even where a person had submitted unsolicited written objections. Fortunately, this interpretation of the law was set aside on review. In the case of *Escarpment Environment Protection Group & another v Department of Water Affairs & others* 2013 JDR (GNP), the court had no difficulty in overruling the Water Tribunal's stance on the question of locus standi, finding that an interpretation that limited standing on the basis of submission of a written objection in a process initiated by the water authorities was arbitrary and eccentric.

In the meantime, however, the Minister of Water Affairs had also decided to 'suspend' the operation of the Water Tribunal – a decision that was successfully challenged in the *Exxaro Coal* case. A new chairperson and members of the Water Tribunal have since been appointed. It is hoped that with the question of locus standi now clarified, the Water Tribunal will begin to play a more robust role as a forum of contention and resistance in the service of protecting the nation's water resources.

Judicial review

Appeals are distinguished from reviews in that they involve a new decision on the merits: The second decision-maker may examine the facts of the case and come to a different decision from the decision-maker of first instance. This differs from a review where the courts examine how a decision was taken. On the basis of the grounds now set out in the Promotion of Administrative Justice Act 3 of 2000, the courts may set the decision aside and refer it back to the original decision-maker, with instructions to remedy the cause of defects in the decision-making process. In certain cases, the court can make an order substituting their own decision for that of the original decision-maker. This occurs however only in exceptional cases.

Section 6 of the PAJA lays down the grounds of judicial review in South Africa. These include a variety of procedural grounds for setting the decision aside (e.g. the administrator who took the decision was not authorised to do so by the empowering provision; a mandatory or material procedure or condition prescribed by the empowering provision was not complied with; the action was procedurally unfair; the action was taken for an ulterior purpose or motive; etc.) in addition to grounds that allow for more substantive scrutiny of the decision. These include the forms of rationality review in s 6(2)(f) and review on the basis of reasonableness in s 6(2)(h). Following the Constitutional Court's decision in *Bato Star Fishing (Pty) Ltd v Minister of Environmental Affairs* 2004 (4) SA 490 (CC), it is now clear that reasonableness refers to 'simple reasonableness' and not the 'gross unreasonableness' that was symptomatic of other grounds of judicial review under the common law.

Judicial review can serve as a further platform for contestation and resistance if a ministerial appeal does not succeed. It is, however, a human, financial and time resource intensive process with an inherent level of uncertainty as to the outcome. The risks of using judicial review are illustrated by the Eyesizwe-Zoekop case, discussed in the Centre for Environmental Rights' *Mining and Environment Litigation Review* (2011: 119):

In this case, the prospecting right was granted to Eyesizwe Coal on 30 October 2006. The civil society applicants were not notified of the grant of the right. Review proceedings were launched more than a year later on 23 January 2008. The respondents, which included the DMR, indicated their intention to defend but did not deliver any answering affidavits. In a surprising move, Eyesizwe then withdrew its opposition on 22 July 2009 and agreed to pay costs on the opposed scale to the date of withdrawal and on the unopposed scale thereafter, contingent upon the court granting the order to set aside the prospecting right and approval of the EMP. Sometime between 12 and 16 August 2009 it appears that the other respondents withdrew their defence as well. Documentation available, however, indicates that while this battle was playing out Exxaro Coal Mpumalanga (with which Eyesizwe Coal had in the meantime merged) had already for some time been preparing for submission of a mining right in respect of the same properties. In August 2008 consultants had been appointed to conduct baseline water studies for the proposed mine. Another set of consultants was appointed subsequent to this to prepare the scoping and environmental impact report for the EMP. A background information document, dated 21 July 2009, had already been prepared by these consultants for the scoping phase of the project. This report in turn indicates that a mining right application for the proposed Belfast coal mine had been submitted during June 2009 and accepted by the DMR on 10 July 2009. This suggests that while the civil society applicants were engaged in launching and managing the review proceedings for the prospecting right, the DMR and the mining company concerned were simply gearing up to obtain the more far-reaching mining right. This case points to the need to use judicial review as a form of contestation strategically.

1.1.3.3 Contestation associated with enforcing licensing conditions

The third set of formal contestations relating to the licensing relationship revolves around compliance and enforcement of licence conditions, or processes for amending such conditions. They include requests for access to information, licence amendments, complaints relating to law enforcement, directives, environmental audits, suspensions and withdrawals, public participation around closure, criminal proceedings. The disadvantage of these forms of contestation relevant to the forms of contestation and resistance discussed above is that prospecting or mining would have already become entrenched in the area, at the same time changing the ecological characteristics of the landscape.

