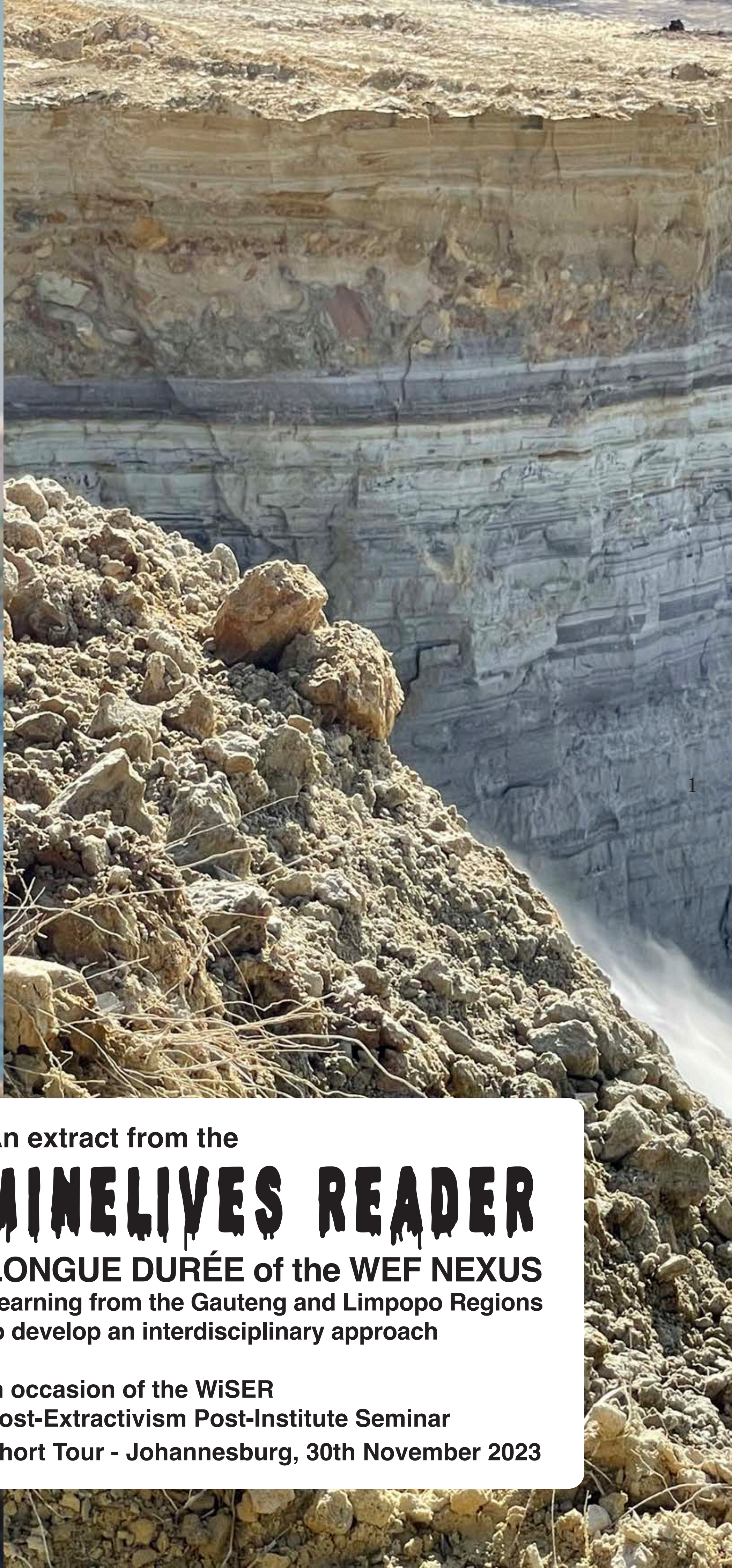


An extract from the

MINELIVES READER

LONGUE DURÉE of the WEF NEXUS

Learning from the Gauteng and Limpopo Regions to develop an interdisciplinary approach

in occasion of the WiSER
Post-Extractivism Post-Institute Seminar
Short Tour - Johannesburg, 30th November 2023

LONGUE DURÉE of the WEF NEXUS

Learning from the Gauteng and Limpopo Regions to develop an interdisciplinary approach

The project is an interdisciplinary research collaboration
between TUDelft, Venda and the Witwatersrand Universities

Principal Investigators:
Hannah le Roux - Wits School of Architecture and Planning - hannah.leroux@wits.ac.za
Fransje Hooimeijer - TU Delft Department of Urbanism - F.L.Hooimeijer@tudelft.nl

Project funded by the Merian Fund

Extract from the WEF Nexus Project Reader in occasion of the
WiSER Post-Extractivism Post-Institute Seminar
held at Wits on the 27th - 30th of November 2023

CONTENTS

Blesbokspruit Wetland

Site description

Located 4 km north-east of Nigel at an altitude of 1 585 m a.s.l., the Blesbokspruit IBA is a large, highly modified, high-altitude wetland with a narrow fringe of degraded grassland. It extends along the Blesbokspruit, one of the Vaal River's larger tributaries, from the Grootvaly Wetland Reserve (R555) in the north to the Marievale Bird Sanctuary (R42) in the south.

Water levels in the Blesbokspruit are artificially maintained by the inflow of mining, industrial and municipal effluents that are contained by embankments. The addition of organic matter produces the highly eutrophic conditions that are favoured by marginal vegetation. Reedbeds (Phragmites australis and Typha capensis) are estimated to cover more than 70% of the Marievale Bird Sanctuary (Joshua 2014) and the remainder of the IBA is similarly affected.

The average annual rainfall is 650–700 mm and temperatures vary from -10 °C in winter to 35 °C in summer (Koen et al. 2007).

Birds

More than 220 species have been recorded for the IBA in SABAP2. The Blesbokspruit, which in the past regularly supported 20 000 waterbirds, was designated a Ramsar Wetland of International Importance for waterbirds in 1986.

The water is highly productive, providing ample food for Lesser Flamingo Phoeniconaias minor and Greater Flamingo Phoenicopterus roseus. The system supports a diversity of waterbird species, including Goliath Heron Ardea goliath, Purple Heron A. purpurea, African Spoonbill Platalea alba, Glossy Ibis Plegadis falcinellus, Pied Avocet Recurvirostra avosetta, Red-knobbed Coot Fulica cristata and White-winged Tern Chlidonias leucopterus. African Marsh Harrier Circus ranivorus, which has been displaced from much of the surrounding veld as a result of intense industrialisation, urbanisation and habitat modification, is a breeding resident. African Grass Owl Tyto capensis is now rarely recorded along the Blesbokspruit, its local population decline being attributed to a reduction in its preferred rank grassland habitat adjacent to the wetland. Large volumes of water discharged upstream have increased the extent and permanence of flooded ground, while reed encroachment, unplanned fires, uncontrolled grazing by cattle and invasion by alien forbs contribute to the degradation of the remaining terrestrial habitat.

IBA trigger species

There is insufficient data to indicate that any species pass the IBA criteria. However, since the wetland is thought to hold more than 20 000 waterbirds, its importance for waterbird conservation should not be underestimated.

Other biodiversity

None.

Conservation issues

Threats

The Blesbokspruit was originally a perennial river with few or no reedbeds along its narrow banks and only a few expanses of open shallow water. During the gold rush of the 1940s, many buildings, roads and railways were constructed in this area, resulting in the creation of several large sand embankments that impeded the river's flow. The large, open, shallow stretches of water that subsequently formed were colonised by sedges, reeds, bulrushes, duckweed and other vlei vegetation. Large volumes of water now flow into the wetland and, together with insufficient drainage, have 'drowned' it. Prolific reed growth and almost permanently high water levels have reduced the extent of habitat available for wading birds. The additional water has also reduced the seasonally flooded 'wet meadow' and other suitable habitat for ducks, resulting in reduced numbers of Anatidae.

Conservation action

The IBA incorporates a 220-ha municipal protected area (Grootvaly Wetland Reserve) and a 1 012-ha provincial protected area (Marievale Bird Sanctuary) managed by the GDARD. Daggafontein, a 550-ha property that borders Marievale to the north, was donated to GDARD by AngloGold. However, due to financial and capacity constraints, this property has not yet been fully incorporated into the day-to-day management of the provincial protected area.

The rest of the properties between Daggafontein and Grootvaly are in the hands of private individuals and companies. This diverse ownership makes it difficult to implement conservation actions within the IBA. There is an environmental management plan for the reserve and the officer-in-charge is supported by a management plan committee that meets several times a year, as well as by the Friends of Marievale. The reserve is under-resourced and not all actions included in the management plan can be implemented at present.

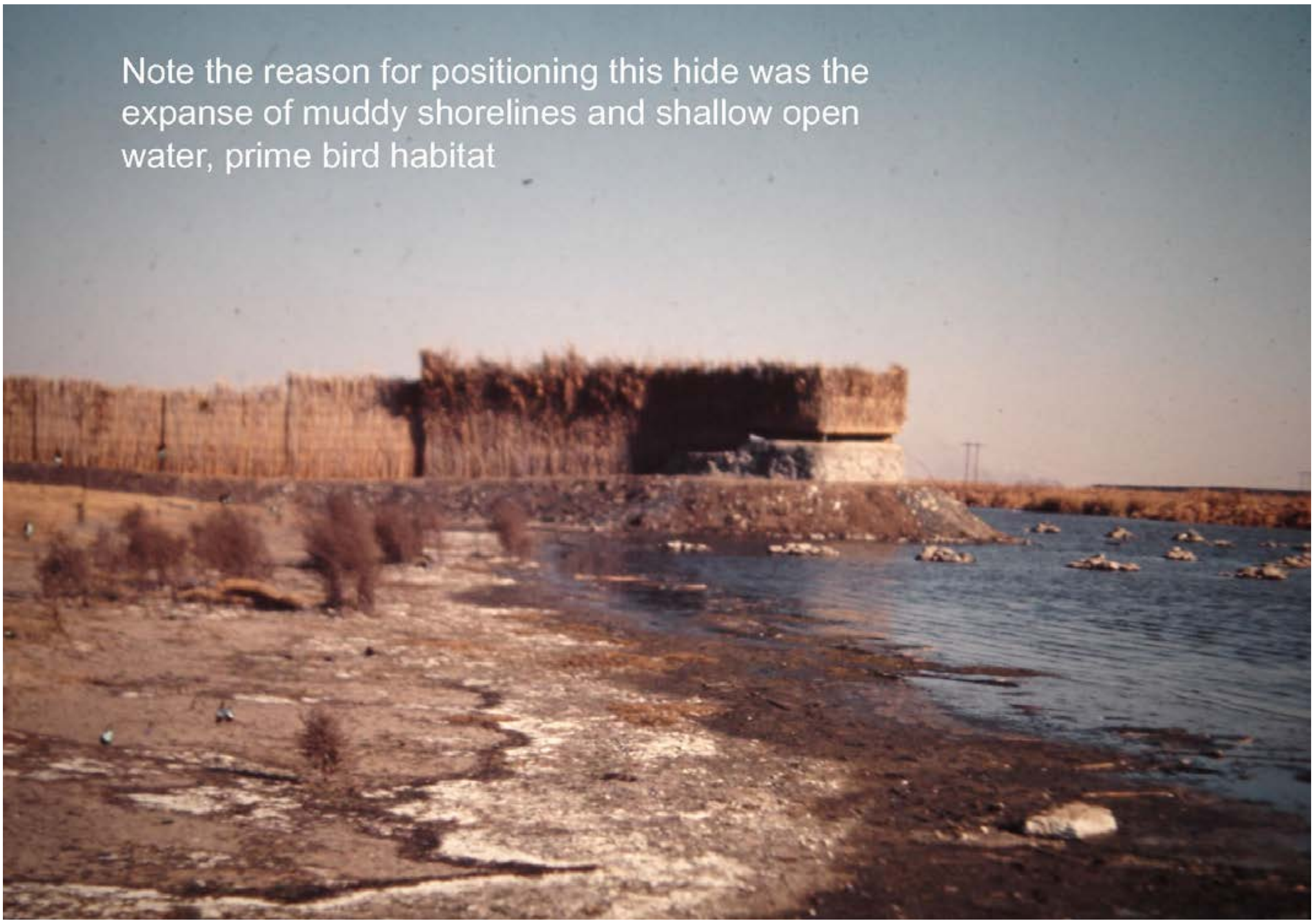
Despite regular waterbird counts along sections of the Blesbokspruit, there are no reliable population estimates for individual species in the whole IBA. Although it is possible that some species, such as Spur-winged Goose Plectropterus gambensis, do pass the IBA criteria, this cannot be stated with certainty. The IBA does pass the sub-regional IBA criteria of 10 000 waterbirds and, on occasion, also the 20 000 waterbird criteria for a global IBA. More frequent monitoring and an intensive ringing programme are needed to better understand waterbird population dynamics at this site.

https://www.birdlife.org.za/iba-directory/blesbokspruit/

Related webpages

https://rsis.ramsar.org/ris/343


FIRST BIRD HIDE
(Duiker hide)
1970


Note the reason for positioning this hide was the
expanse of muddy shorelines and shallow open
water, prime bird habitat

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FIRST BIRD HIDE AT PICNIC SITE 1973
(Flamingo hide)

TREE PLANTING: July 1973. Witwatersrand Bird Club Members. (Wits Bird Club 1st visit June 1971)

1974: INFORMAL HAND OVER OF BIRD SANCTUARY TO TRANSVAAL DEPARTMENT NATURE CONSERVATION

LEFT TO RIGHT: Deputy Director T.D.Nature Conservation,Dr Kitlitz, Gen Manager Marievale Ron Munro, Stan Madden and Consulting Engineer Derick Mac Namara


WESSA CAMP WEEKEND OCTOBER 1974
GET TOGETHER OF GERMISTON AND
SPRINGS BRANCHES
MARIEVALE PICNIC AREA


MARIEVALE BOUNDARY FENCING SEPTEMBER 1974


MARIEVALE BECOMES AN "IBA"--- IMPORTANT BIRD AREA








1975: Owl Conservation: A Barn Owl being fed while confined in an artificial
nest by Cheryl Madden (Thompson) to encourage breeding.


Clive Hopcroft
Late Manfred Schmit
BIRD RINGING COMMENCED JAN 1974


Stan Mdden


Stan
Madden


FLORA

David Madden

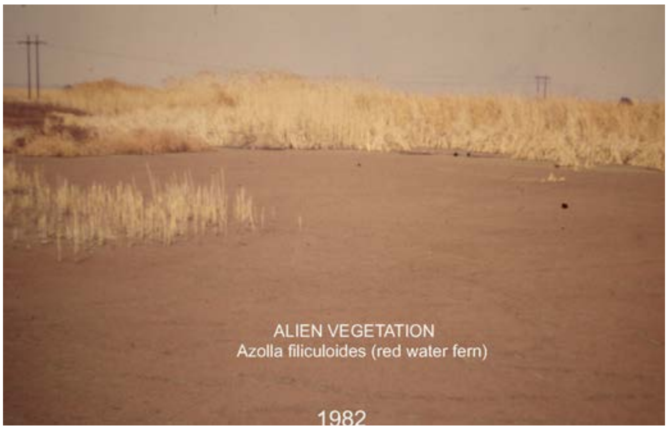
Lion Spoor Marievale 1975

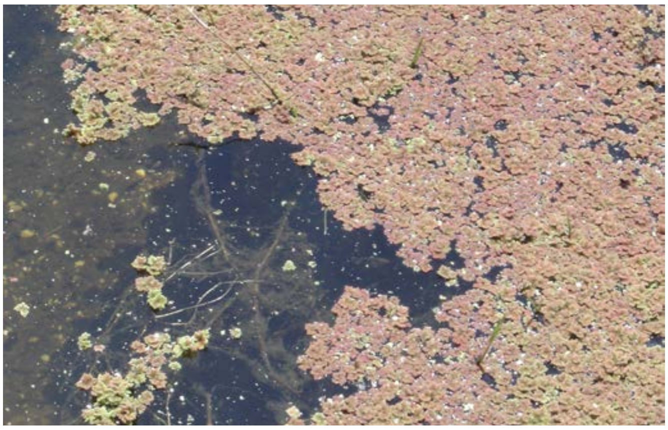
The "Old Bridge"
Built in 1898 by a man named Sartorious for the farmer Dearlove. The approaches were washed away by a flood in 1942. During 1975 the approaches were repaired. The bridge has become a well known landmark within the Marievale Bird Sanctuary

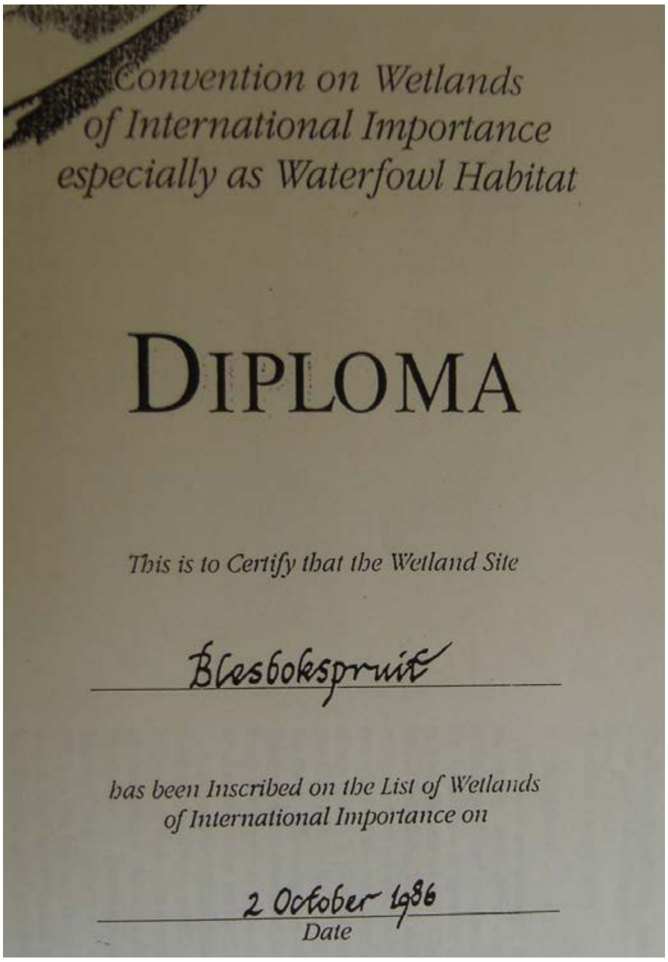
UNCONTROLLED FIRES

The Kleinhuisie was saved!

A fire in May 1980 burnt 80% of the area and destroyed the Nigel Municipal Fire Tender and injured 2 Firemen






Convention on Wetlands
of International Importance
especially as Waterfowl Habitat

DIPLOMA

This is to Certify that the Wetland Site

Blesbokspruit

has been Inscribed on the List of Wetlands
of International Importance on

2 October 1986
Date

"CWAC" counting at Marievale July 2011: Members from Wessa, President Ridge and Cuckoo Birds Clubs (CWAC commenced here in 1989)

22nd June 2010:
Her Imperial Highness Princess Takamado visited Marievale Bird Bird Sanctuary. She is Hon Life President of Birdlife International and was accompanied by Mark Anderson, Executive Director of Birdlife South Africa and Peter Sullivan, Chairman of Birdlife SA.
Stan Madden spent time with the princess guiding and informing her of the threats to this important Ramsar Site.
She is a passionate photographer and took photos of African Marsh Harrier, Black-shouldered Kite, Malachite Kingfisher and other birds.

The Springs – Nigel Branch of WESSA have been involved with the Marievale Bird Sanctuary from its early beginnings.
The members are all volunteers and are dedicated to the conservation of this well known international Bird Sanctuary and the Blesbokspruit Ramsar Site.

The Branch have been responsible for providing most of the visitor facilities such as the first shelters, tables and toilets in the picnic area. The construction and maintenance of hides is ongoing.
The repair of roads is also another important function they have been able to assist with.

The Branch is also involved in conservation projects. It has also for many years hosted the bi annual CWAC counts, encouraging birders to enjoy a social after the counts by supplying braai fires and hot soup on cold winter mornings.
The management of the reed encroachment is another of the serious conservation issues that they are assisting with.

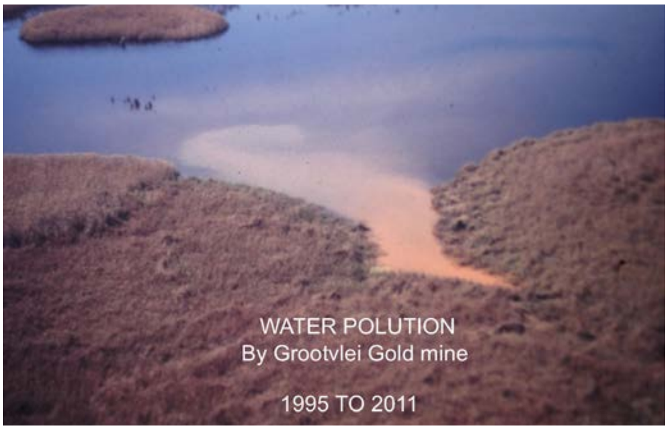
A good relationship with the present managing authority, GDARD, bode well for the conservation of Marievale.

Marievale Picnic Area

Wheel chair friendly toilet Duiker Hide

1973: Marievale Picnic area

First Mobile Hide at Marievale


WATER POLUTION
By Grootvlei Gold mine
1995 TO 2011


Grootvlei Mine water
discharge site Feb 2010


R42
Flooded
Grassland
Flooding January 2011


Illegal bridge built by Grootvlei
Mine
Grootvaly Wetland Reserve


Raised water levels due to
illegal bridge built by Grootvlei
Mine
Vandalisation: Remains of precast walling of
passage way to Bevcan Hide, Grootvaly
Wetland Reserve


Management of Reed
Encroachment: Herbicide
spraying


Resulting open areas from spraying improve drainage and bird habitat

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ERGO MINING (PTY) LTD: THE MARIEVALE TAILINGS RECLAMATIONS PROJECT.

FINAL ENVIRONMENTAL IMPACT ASSESSMENT REPORT

31 August 2020

DMRE Reference Number: GP 30/5/1/1/2 (000007BP) BAR mineral resources

Department:
Mineral Resources
REPUBLIC OF SOUTH AFRICA

FINAL ENVIRONMENTAL IMPACT ASSESSMENT REPORT

FOR LISTED ACTIVITIES ASSOCIATED WITH THE MARIEVALE TAILINGS RECLAMATION PROJECT NEAR NIGEL, EKURHULENI METROPOLITAN MUNICIPALITY, GAUTENG PROVINCE.

APPLICATION FOR ENVIRONMENTAL AUTHORISATION (EA):

SUBMITTED FOR ENVIRONMENTAL AUTHORISATIONS IN TERMS OF THE NATIONAL ENVIRONMENTAL MANAGEMENT ACT (ACT 107, 1998) (AS AMENDED), THE NATIONAL ENVIRONMENTAL MANAGEMENT WASTE ACT (ACT 59, 2008) (AS AMENDED), AND THE NATIONAL WATER ACT (ACT 36, 1998) (AS AMENDED).

Name of Applicant: Ergo Mining (Pty) Ltd
Tel No: +27 11 248 9000
Postal Address: PO Box 12442, Selcourt, Springs, 1567
Physical Address: 1 Sixty Jan Smuts Building, 2nd Floor – North Tower,
160 Jan Smuts Avenue, Rosebank, 2196.
Document prepared by: Kongiwe Environmental (Pty) Ltd
Document Date: 31 August 2020
DMRE Reference Number: GP 30/5/1/1/2 (000007BP) BAR

FINAL ENVIRONMENTAL IMPACT ASSESSMENT

PROJECT:	MARIEVALE PROJECT
Report Title:	THE MARIEVALE TAILINGS RECLAMATION PROJECT IN NIGEL, EKURHULENI METROPOLITAN MUNICIPALITY, GAUTENG PROVINCE
Applicant:	Ergo Mining (Pty) Limited
Project No:	DRDG#005
Compilation Date:	28 July 2020
Status of Report:	**Final EIA and EMPr reports for Authority review**

Verification	Capacity	Name	Signature	Date
By Author	The Report Compiler	Ashleigh Blackwell		16 April 2020
Reviewed by	Technical Director and EAP	Gerlinde Wilreker		01 June 2020
Reviewed by:	Legal Director	Michael Hennessy		10 June 2020
Authorised by	Chief Executive	Bradly Thornton		28 July 2020

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SECTION 1:

ENVIRONMENTAL IMPACT ASSESSMENT REPORT OVERVIEW

Important Notice

Unless an Environmental Authorisation can be granted following the evaluation of an Environmental Impact Assessment and an Environmental Management Programme report in terms of the National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA), it cannot be concluded that the said activities will not result in unacceptable pollution, ecological degradation or damage to the environment.