(a) Access to information requests

The Promotion of Access to Information Act 2 of 2000 (PAIA), which supposedly gave effect to the right of access to information in s 32 of the Constitution, lays down standards and procedures in order to obtain information from public and private bodies. Access to information is critical for purposes of understanding the state of ecological infrastructure in a particular locality and the level of exogenous shock it is facing from prospecting and mining, amongst other land uses. The difficulties of gaining access to information, even with the constitutional right and the PAIA framework are well illustrated by a case such as *Biowatch Trust v Registrar, Genetic Resources & others* 2009 (6) SA 232 (CC) (in which the applicant sought information from the State relating to genetically modified organisms). Empirical research conducted by the Centre for Environmental Rights has also established that the response on the part of key state departments to requests for access to information is also extremely poor (see CER 2012, 2013a, 2013b, 2014).

The tide on access to information, however, appears to be determining with new requirements enforcing transparency specified in the 2014 EIA regulations. Further, in *Company Secretary of ArcelorMittal, South Africa & another v Vaal Environmental Justice Community Alliance* 2015 (1) SA 515 (SCA) the Supreme Court of Appeal decided that the Vaal Environmental Justice Alliance (VEJA) had meet the threshold requirement for being granted access to Arcelor Mittal's Environmental Master Plan, and that Arcelor's status as a private body did not present a hurdle to them being granted access to the information. Significantly, at para 82 Navsa DJP held: 'Corporations operating within our borders, whether local or international, must be left in no doubt that in relation to the environment in circumstances such as those under discussion, there is no room for secrecy and that constitutional values will be enforced.'

(b) Licence amendments

Prior to the establishment of the SES, amendments to the environmental management plan or programme attached to a prospecting or mining right did not require any form of public participation, but simply the written consent of the Minister of Minerals (see s 102, MPRDA). The EIA regulations that are now applicable to environmental authorisations for prospecting and mining establish new thresholds for public participation in this process. Chapter 5 of the EIA regulations distinguishes between amendments of the environmental authorisation and environmental management programme (i) where no change in scope occurs or where there is a change in ownership or the transfer of rights and obligations; and (ii) where a change in scope occurs. In the first instance, the competent authority that issued the authorisation has jurisdiction to decide the amendment and no public participation process is required. This is contentious as regards change of ownership or transfer of rights and obligations as interested and affected parties may have a material interest in, for example, an operation being sold from a multinational company to a more junior miner. In the second case (change of scope), the rights holder must compile a report of the proposed changes and submit the report to a public participation process as defined and agreed to with the competent authority, provided that the process must be 'appropriate to bring the proposed change to the attention of potential registered interested and affected parties, including organs of state, which have jurisdiction in respect of any aspect of the relevant activity.' Theoretically this provides another avenue for contestation and resistance, however, the participation here is conducted after the process of identifying the impacts of the proposed amendment, and the integrity of the process is a function of the Minister of Mineral's discretion. Like public participation conducted prior to the granting of the right, if therefore appears to guarantee nothing more than a 'right to comment'.

(c) Complaints regarding enforcement

The SES establishes a new avenue for civil society to intervene when it is believed that a 'compliance monitoring and enforcement function' has not been implemented or has not been adequately implemented. In this instance, 'complainants' may write to the Minister of Mineral Resources, submitting information supporting the complaint (s 31D (5) NEMA). The Minister must presumably reply (though there is no legal duty or legally constrained time limit in which to do so). If the complainant is dissatisfied with the Minister's response he or she may submit the complaint, supporting information and history of engagement with the Minister of Mineral Resources to the Minister of Environmental Affairs (s 31D (6) NEMA). On receiving such a complaint, the Minister of Environmental Affairs must consult with the Minister of Mineral Resources, leading to a situation where either the former 'assists or supports' the latter in his compliance and monitoring function, or directs environmental management inspectors (as opposed to the environmental management resource inspectors) to undertake the function directly (ss 31D (7)(8) NEMA).

In a circuitous, indirect way this provision could theoretically protect wetlands, biodiversity and ecological infrastructure if the lack of compliance and monitoring was impairing such. It is one of the 'co-operative governance' mechanisms discussed by the parliamentary portfolio committee prior to the introduction of the SES. Nevertheless, it does institute civil society as a watchdog of sorts in respect of the compliance and monitoring function.