In terms of Regulation 16(3) (b) of the Environmental Impact Assessment Regulations 2017, any report submitted as part of an application must be prepared in a format that may be determined by the Competent Authority and in terms of Regulation 17 (1) (c) the Competent Authority must check whether the application has considered any minimum requirements applicable or instructions or guidance provided by the Competent Authority to the submission of applications.

It is therefore an instruction that the prescribed reports required in respect of applications for an Environmental Authorisation for listed activities triggered by an application for a right or permit are submitted in the exact format of, and provide all the information required in terms of, this template. Furthermore, please be advised that failure to submit the information required in the format provided in this template will be regarded as a failure to meet the requirements of the Regulations and will lead to the Environmental Authorisation being refused. 19

It is furthermore an instruction that the Environmental Assessment Practitioner (EAP) must process and interpret his/her research and analysis and use the findings thereof to compile the information required herein. (Unprocessed supporting information may be attached as appendices). The EAP must ensure that the information required is placed correctly in the relevant sections of the Report, in the order, and under the provided headings as set out below, and ensure that the report is not cluttered with un-interpreted information and that it unambiguously represents the interpretation of the applicant.

Objective of the Environmental Impact Assessment Process

1) The objective of the Environmental Impact Assessment process is to, through a consultative process —

(a) determine the policy and legislative context within which the activity is located and document how the proposed activity complies with and responds to the policy and legislative context;
(b) describe the need and desirability of the proposed activity, including the need and desirability of the activity in the context of the preferred location;
(c) identify the location of the development footprint within the preferred site based of an impact and risk assessment process inclusive of cumulative impacts and a ranking process of all the identified development footprint alternatives focusing on geographical, physical, biological, social, economic, heritage and cultural aspects of the environment;
(d) determine the –

   I. nature, significance, consequence, extent, duration and probability of the impacts occurring to inform identified preferred alternatives; and
   II. degree to which these impacts –
      - can be reversed;
      - may cause irreplaceable loss of resources; and
      - can be avoided, managed or mitigated;

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(e) identify the most ideal location for the activity within the preferred site based on the lowest level of environmental sensitivity identified during the assessment;
(f) identify, assess, and rank the impacts the activity will impose on the preferred location through the life of the activity;
(g) identify suitable measures to manage, avoid or mitigate identified impacts; and
(h) identify residual risks that need to be managed and monitored.

Executive Summary

Kongiwe Environmental (Pty) Ltd ('Kongiwe') has been appointed as the Independent Environmental Service Provider, tasked with conducting the Scoping and Environmental Impact Assessment (S&EIA) process which is aimed at critically evaluating the potential environmental and social impacts of the proposed **Marievale Project** (hereafter the Proposed Project).

The Application for Environmental Authorisation was submitted to the Department of Mineral Resources and Energy (DMRE), who are the Competent Authority (CA), on **Tuesday, 15 October 2019.** The Draft Scoping Report (DSR) was made available for public review from **23 October 2019 to 21 November 2019.** The Final Scoping Report (FSR) was submitted to the DMRE for its consideration and comment on the **28 November 2019.**

The CA's 43-day review and decision making period on the FSR ran until **31 January 2020.** Acceptance of the Scoping Report was received by the DMRE on the **27 January 2020.**

The initial public review period on the draft Environmental Impact Assessment and Environmental Management Programme (EIA/EMPr) reports was scheduled from **Thursday, 19 March 2020** to **Tuesday, 21 April 2020.**

In accordance with Regulation GN R439 of 31 March 2020, the Minister of Forestry, Fisheries and the Environment, acting in terms of the Regulations issued in terms of section 27(2) of the Disaster Management Act, 2002, extended the timeframes prescribed in terms of the Environmental Impact Assessment Regulations 2014, the National Environmental Management: Waste Act, 2008 and National Environmental Management: Air Quality Act, 2004, by the number of days of the duration of the lockdown period of the national state of disaster declared for the COVID-19 pandemic, including any extensions to such duration, with effect from 27 March 2020 until the termination of the lockdown period.

Considering the above, the Draft EIA/EMPr reports for the proposed Marievale project were made available for an additional 21 days for public review and comment until **Thursday, 14 May 2020.** An extended lockdown was then announced by the President on the Thursday 9 April 2020. In view of this, the public review and comment was further extended until **Thursday, 28 May 2020.** Notification letters announcing the extensions of the public review and comment period were emailed to all stakeholders on the database on **Wednesday, 1 April 2020 and Thursday, 16 April 2020,** respectively.

In light of the Directions issued on 5 June 2020 by the Minister of Environment, Forestry and Fisheries in terms of Regulation 4(10) of the Regulations published by the Minister of Cooperative Governance and Traditional Affairs in terms of section 27(2) of the Disaster Management Act, 2002 on 29 April 2020 ("the Permitting Directions"), Kongiwe re-evaluated its decision regarding the submission of the Final EIA/EMPr to the DMRE, which was submitted on 26 June 2020. As such, a formal request to withdraw the Final EIA/EMPr, and to re-open the public participation process (Public Participation Process Plan) was submitted to the DMRE on 15 July 2020 and the request was positively welcomed and approved by the DMRE on 16 July 2020.

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Accordingly, the EIA/EMPr was made available for public review and comment for an additional 21 days, being the period stipulated in the Directions. The Draft EIA/EMPr reports were made available for public review and comment from **Wednesday, 29 July to Thursday, 20 August 2020.**

This document is the final EIA/EMPr which is submitted to DMRE for consideration.

Project Intentions

Ergo Mining (Pty) Limited (hereafter Ergo) intends to reclaim and reprocess gold residues from the Marievale tailings storage facilities (TSFs) Nos. 7L5, 7L6 and 7L7. These TSFs are historical mineral deposits (slimes dams), situated approximately 6 km north-east of Nigel and 10 km south-east of Springs, in the Ekurhuleni Metropolitan Municipality (EMM). These TSFs were created prior to the promulgation of the Mineral and Petroleum Resources Development Act, 2002 (Act No 28 of 2002) (MPRDA) and are accordingly not regulated by the MPRDA.

Ergo intends to conduct the project in accordance with the summary flow diagram below:

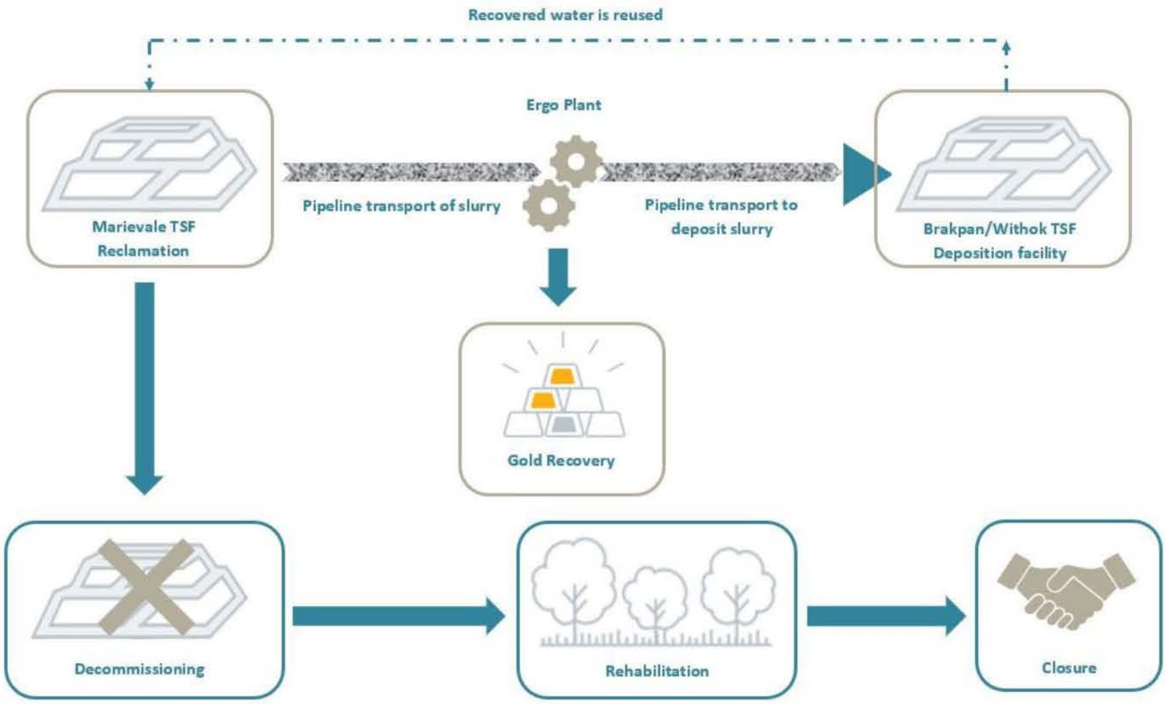

Figure 0. 1: A short summary of the Proposed Project Process

Before reclamation can commence, the sites will be prepared to prevent unwanted material from entering the slurry. Suitable aggregate will be stockpiled for reuse and cleared vegetation could be sold locally or disposed of at a licenced facility.

A baseline radiological assessment will be undertaken by a registered professional once the site has been cleared of vegetation. Temporary and mobile site infrastructure will be established at the reclamation sites with existing connections to the power grid and potable water sources. As part of construction and site preparation activities, the existing Marievale paddocks and stormwater systems will be reinstated and upgraded for capturing and managing dirty water around the site.

Once site preparation and construction are completed, hydraulic reclamation can begin. To remove unconsolidated tailings material within the TSFs, a movable high pressure water monitor (or cannon) will be directed onto the face of the TSF. Reclamation will take place in predetermined benches (or 'cuts') and will move unidirectionally until the entire TSF has been reclaimed. Generally, 30 m – 40 m cuts are made as reclamation progresses. The water from the monitor mixes with the tailings and forms a slurry with a high solid content. The slurry then flows under gravity, along the base of the TSF, to a collection sump which is positioned at the lowest elevation of the bench being reclaimed. The collection sump is then able to filter and screen appropriately sized slurry, and direct it into pipelines which will pump the slurry to the existing Ergo Plant for gold recovery. Residual slurry will then be pumped to the licenced Brakpan/Withok TSF. The water which accumulates atop the Brakpan/Withok TSF is pumped to and reused at Ergo's various operations.

Project Rehabilitation and Future Land use

Once reclamation is completed, the project will be decommissioned. During this phase, all project infrastructure will be removed, a final radiological survey will be undertaken, and rehabilitation can commence. The rehabilitation should invariably be evaluated in view of the future land use. The primary aim of rehabilitation is to:

- Reduce the actual or potential environmental risks to acceptable levels.
- Protect the future value of the land by re-establishing a sustainable land use as similar to its pre-mining condition as possible.

Kongiwe's suggested end land use is the extension of the Marievale Bird Sanctuary and the Blesbokspruit wetland, however, this would be at the discretion and approval of the end landowner. To achieve this preferred end land use, the land must be levelled, and remnants of contaminated slime removed. Dust generation will be minimised by planting appropriate plant and grass species. Lastly, paddocks will remain as a short-term method of containing the potential surface migration of contaminants towards the Blesbokspruit and will be removed and rehabilitated once rehabilitation has proven successful. Since the TSFs lie within close proximity to the wetland system, it is expected that the flat lying areas directly adjacent to the Blesbokspruit may fill with water once again, thereby extending the Marievale Bird Sanctuary and contributing to ecological success and sustainability.

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Project Background and Motivation

The following points below summarise the project motivations:

- Ergo makes use of sophisticated metallurgical processes which make it viable to retreat the historic Marivale TSFs and extract the residual gold, having retreated millions of tonnes of material since its inception in December 1977. With the upturn of the gold price, the grade in the Marivale TSFs has become economically viable to extract. Although gold will be the main mineral for extraction, the concentrations of uranium, nickel and silver will also be investigated in conjunction with the availability of stone, gravel and waste rock.
- Although there is a strong economic case for the project, the removal of these TSFs also forms part of DRDGold Limited's broader strategy to clean-up and remove the remaining TSFs across Gauteng and contain them in two mega facilities known as the Brakpan/Withok TSF and the Regional TSF (RTSF – still to be constructed). It is envisioned that the Brakpan/Withok TSF will hold tailings removed and re-treated by Ergo from the East Rand and other parts of the Central Rand, and the RTSF will hold tailings treated and removed on the West Rand.
- Ergo Mining will align to the National Environmental Management Act (Act 109 of 1998) EIA Regulations, in accordance with the One Environmental System for the reclamation of historic mine residue tailings.
- Ergo intends to remove a historic pollution point-source and rehabilitate the land to a state that is sustainable, functioning and represents a pre-mining landscape.

Project Alternatives

The following sections below provide a short summary of the project alternatives that were assessed within this EIA.

The location of the proposed project:

The Proposed Project is the reclamation of already existing TSFs (7L5, 7L6 and 7L7). Therefore, there are **no alternative sites.**

The type of activity to be undertaken:

The only optional activity for Ergo is to reclaim and reprocess the existing Marievale TSFs. Therefore, there are **no alternative activities undertaken by Ergo.**

The technology to be used:

The reclamation of the Marievale TSFs is the "Preferred Activity" and there are no alternatives. The dumps will be reclaimed using **Hydraulic Mining.**

The Design and Layout of the Activity:

The current layout plan alternatives for the Proposed Project are considered as the preferred layout plan. The layout plan is dictated by independent specialist study recommendations, the existing location of the TSFs, their associated infrastructure and the routes of the proposed pipelines. The routes of these pipeline are limited to existing surface right permits (SRPs) that are held by Ergo. Where Ergo does not hold an SRP, a new servitude, right of way or wayleave will be sought. 25

Operational Alternatives:

The Proposed Project will investigate various pipeline routes to convey slurry from the TSFs to the Ergo Plant for reprocessing; and return process water to the project site for reclamation.

- **Pipeline Route 1:** There will be a 600 mm pipeline from the Trans-Caledon Tunnel Authority (TCTA) AMD treatment project towards the Daggafontein plant. This pipeline will continue on the alignment of Ergo's existing Surface Right Permits to the Ergo Plant, and hence to the Brakpan/Withok TSF where the brine will be deposited.
- **Pipeline Route 2:** There will be three 600 mm pipelines, with two transporting slurry and the other process water, that will run between 7L7, 7L6 and 7L5 north towards the Daggafontein plant. These pipes will then continue along Ergo's existing Surface Right Permit to the Ergo Plant, where resultant process residue will be disposed on the Brakpan/Withok TSF via existing and authorised pipelines.
- **Pipeline Route 3 (alternative to Pipeline Route 2):** This route will also consist of the same pipeline configuration as Route 2 but is proposed to run south of 7L5, 7L6 and 7L7 and then north westerly to

the Ergo Plant. This route is approximately 19 km long. Residue will be disposed on the Brakpan/Withok TSF via existing and authorised pipelines.

These options are all preferred pipeline options for the transport of slurry and return water.

The proposed reclamation site will be situated in Zone 3 of the Gauteng Provincial Environmental Management Framework (GPEMF) (2018); and even though some parts of the proposed pipelines may be laid in Zones 1 and 5, they may require authorisation in terms of the National Water Act (Act No. 36 of 1998) (NWA) for Section 21 water uses. An Integrated Water Use Licence Application (IWULA) will be prepared and submitted in accordance with the Water Use Licence Application and Appeals Regulations 2017, published in GNR 267 on 24 March 2017, and will be supported by a Technical Report and other necessary supplementary reports.

Two locations for temporary site infrastructure will be assessed:

- **Alternative 1:** Temporary site administration, ablution and contractors' yard to be located at the Marievale TSFs. Grid connection and portable water connection would need to be established.
- **Alternative 2:** Temporary site administration, ablution and contractors' yard to be located at the Daggafontein TSF. Grid connection and portable water connection would not need to be established

In terms of water make-up and process water use, Ergo will make use of its Centralised Water Distribution System to recycle process water in a closed circuit. Where water makeup is required, this could be from TCTA, the Strubenvale Water Treatment Plant (WTP) or other potential sources.

The No-Go Alternative:

The Option of the project not proceeding would mean that the environmental and social status would remain the same as current. This implies that both negative and positive impacts would not take place. As such, the short-term negative impacts on the environment would not transpire; equally so, the long term positive impacts such as environmental pollution source removal, economic development, skills development, and the availability of land for re-development would not occur.

Environmental Impacts of the Marievale Project

The table overleaf represents a summary of the significance of impacts identified during the project lifetime for each environmental aspect. Impacts are expected to occur predominantly during the construction and operation phases, and to a lesser extent during decommissioning and post-decommissioning. Post decommissioning, the following positive benefits are expected:

- Job Security for staff and contractors currently contracted or employed by Ergo;
- Skills Development for those employed for the project;
- Economic growth and contribution to the economy;
- Improved surface water quality over time;
- Improved groundwater quality over time; and
- Improved ecosystem health and functioning over time.

Table 0. 1: Risk Matrix of Assessed Project Impacts

IMPACT	RATING PRE-MITIGATION	CONSTRUCTION	OPERATION	DECOMMISSIONING	POST DECOMMISSIONING	RATING POST MITIGATION	CONSTRUCTION	OPERATION	DECOMMISSIONING	POST DECOMMISSIONING
Positive (+)	Major (high)					Major (high)	❖ Increased economic revenue	❖ Increased economic revenue	❖ Availability of land use	
Positive (+)	Moderate (medium)	❖ Increased economic revenue	❖ Increased economic revenue	❖ Improved water quality ❖ Availability of land use	❖ Improved water quality	Moderate (medium)	❖ Job security and skills development	❖ Groundwater quality ❖ Job security and skills development	❖ Improved water quality ❖ Health impacts from dust Ecosystem services	❖ Improved water quality
Positive (+)	Minor (low)	❖ Job security and skills development	❖ Reduction in aquifer yield ❖ Job security and skills development	❖ Improved water quantity ❖ Health impacts from dust ❖ Ecosystem services		Minor (low)		❖ Reduction in aquifer yield	❖ Dust ❖ Improved water quantity ❖ Disruption of movement patterns	
No Impact	**No Impact**					**No Impact**				
Negative (-)	Minor (low)	❖ Vegetation clearance for pipelines outside wetlands ❖ Impact on groundwater quality ❖ Noise ❖ Increased traffic ❖ Vehicle impacts	❖ Daytime Noise	❖ Job security and skills development ❖ Noise		Minor (low)	❖ Loss of CBA and ESA areas ❖ Disturbance of habitat ❖ Fauna displacement ❖ Loss of migration corridors ❖ Loss of biodiversity ❖ Alien vegetation encroachment ❖ Erosion ❖ Vegetation clearance ❖ Vegetation clearance for pipelines outside wetlands ❖ Impact on groundwater quality ❖ Damage to heritage structures ❖ Ecosystem services impacts ❖ Disruption of	❖ Habitat disturbance ❖ Fauna displacement ❖ Loss of migration corridors ❖ Loss of floral species ❖ Alien vegetation encroachment ❖ Erosion ❖ Vegetation clearance ❖ Loss of avifauna due to powerlines ❖ Loss of CBA and ESA areas ❖ Flooding of operation ❖ Water quantity reduction ❖ Leaks from pipelines ❖ Damage to heritage structures ❖ Ecosystem	❖ Alien vegetation encroachment ❖ Faunal displacement ❖ Erosion ❖ Damage to heritage structures ❖ Spatial development and land use ❖ Noise	

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Final Environmental Impact Assessment Report
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Table 0. 1: Risk Matrix of Assessed Project Impacts

IMPACT	RATING PRE-MITIGATION	CONSTRUCTION	OPERATION	DECOMMISSIONING	POST DECOMMISSIONING	RATING POST MITIGATION	CONSTRUCTION	OPERATION	DECOMMISSIONING	POST DECOMMISSIONING
Positive (+)	Major (high)					Major (high)	❖ Increased economic revenue	❖ Increased economic revenue	❖ Availability of land use	
Positive (+)	Moderate (medium)	❖ Increased economic revenue	❖ Increased economic revenue	❖ Improved water quality ❖ Availability of land use	❖ Improved water quality	Moderate (medium)	❖ Job security and skills development	❖ Groundwater quality ❖ Job security and skills development	❖ Improved water quality ❖ Health impacts from dust Ecosystem services	❖ Improved water quality
Positive (+)	Minor (low)	❖ Job security and skills development	❖ Reduction in aquifer yield ❖ Job security and skills development	❖ Improved water quantity ❖ Health impacts from dust ❖ Ecosystem services		Minor (low)		❖ Reduction in aquifer yield	❖ Dust ❖ Improved water quantity ❖ Disruption of movement patterns	
No Impact	**No Impact**					**No Impact**				
Negative (-)	Minor (low)	❖ Vegetation clearance for pipelines outside wetlands ❖ Impact on groundwater quality ❖ Noise ❖ Increased traffic ❖ Vehicle impacts	❖ Daytime Noise	❖ Job security and skills development ❖ Noise		Minor (low)	❖ Loss of CBA and ESA areas ❖ Disturbance of habitat ❖ Fauna displacement ❖ Loss of migration corridors ❖ Loss of biodiversity ❖ Alien vegetation encroachment ❖ Erosion ❖ Vegetation clearance ❖ Vegetation clearance for pipelines outside wetlands ❖ Impact on groundwater quality ❖ Damage to heritage structures ❖ Ecosystem services impacts ❖ Disruption of	❖ Habitat disturbance ❖ Fauna displacement ❖ Loss of migration corridors ❖ Loss of floral species ❖ Alien vegetation encroachment ❖ Erosion ❖ Vegetation clearance ❖ Loss of avifauna due to powerlines ❖ Loss of CBA and ESA areas ❖ Flooding of operation ❖ Water quantity reduction ❖ Leaks from pipelines ❖ Damage to heritage structures ❖ Ecosystem	❖ Alien vegetation encroachment ❖ Faunal displacement ❖ Erosion ❖ Damage to heritage structures ❖ Spatial development and land use ❖ Noise	

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IMPACT	RATING PRE-MITIGATION	CONSTRUCTION	OPERATION	DECOMMISSIONING	POST DECOMMISSIONING	RATING POST MITIGATION	CONSTRUCTION	OPERATION	DECOMMISSIONING	POST DECOMMISSIONING
							movement patterns ❖ Creation of informal settlements ❖ Noise ❖ Increased traffic ❖ Traffic congestion ❖ Vehicle impacts	services impacts ❖ Disruption of movement patterns ❖ Creation of informal settlements ❖ Daytime Noise ❖ Nighttime noise		
Negative (-)	Moderate (medium)	❖ Loss of CBA and ESA areas ❖ Disturbance of habitat ❖ Fauna displacement ❖ Loss of migration corridors ❖ Loss of biodiversity ❖ Alien vegetation encroachment ❖ Erosion ❖ Vegetation clearance ❖ Dust from vegetation stripping ❖ Damage to heritage structures ❖ Ecosystem services impacts ❖ Disruption of movement patterns ❖ Creation of informal settlements ❖ Traffic congestion	❖ Habitat disturbance ❖ Fauna displacement ❖ Loss of migration corridors ❖ Loss of floral species ❖ Alien vegetation encroachment ❖ Erosion ❖ Vegetation clearance ❖ Dust ❖ Loss of CBA and ESA areas ❖ Water quantity reduction ❖ Damage to heritage structures ❖ Ecosystem services impacts ❖ Disruption of movement patterns ❖ Creation of informal settlements ❖ Nighttime noise	❖ Alien vegetation encroachment ❖ Faunal displacement ❖ Dust ❖ Damage to heritage structures ❖ Economic revenue ❖ Disruption of movement patterns ❖ Spatial development and land use		Moderate (medium)	❖ Loss of habitat for protected species ❖ Dust from vegetation stripping ❖ Damage to graves and burial sites ❖ Safety impacts ❖ Land use impacts ❖ Exposure to dust fallout	❖ Surface water runoff ❖ Damage to graves and burial sites ❖ Safety impacts ❖ Land use impacts ❖ Job security and skills development ❖ Creation of informal settlements ❖ Safety impacts	❖ Damage to graves and burial sites	
Negative (-)	Major (high)	❖ Loss of habitat for protected species ❖ Damage to graves and burial sites ❖ Safety impacts ❖ Land use impacts ❖ Exposure to dust	❖ Loss of avifauna due to powerlines ❖ Surface water runoff ❖ Flooding of operation ❖ Leaks from	❖ Erosion ❖ Damage to graves and burial sites ❖ Creation of informal settlements		Major (high)				

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IMPACT	RATING PRE-MITIGATION	CONSTRUCTION	OPERATION	DECOMMISSIONING	POST DECOMMISSIONING	RATING POST MITIGATION	CONSTRUCTION	OPERATION	DECOMMISSIONING	POST DECOMMISSIONING
		fallout	pipelines ❖ Groundwater quality ❖ Damage to graves and burial sites ❖ Safety impacts ❖ Land use impacts	❖ Safety impacts						

Conclusions

An impact assessment has been undertaken using qualified specialists, which has incorporated extensive consultation with and participation of interested and affected parties. Applying the hierarchical approach to impact management, alternatives were firstly considered to avoid negative impacts, but where avoidance was not possible, various mitigation measures to manage and monitor the impacts of the project have been proposed.