(d) Directives

The regulatory framework for mining allows for various orders to be issued to prospecting and mining rights holders where there is a lack of compliance with the conditions of the right. These include the Minister of Mineral Resources' power to recover costs in the event of urgent remedial measures (s 45 MPRDA), the Minister of Environmental Affairs' or MEC's responsible for the environment to issues directives under s 28 of the NEMA, and the power of responsible authorities to issue directives under s 19 of the NWA. These are further discussed in s 3.2.4 below.

(e) Environmental audits

The 2014 EIA regulations cementing the SES have formalised an environmental audit requirement that now includes a public participation component. For the period during which an environmental authorisation is valid, a holder must ensure that compliance with the conditions of the authorisation is audited (reg. 34(1) EIA Regulations). An environmental audit report, which must be prepared by an independent person with relevant auditing expertise, must be submitted to the competent authority. The environmental audit report must include 'verifiable findings' both of the holder's performance against the provisions of the authorisation, as well as on the provisions themselves to sufficiently provide for the avoidance, management and mitigation of environmental impacts associated with the undertaking of the activity (reg. 34(2) EIA regulations). Where the findings indicate insufficient compliance with the environmental authorisation or insufficient mitigation of impacts, the holder must submit recommendations to amend the associated environmental management programme in order to rectify the shortcomings identified in the environmental audit report (reg. 34(4) EIA regulations). Such recommendations must have been subjected to a public participation process (reg. 34(5) EIA regulations). These provisions regarding environmental auditing also apply to the auditing of closure plans.

The need for ongoing independent environmental auditing of an environmental authorisation situates environmental assessment within a resilience paradigm: Instead of a 'once-off' assessment of impacts with holder-initiated amendments thereafter, the regulations require an independent assessment that examines not only compliance, but the ability of the plan itself to mitigate impacts. This is a positive development. The need for public participation also creates an additional avenue for contestation and resistance, but is subject to the same caveat voiced regarding other points of public participation in the mining licensing process.

(f) Suspensions and Withdrawals

Section 47 of the MRPDA allows the Minister of Mineral Resources to suspend or cancel any prospecting or mining right in the following circumstances: (i) the holder (or owner of previous works) is conducting any prospecting or mining operation in contravention of the MPRDA; (ii) the holder has breached any material term or condition of such right; (iii) the holder has contravened any condition of the environmental authorisation; and (iv) the holder has submitted inaccurate, false, fraudulent, incorrect or misleading information for the purposes of the application or in connection with any matter required to be submitted under the MPRDA (s 47(1) MPRDA). A process must be followed whereby the holder must is given an opportunity to respond and to take specified measures to remedy any contravention, breach or failure (s 47(2)(3) MPRDA). If the rights holder fails to do so the right may in fact be suspended (s 47(4) MPRDA). Powers of suspension and withdrawal are also conferred upon the Minister of Mineral Resources in terms of the NEMA, in this instance linked to the issuing of compliance notices on the part of environmental management inspectors or environmental management resources inspectors. If a person fails to comply with a compliance notice the inspector must report the non-compliance to the Minister or MEC (as the case may be), who may then revoke the relevant authorisation and take any 'necessary steps', the costs of which may be recovered from the person who failed to comply (s 31N (2) NEMA). The EIA regulations also provide the competent authority with a more direct suspension power: Where the authority has reason to believe that the authorisation was obtained through fraud, non-disclosure or material information, or misrepresentation of a material fact (reg. 38). In the case of water use authorisations or entitlements, ss 54 and 55 of the NWA allows the responsible authority to suspend or withdraw entitlements. Like the provisions in the MPRDA and NEMA this power must be exercised with due regard to procedural fairness.

Suspensions and withdrawals may protect wetlands, biodiversity and ecological infrastructure by compelling the rights holder to desist from actions that impair their integrity. The primary actor in this regard is the State. However, in each case directives may be contested by the rights holder as well, which not infrequently leads to judicial review of the decision (see the *Harmony Gold* cases mentioned in s 3.2.4 below). This may delay preventive and remedial action, with the exception of directives issued under the NEMA where lodging an appeal against a directive does not suspend its effect.