The findings of the impact assessment have shown that the Marievale Project would conclusively result in certain negative impacts during the operational phase to the environment, however, none of the specialist studies objected to the project. Impacts are largely Moderate (negative) in significance, being mitigated to Low (negative) Significance. During the decommissioning and post-decommissioning phases, most of the impact are expected to be Moderate – High (positive) in significance after mitigation.

The specialist mitigations measures have been included into this EIA and EMPr report to reduce the significance of all the identified negative impacts. Most of the negative impacts from the proposed project can be reduced through the implementation of mitigation measures. Based on the information contained in this report, it is the opinion of the EAP that the negative environmental impacts resulting from the Marievale Project can be mitigated to within acceptable limits and that the project should be authorised, provided all the recommendations proposed in the specialist studies and the EIA and EMPr report as well as legislative requirements are implemented and adhered to.

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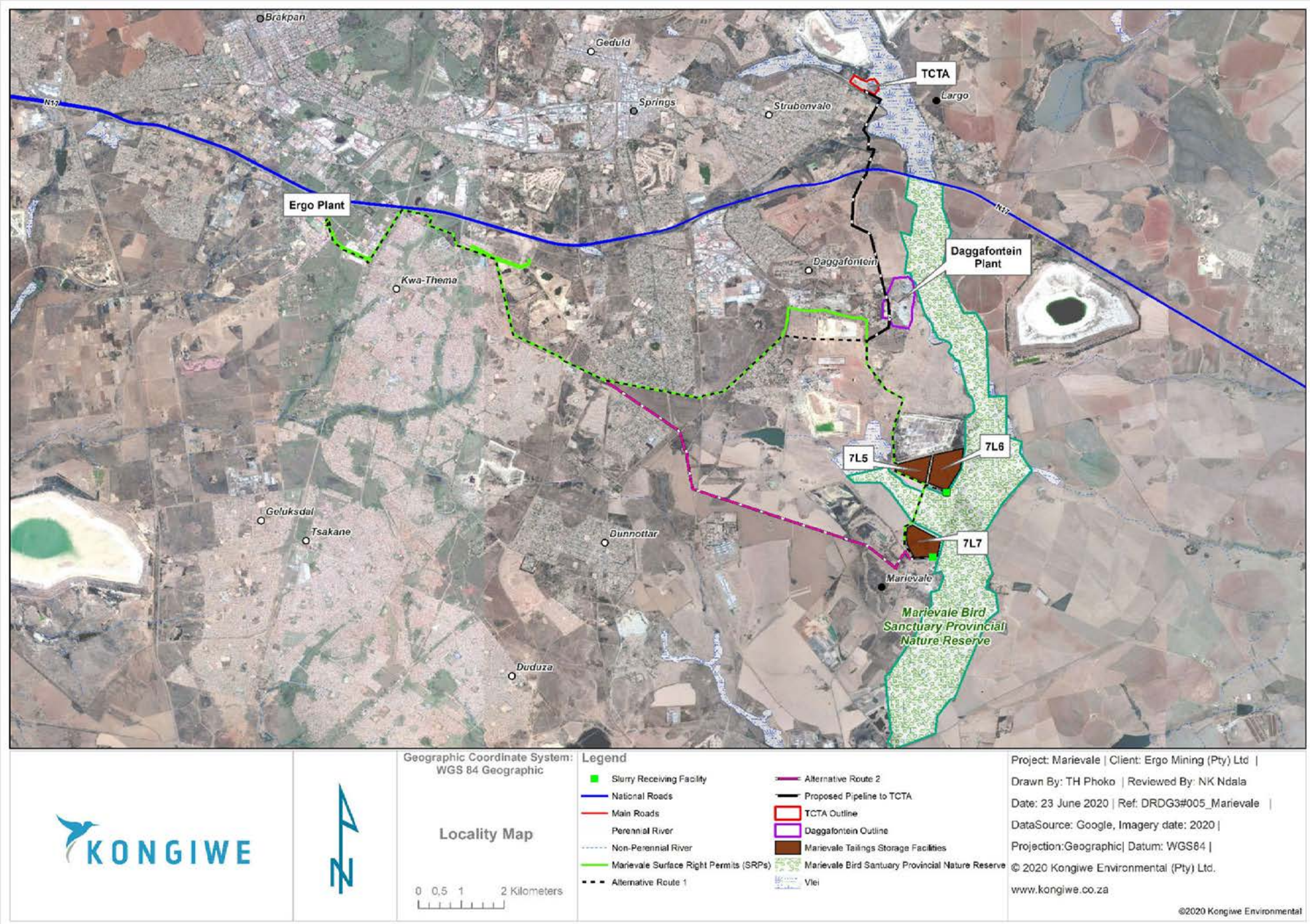
The water quality in the Blesbokspruit is already impacted, and there is a possibility of some temporary contamination of downstream watercourses during operation of the Marievale project. If authorised, Ergo will need to minimise such contamination by following the prescribed mitigation stipulated in this EIA / EMPr, the water use licence and all relevant best practice guidelines and legislation regarding the rehabilitation of contaminated land. It is anticipated that through carefully planned reclamation efforts, the Blesbokspruit wetland could expand to a state where it represents a viable and functioning pre-mining land use.

In conclusion, the EAP is of the reasoned opinion that the **project should be authorised to proceed** provided that the conditions of this EIA and the mitigation measures and objectives proposed by the EMPr are implemented by Ergo. Given that the Ramsar site is directly adjacent to 7L5, 7L6 and 7L7, extra care and diligence is required by Ergo to minimise negative impacts and maintain the status quo of the Marievale Bird Sanctuary and Blesbokspruit through the construction and operation of the project. An improvement of the functioning of the wetland is expected following decommissioning and rehabilitation.



Brakpan
Geduld
TCTA
Largo
Springs
Strubenvale
N17
Ergo Plant
N17
Daggafontein
Daggafontein Plant
Kwa-Thema
7L5
7L6
Geluksdal
Tsakane
Dunnottar
7L7
Marievale
Marievale Bird Sanctuary Provincial Nature Reserve
Duduza
KONGIWE
Geographic Coordinate System: WGS 84 Geographic
Locality Map
0 0,5 1 2 Kilometers
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Slurry Receiving Facility
National Roads
Main Roads
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Marievale Surface Right Permits (SRPs)
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Marievale Bird Santuary Provincial Nature Reserve
Vlei
Project: Marievale | Client: Ergo Mining (Pty) Ltd |
Drawn By: TH Phoko | Reviewed By: NK Ndala
Date: 23 June 2020 | Ref: DRDG3#005_Marievale |
DataSource: Google, Imagery date: 2020 |
Projection:Geographic| Datum: WGS84 |
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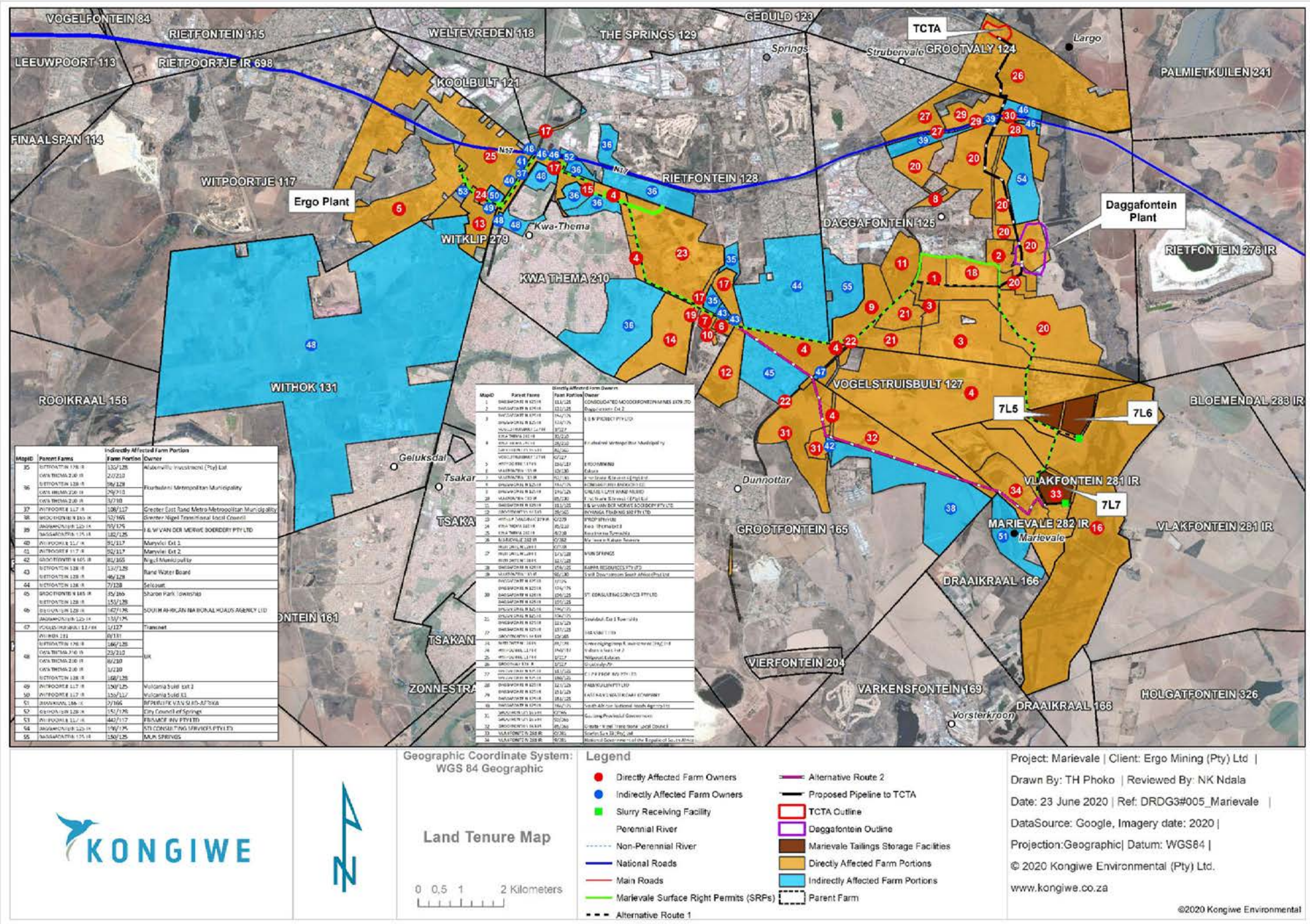
VOGELFONTEIN 84
RIETFONTEIN 115
LEEUWPOORT 113
RIETPOORTJE IR 698
WELTEVREDEN 118
THE SPRINGS 129
GEDULD 123
Springs
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Strubenvale
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KOOLBULT 121
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WITPOORTJE 117
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WITHOK 131
ROOIKRAAL 156
VOGELSTRUISBULT 127
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Marievale
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DRAAIKRAAL 166
VIERFONTEIN 204
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Vorsterkroon
HOLGATFONTEIN 326
Indirectly Affected Farm Portion
Directly Affected Farm Owners
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Directly Affected Farm Portions
Indirectly Affected Farm Portions
Parent Farm
KONGIWE
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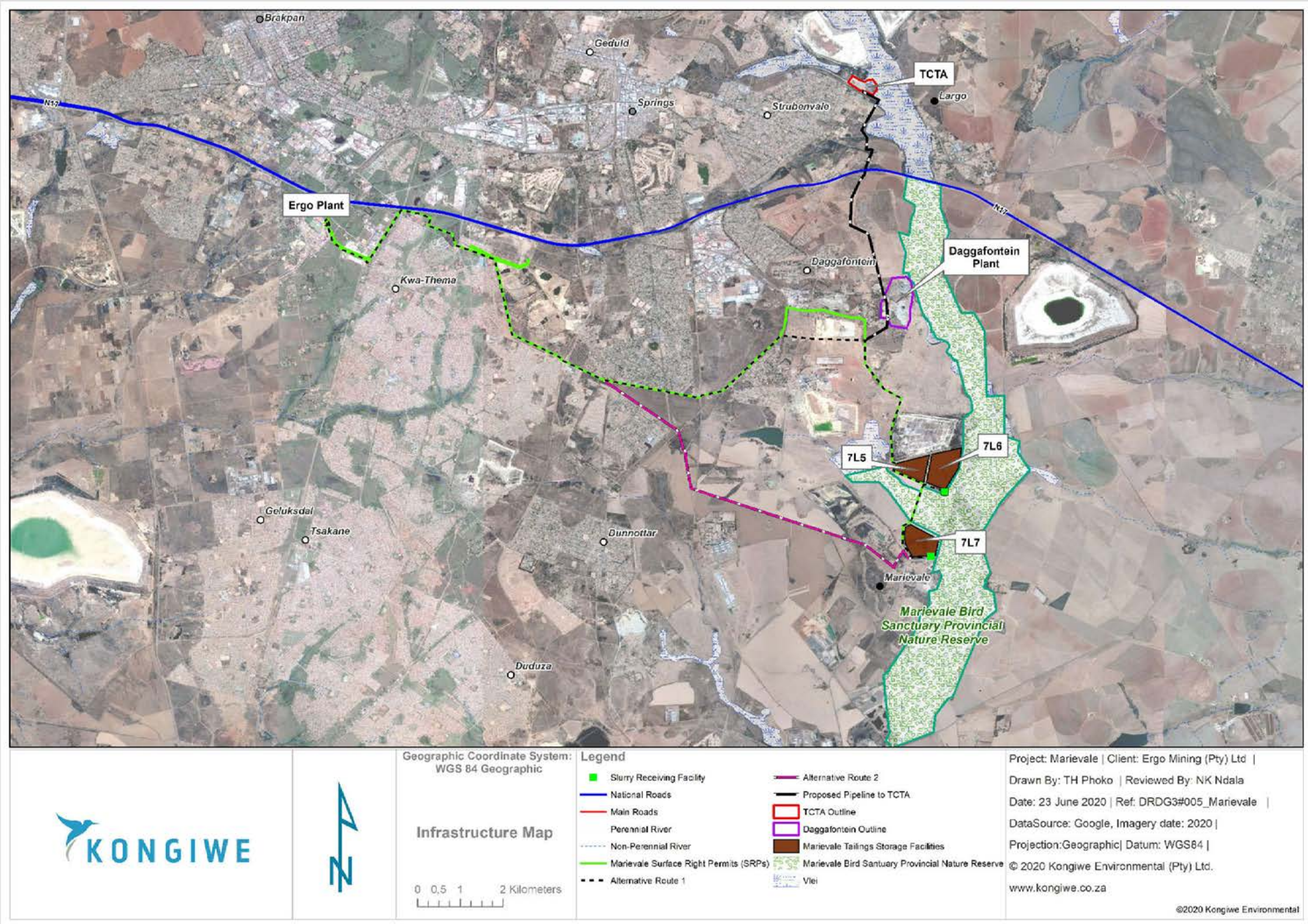
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Geographic Coordinate System: WGS 84 Geographic
Infrastructure Map
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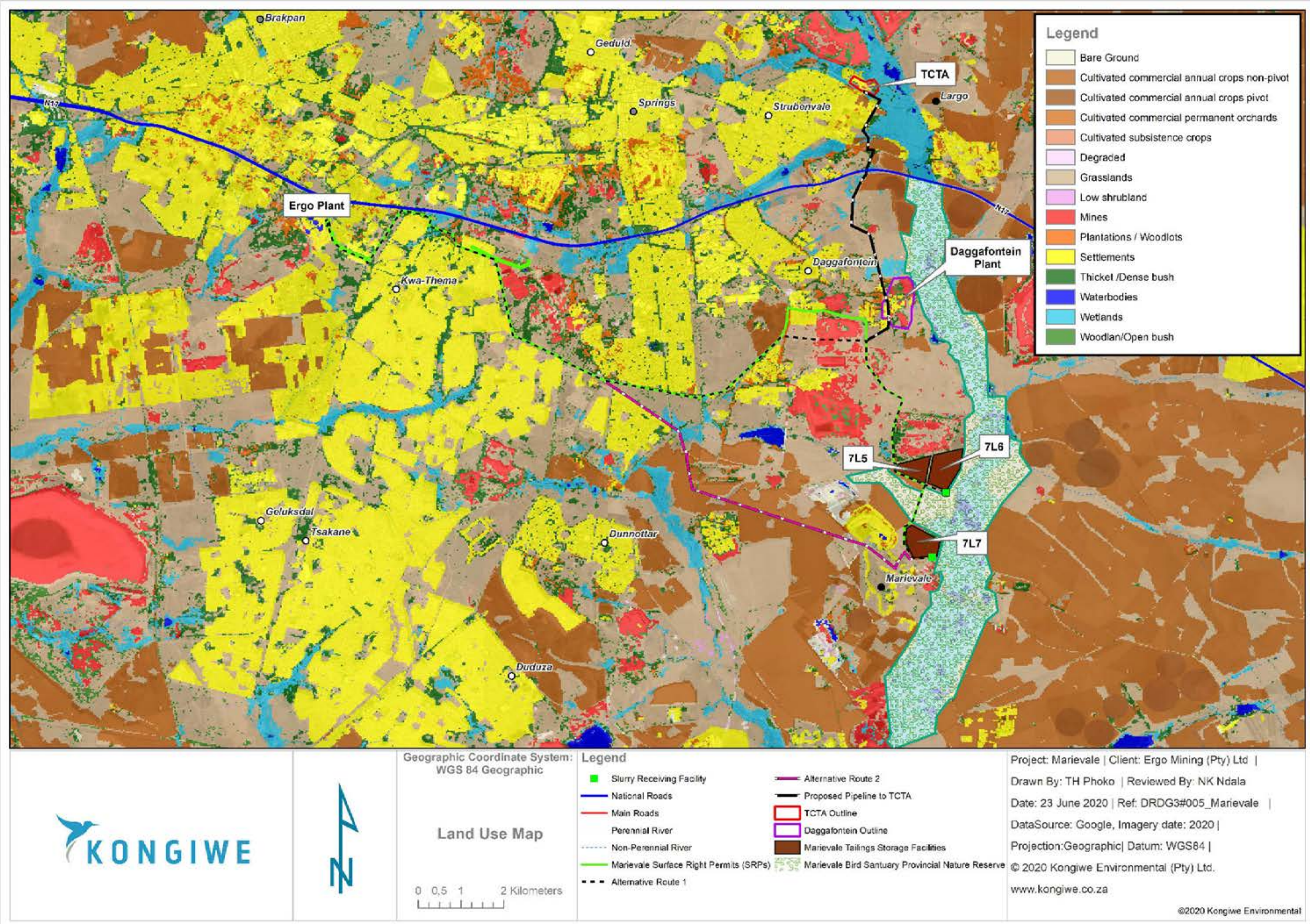
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Daggafontein
Daggafontein Plant
7L5
7L6
7L7
Geluksdal
Tsakane
Dunnottar
Marievale
Duduza
Legend
Bare Ground
Cultivated commercial annual crops non-pivot
Cultivated commercial annual crops pivot
Cultivated commercial permanent orchards
Cultivated subsistence crops
Degraded
Grasslands
Low shrubland
Mines
Plantations / Woodlots
Settlements
Thicket /Dense bush
Waterbodies
Wetlands
Woodlan/Open bush
KONGIWE
Geographic Coordinate System: WGS 84 Geographic
Land Use Map
0 0,5 1 2 Kilometers
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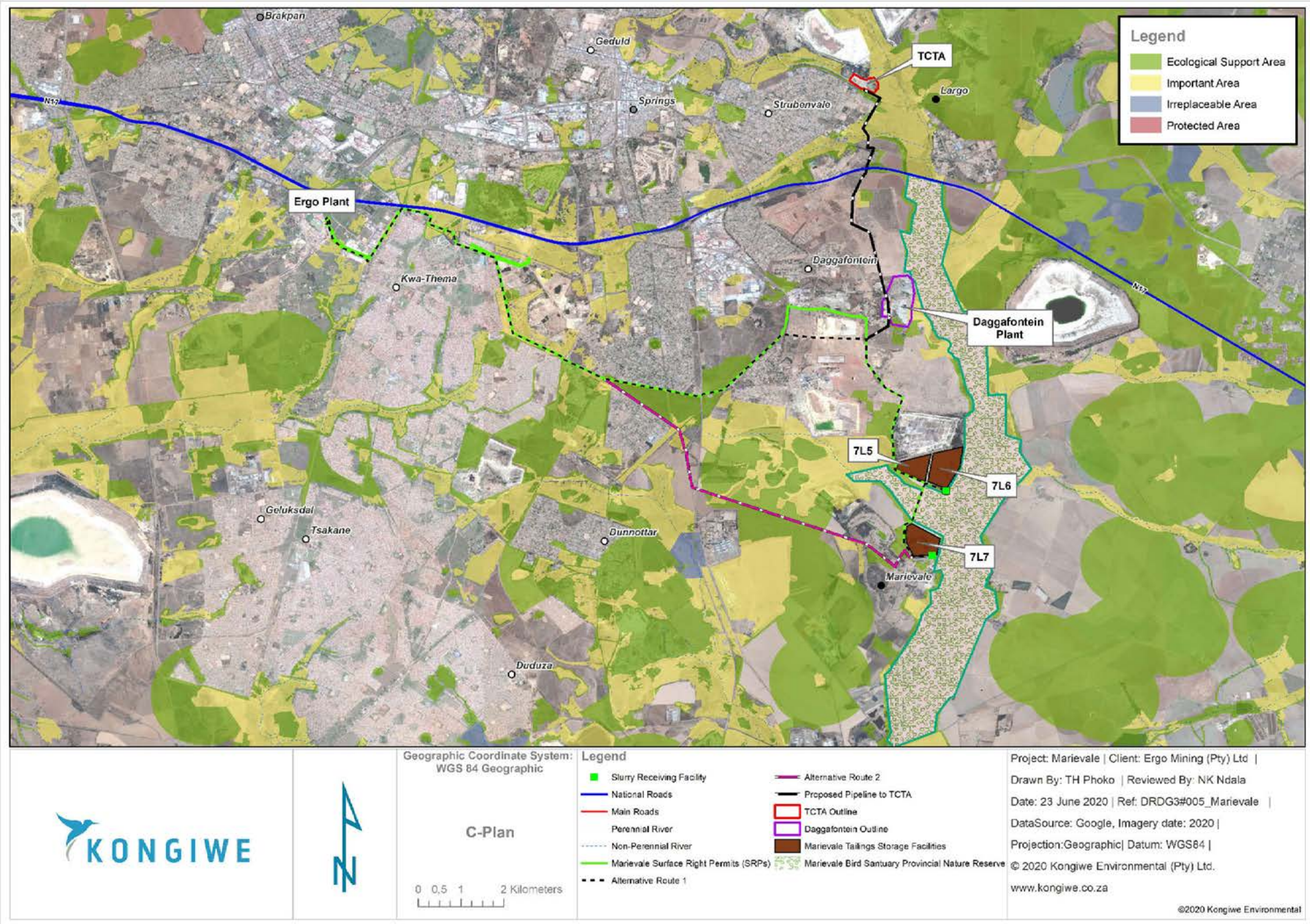