(g) Public participation at closure

Prior to the establishment of the SES, the issuing of a closure certificate involved only government officials – the Regional Manager, Chief Inspector of Mines, and 'each government department charged with the administration of any law which relates to any matter affecting the environment' (s 43(5) MPRDA). Now however, the EIA listed activities include the decommissioning of any activity that requiring a closure certificate under s 43 of the MPRDA. Additionally, the listed activities include a form of deemed closure, i.e. where the throughput of activities associated with a prospecting right, mining right or mining permit have reduced by 90% or more over a five-year period. In this case, an environmental authorisation is also required, unless the competent authority agrees in writing that such reduction of throughput does not constitute closure (List 1: Activity 22, EIA regulations). This new authorisation requirement therefore expands the range of public participation processes already required for mining licensing.

(h) Criminal proceedings

The MPRDA, the NEMA and specific environmental management Acts such as the NWA, NEMWA, NEMAQA and NEMBA establish a number of statutory offenses. The nature of the offences and the prescribed level of penalties differ from Act to Act. While the National Prosecuting Authority would ordinarily prosecute such offenses, any of these statutory offenses could also be the object of a private prosecution initiated in terms of s 33 of the NEMA. To the best of our knowledge such a private prosecution in the environmental field has never been launched. Criminal proceedings do not necessarily protect ecological infrastructure, as the damage would already have been done. However, successful prosecutions may have a deterrent effect on other operators in the same field.

1.1.3.4 Contestation outside of the licensing relationship

Sections 28 of the NEMA and 19 of the NWA were passed to establish a statutory duty of care in relation to the environment and water resources respectively. The obligation not to cause significant pollution or degradation of the environment or of water resources attaches to everyone with a material relationship to the land and, at least in the case of NEMA, expressly applies retrospectively. As such, for purposes of the authorities exercising their powers to require the undertaking of reasonable measures to prevent the pollution or ecological degradation, it is not necessary that any form of licensing relationship with the polluter should exist. These sections also allow the authorities to step in, taking reasonable measures themselves, and then to recover costs from an even wider range of persons. In the case of the NEMA provision, some level of citizen participation is envisaged through s 28(12), which allows any person to give the authorities notice of its intent to apply to a court for an order directing the authorities to exercise their powers under s 28, presumably this is intended as a mechanism to galvanise the authorities into action. The series of cases around the Harmony Gold matter (*Harmony Gold Mining Company Limited v Free State, Department of Water Affairs and Forestry* 2005 JDR 0465 (SCA); *Harmony Gold Mining Company Ltd v Regional Director: Free State Department of Water Affairs & others* [2012] ZAGPPHC 127 (29 June 2012); *Harmony Gold Mining Company Ltd v Regional Director: Free State Department of Water Affairs & others* 2014 (3) SA 149 (SCA)) have demonstrated the power of s 19 of the NWA to hold polluters to account, even where they have severed all ties with the land in question, provided that the directive is issued whilst the polluter still maintains a relationship to the land as owner, lessee or user. Like many of the other forms of contestation and resistance described in s 3.2.3 however, ss 28 and 19 are 'back-footed', helping the authorities and civil society to deal with pollution and ecological degradation to wetlands, biodiversity and ecological infrastructure where this has mostly already occurred.

1.1.4 Conclusions and recommendations

From the review above it appears that the establishment of the SES has strengthened the frame for resistance and contestation by improving the legislative basis for access to information, requiring public participation in amendments of environmental authorisations, formalising the need for environmental audits that audit not only compliance but the capacity of the plans in question to protect ecological integrity, formalising the need for public participation upon mine closure, allowing any person to submit complaints regarding enforcement, and allowing for appeals to be submitted to the Minister of Environment. There is also hope that the newly-instituted Water Tribunal will play a significant role as a forum in which the merits associated with the grant of water use licences can be contested.

In other aspects, however, the legal framing does not allow for vigorous or effective resistance and contestation. This is particularly evident prior to the decision to prospect or mine being taken. Section 10 objections, resistance associated with access to land, and reliance on the Maccsand principle to align prospecting and mining authorisations with land use planning requirements have so far proved to be ineffective to balance prospecting and mining with the imperatives of protecting wetlands, biodiversity and ecological infrastructure. Resistance and contestation at this point is more imperative than at the stage at which extraction has already been authorised, as it affords a different form of protection of the natural landscape.

While the use of the rights articulated in the Bill of Rights and the constitutional principle of legality could be used to challenge the parts of the legal frame that are weak, this is a drawn out and risky process, unfairly placing the burden of reform on civil society.