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Daggafontein Plant
7L5
7L6
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Dunnottar
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Legend
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Important Area
Irreplaceable Area
Protected Area
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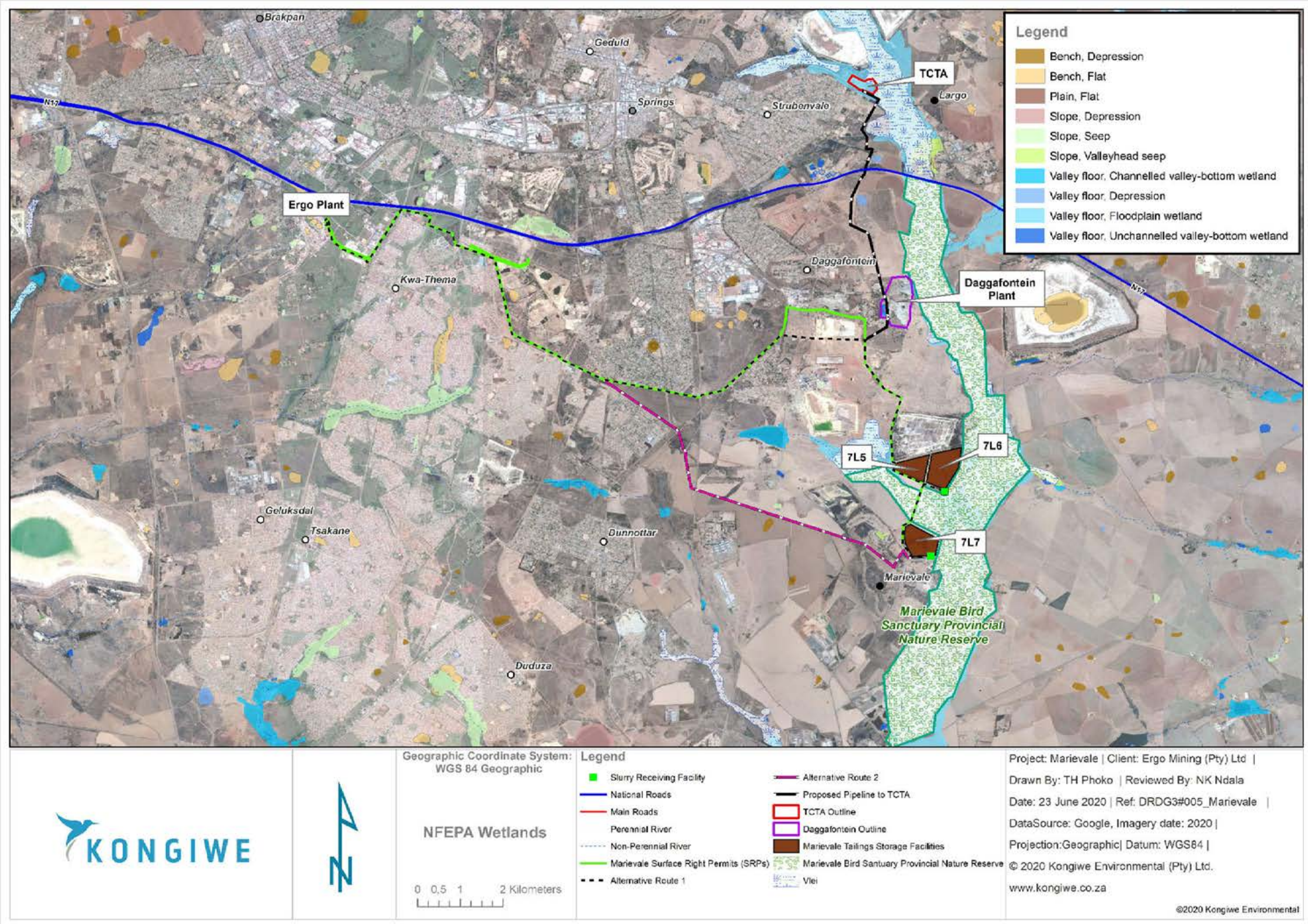
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Marievale Bird Sanctuary Provincial Nature Reserve
Geluksdal
Tsakane
Dunnottar
Duduza
Legend
Bench, Depression
Bench, Flat
Plain, Flat
Slope, Depression
Slope, Seep
Slope, Valleyhead seep
Valley floor, Channelled valley-bottom wetland
Valley floor, Depression
Valley floor, Floodplain wetland
Valley floor, Unchannelled valley-bottom wetland
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7L3 Zinc Tailings Storage Facility Reclamation Project, located approximately 1 km north-west from Site 1 of the Proposed Project site.

Latitude: 26°19'14.79"S
Longitude: 28°29'1.62"E

Blesbok Shooting Range, also located approximately 1 km north-west of the Proposed Project site.

Latitude: 26°19'15.01"S
Longitude: 28°29'39.45"E

Vlakfontein Quarry Mine, located approximately 1 km south-west from Site 2 of the Proposed Project.

Latitude: 26°20'20.54"S
Longitude: 28°29'4.12"

Powerlines near the Proposed Project Site. Just north of dump 7L5 and 7L6.

Latitude: 26°19'45.17"S
Longitude: 28°30'9.69"E

Dump 7L5 (left) and 7L6 (right).

Latitude: 26°19'43.69"S
Longitude: 28°30'10.38"E

Dump 7L7.

Latitude: 26°20'48.28"S
Longitude: 28°29'50.61"E

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THE PROPOSED RECLAMATION OF THE MARIEVALE TAILINGS STORAGE FACILITIES IN EKURHULENI, GAUTENG PROVINCE

Heritage Impact Assessment Report

Issue Date: **06 March 2020**
Revision No.: **0.2**
Project No.: 413HIA

+ 27 (0) 12 332 5305 +27 (0) 86 675 8077 contact@pgsheritage.co.za PO Box 32542, Totiusdal, 0134

Offices in South Africa, Kingdom of Lesotho and Mozambique

Head Office:
906 Bergarend Streets
Waverley, Pretoria,
South Africa

Directors: HS Steyn, PD Birkholtz, W Fourie

Declaration of Independence

I, Jennifer Kitto, declare that –

General declaration:

- I act as the independent heritage practitioner in this application
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting heritage impact assessments, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I will take into account, to the extent possible, the matters listed in section 38 of the NHRA when preparing the application and any report relating to the application;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- I will ensure that information containing all relevant facts in respect of the application is distributed or made available to interested and affected parties and the public and that participation by interested and affected parties is facilitated in such a manner that all interested and affected parties will be provided with a reasonable opportunity to participate and to provide comments on documents that are produced to support the application;
- I will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not

- All the particulars furnished by me in this form are true and correct;
- I will perform all other obligations as expected from a heritage practitioner in terms of the Act and the constitutions of my affiliated professional bodies; and
- I realise that a false declaration is an offence in terms of regulation 71 of the Regulations and is punishable in terms of section 24F of the NEMA.

Disclosure of Vested Interest

- I do not have and will not have any vested interest (either business, financial, personal or other) in the proposed activity proceeding other than remuneration for work performed in terms of the Regulations;

HERITAGE CONSULTANT: PGS Heritage (Pty) Ltd

CONTACT PERSON: Jennifer Kitto – Heritage specialist

Tel: +27 (0) 12 332 5305

Email:jennifer@pgsheritage.co.za

SIGNATURE: ______________________

ACKNOWLEDGEMENT OF RECEIPT

Report Title	*THE PROPOSED RECLAMATION OF THE MARIEVALE TAILINGS STORAGE FACILITIES IN EKURHULENI, GAUTENG PROVINCE*		
Control	**Name**	**Signature**	**Designation**
Author	**Jennifer Kitto**		**Heritage Specialist/ PGS Heritage**
Reviewed	**Wouter Fourie**		**Principal Heritage Specialist**
Reviewed	**Ashleigh Blackwell**		**Kongiwe Envronmental**

CLIENT: Kongiwe Environmental

CONTACT PERSON: Ashleigh Blackwell
Tel: +27 (10) 140 6508
E-mail: ablackwell@kongiwe.co.za

SIGNATURE: ______________________________

The heritage impact assessment report has been compiled considering the NEMA Appendix 6 requirements for specialist reports as indicated in the table below.

Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017	**Relevant section in report**
1.(1) (a) (i) Details of the specialist who prepared the report	Page 2 of Report – Contact details and company
(ii) The expertise of that person to compile a specialist report including a curriculum vita	Section 1.2 – refer to **Appendix D**
(b) A declaration that the person is independent in a form as may be specified by the competent authority	Page ii of the report
(c) An indication of the scope of, and the purpose for which, the report was prepared	Section 1.1
(cA) An indication of the quality and age of base data used for the specialist report	Section 1.1
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 3, Section 6
(d) The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 5
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used	Section 6 and **Appendix B**
(f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Section 5.
(g) An identification of any areas to be avoided, including buffers	Section 5
(h) A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 5.1
(i) A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 1.3
(j) A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Section 3 and Section 5
(k) Any mitigation measures for inclusion in the EMPr	Section 6.8

(l) Any conditions for inclusion in the environmental authorisation	
(m) Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 6.8
(n)(i) A reasoned opinion as to whether the proposed activity, activities or portions thereof should be authorised and	Section 7
(n)(iA) A reasoned opinion regarding the acceptability of the proposed activity or activities; and	
(n)(ii) If the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Section 6.8
(o) A description of any consultation process that was undertaken during the course of carrying out the study	N/A.
(p) A summary and copies if any comments that were received during any consultation process	In EIA Report
(q) Any other information requested by the competent authority.	Not applicable.
(2) Where a government notice by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	Section 38(3) of the NHRA

EXECUTIVE SUMMARY

PGS Heritage (Pty) Ltd (PGS) was appointed by Kongiwe Environmental (Pty) Ltd (Kongiwe) to undertake a scoping and heritage impact assessment (HIA) which will serve to inform the Environmental Impact Assessment (EIA) and Environmental Management Programme (EMPr) for the proposed Reclamation of Marievale Tailings Storage Facilities, Ekurhuleni, Gauteng Province.

The desktop study (archival research and the evaluation of satellite imagery and topographical maps) of the study area indicated that the proposed project is likely to impact on several types of heritage resources present in the study area. This has been confirmed through the subsequent fieldwork.

The heritage sensitivity analysis does not indicate "no-go" areas in the maps, but rather the possibility of encountering heritage sites that will require further mitigation before construction activities commence.

The following heritage resources were identified from the combined desktop study and fieldwork:

Heritage Sites

The fieldwork identified 38 heritage features in total, four of which were burial grounds (three informal and one municipal), with the remainder of sites (33) being historical structures or remains associated with the historic mines or residential areas. The four burial ground sites are considered to have very high significance and would require mitigation measures. Of the historical structures, nine residential or non-mining structures had a medium heritage significance (grading of IIIB) which would require mitigation measures. Only three historical mining structures sites had a medium heritage significance (grading of IIIB) which would require mitigation measures. The remaining historical structure sites are considered to be of low to no heritage significance.

Most of the sites identified are located in the vicinity of the two pipeline alternatives, while a few are located in the region of the three slimes dams or the three processing plants.

Historical structures: Residential or non-mining

Of the 13 single or groups of historical residential or other non-mining related structures, nine of these sites had a medium heritage significance with a heritage grading of IIIB (MV001, MV006, MV018, MV021, MV023, MV028, MV031, MV032, MV036). The impact significance before mitigation on these nine historical residential structures will be Medium negative before mitigation. Implementation of the recommended mitigation measures will modify this impact rating to an acceptable LOW negative.

The remaining sites had a low or negligible heritage significance will not require any mitigation measures. However, a destruction permit may be required if the structure remains are likely to be 60 years or older.

Historical structures: Mining

A total of 14 single or groups of mining-related structures were identified. However, only three of these sites had a medium heritage significance with a heritage grading of IIIB (MV003, MV011 and MV036).

The impact significance before mitigation on these three historical mining structures will be Medium negative before mitigation. Implementation of the recommended mitigation measures will modify this impact rating to an acceptable LOW negative.

The remaining sites had a low or negligible heritage significance will not require any mitigation measures. However, a destruction permit may be required if the structure remains are likely to be 60 years or older.

Burial Grounds and graves

The three informal burial grounds and the municipal cemetery all have a high heritage rating and a heritage grading of IIIA (MV005, MV009, MV025, MV033). However, the Municipal cemetery is anticipated not to be impacted by the project.

The impact significance before mitigation on the three burial ground and graves sites will be High negative before mitigation. Implementation of the recommended mitigation measures will modify this impact rating to an acceptable Medium to Low negative.

The three historic slimes dams

Although several of the slimes dams/ sand dumps are older than 60 years and could technically be described as "man-made structures", it is the considered opinion of this author that there is no heritage significance attached to the actual slimes dams/sand dumps. However, legally, the historic dumps 7L7, 7L5 and 7L6 may require a permit for their reclamation as they could be 60 years or older. It should also be noted that there is some probability of the presence of historic graves under or adjacent to the historic dumps.

Palaeontology

The desktop PIA found that the proposed Marievale Tailings Storage facilities and two pipeline alternatives are underlain by the Malmani Subgroup, (Chuniespoort Group, Transvaal Supergroup), Dwyka Group, Vryheid Formation (Ecca Group) and Karoo Dolerite Suite. The Palaeontological Sensitivity of the Malmani Subgroup is High, the Dwyka Group has a Moderate Palaeontological Sensitivity, the Vryheid Formation has a Very High Palaeontological

Sensitivity and Karoo Dolerite Suite has a Zero Palaeontological Sensitivity. Impacts on palaeontological heritage during the construction phase could potentially occur are regarded as having a high possibility. This would usually require a field-based assessment to be undertaken on the specific impacts expected.

However, since the proposed pipelines will be constructed overland or within existing servitudes and road reserves, it is anticipated that there should be no excavation into the underlying geology. In addition, the area around the three slimes dams has been disturbed extensively by previous mining-related activities. Therefore, the impacts on palaeontological heritage are anticipated to be minimal and it is recommended that an application for exemption from the standard requirement for a Palaeontological Impact Assessment be made to SAHRA

General

It is the author's considered opinion that overall impact on heritage resources is Medium to Low. Provided that the recommended mitigation measures are implemented, the impact would be acceptably low or could be totally mitigated to the degree that the project could be approved from a heritage perspective. The management and mitigation measures as described in Section 6 of this report have been developed to minimise the project impact on heritage resources.

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Transnet Pipilines 2019

TRANSNET

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Pipelines **2019**

Highlights

- **Petroleum** volumes transported increased by **9,1%**
- **Revenue** increased by **17,2%** to **R5,3 billion**
- **EBITDA** increased by **25,2%** to **R4,0 billion**
- **Achieved** a DIFR of **0,18** against a target of 0,65

Business overview

Transnet Pipelines (Pipelines) is the largest multi-product operator in southern Africa, transporting hydrocarbons and methane-rich gas through a network of 3 800 km of petroleum and gas pipeline infrastructure. The core strategic objective of Pipelines is to ensure security of supply to the inland market. Pipelines offers fully integrated supply chain solutions from source to destination while ensuring the best safety practices, optimum service reliability and exceeding customer expectations at all times through capable human capital.

To this effect, Pipelines currently transports:

- More than 65% of all refined products to the inland market;
- More than 70% of all jet fuel required at OR Tambo International Airport;
- 100% of the crude requirements for the Natref Refinery;
- 100% of the methane-rich gas requirements to KwaZulu-Natal for Sasol Energy and its gas clients; and
- 100% of Tarlton's volumes, of which 60% is distributed cross-border.

The initiative to secure a direct import terminal in the port of Durban and a Terminal Operating Licence has become a key strategic objective for Pipelines, in alignment with the Transnet Liquid Fuels Master Plan to enable:

- New market participants entrance into the pipeline system, in line with the Liquid Fuels Charter expectations which place emphasis on the promotion of broad-based black economic empowerment and overall sector transformation; and
- The Clean Fuels II Programme as per the Department of Energy, which will necessitate increased import terminals due to changes in fuel specification in the short to medium term.

The New Multi-Product Pipeline's (NMPP) 24" trunkline is in full multi-product operation. The line transports two diesel grades (D50 and D500) and two unleaded petrol grades (93 and 95) as well as jet fuel. The inland accumulation facility which was operationalised in December 2017 further facilitates security of supply to the market.

The decommissioning of the Durban-Johannesburg Pipeline (DJP) is currently in execution and is expected to be completed in 2021. The alternative uses for this asset are currently under consideration and have been narrowed down to options for fibre and gas.

A seamless integrated rail and pipeline service offering is currently in operation to OR Tambo International Airport, and other routes are being considered and optimised in this regard.

The International Strategy driven by Transnet International Holdings (International Holdings) encompasses growing beyond borders of the country. Repositioning Pipelines and working with International Holdings to position the division to be a liquid and gas operator of choice across Africa is crucial to the strategy. Opportunities to diversify into the liquefied natural gas (LNG) market are also being pursued.

Where we operate

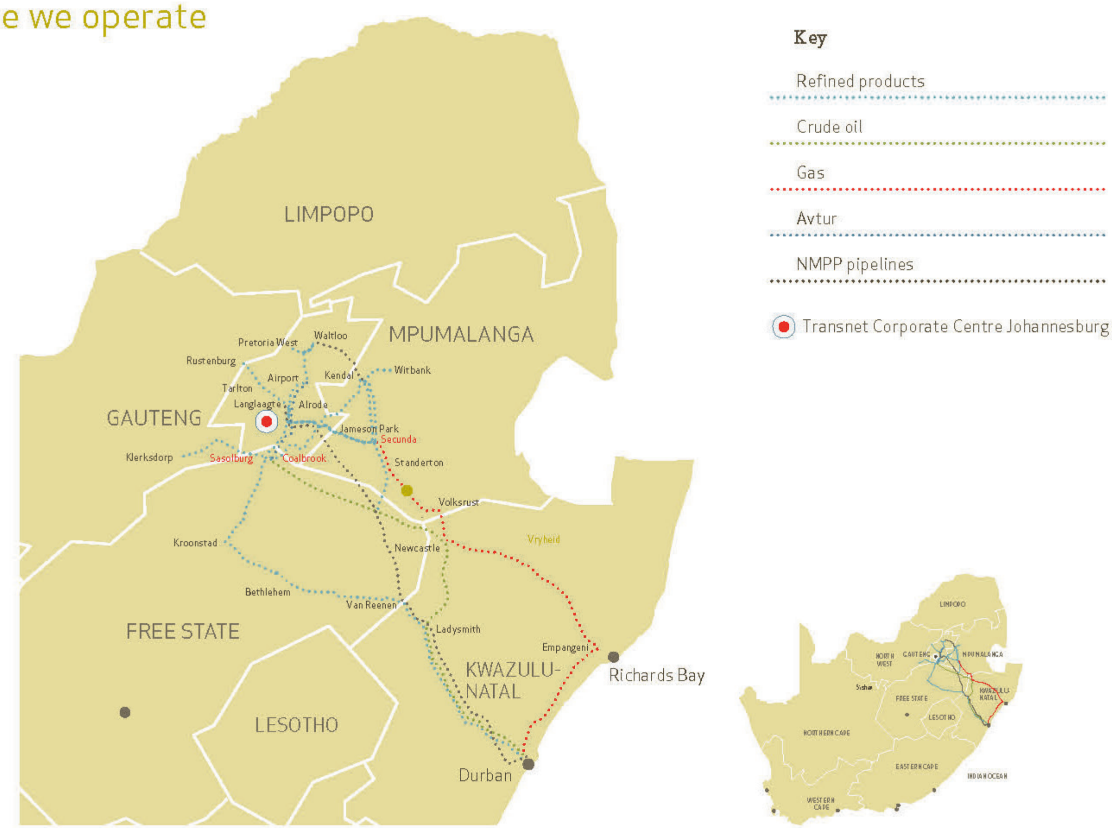

Figure 1: Petroleum and gas pipeline network

Regulatory environment

Pipelines operates in a regulated environment and is regulated by the National Energy Regulator of South Africa (Nersa) and governed by the Petroleum Pipelines Act, No 60 of 2003 and the Gas Act, No 48 of 2001. Almost all critical areas of the Pipeline business require regulatory sanction through the issuing of licences. The maintenance of the licensing status quo is core to Pipelines continuing as a going concern.

Compliance best practice requires that Pipelines reviews its regulatory universe annually in order to remain relevant in the changing regulatory environment.

Performance context

Strategic objective	Contribution to strategic objective
Reduce the total cost of logistics as a percentage of transportable GDP	• Providing competitive integrated customer end-to-end value propositions to lower the cost of doing business. • Facilitate integrated planning across rail, ports and pipelines through the Transnet Value Chain Coordinator (TVCC) that will result in volume growth and reduced supply chain costs.
Effect and accelerate modal shift by maximising the role of rail in the national transport task	• Seamlessly integrating rail and pipeline service offerings to customers is currently in operation to OR Tambo International Airport and other routes are anticipated to be operational in the next few years.
Leverage the private sector in the provision of both infrastructure and operations where required	• Fast-tracking key strategic initiatives for private sector participation, i.e. direct distribution, outlying depots and common-user berth operations
Integrate South Africa with the region and the rest of the world	• Repositioning Pipelines and working with International Holdings to position the division to be a liquid and gas operator of choice across Africa.
Optimise the social and economic impact of all interventions undertaken by the SOC in the achievement of these objectives	• Enable historically disadvantaged individuals to meaningfully participate in the petroleum and gas sector • Develop new players through enterprise development initiatives • Bolster skills in gas operations to build capacity and experience for future gas terminals

Operational performance

Core initiatives for 2019

- Minimise the impact of the 2019 petroleum determination on EBITDA and other key financial ratios.
- Achieve the volume targets for the financial year.
- Continued execution of the following major projects:
  - Construction of the Sapref replacement tanks
  - Upgrade of the fire protection system at its various sites
  - Control system development and crude deployment
- Continue implementation of the TVCC initiative to ensure volumes are maximised for Transnet.
- Develop skills to handle the new assets and new energy opportunities such as gas.

Overview of key performance indicators

Key performance area and indicator	Unit of measure	2017 Actual	2018 Actual	2019 Target	2019 Actual	2020 Target
Financial sustainability						
Revenue	R million	4 355	4 488	6 293	**5 262**	6 725
EBITDA	R million	3 377	3 192	4 925	**3 996**	5 430
Return on invested capital	%	n/a	n/a	n/a	**n/a**	n/a
EBITDA margin	%	77,5	71,1	78,3	**75,9**	80,7
Operating profit margin	%	57,3	48,3	57,7	**51,6**	62,3
Gearing	%	41,0	38,3	32,3	**31,1**	23,4
Net debt to EBITDA	times	3,8	3,9	2,2	**2,4**	1,4
Return on average total assets	%	10,7	7,0	8,8	**7,0**	10,8
Asset turnover – excluding CWIP	times	0,2	0,1	0,15	**0,1**	0,2
Cash interest cover	times	2,6	2,7	4,0	**3,3**	5,8
Capacity creation and maintenance						
Capital investment	R million	1 706	1 544	1 338	**326**	1 407
Actual vs planned maintenance	%	95	n/a	n/a	**n/a**	n/a
Production interruptions	hours	249	371	438	**332**	438
Operational performance						
Volume and revenue growth						
Total petroleum	Mℓ	16 978	16 345	17 516	**17 825**	17 204
Refined	Mℓ	10 563	10 678	11 476	**11 186**	11 556
Crude	Mℓ	5 254	4 534	4 970	**5 462**	4 510
Avtur	Mℓ	1 161	1 133	1 130	**1 177**	1 138
Gas	million m^3	595	489	506	**509**	509
Storage	Mℓ	415	315	338	**553**	553
Capacity utilisation (actual usage: capacity)						
DJP and NMPP	Mℓ/week	116:152	115:148	128:148	**110:148**	124:148
Crude	Mℓ/week	98:134	87:134	94:134	**105:134**	87:134
Avtur	Mℓ/week	22:24	20:24	20:24	**23:24**	20:24
Electricity efficiency	Mℓ.km/MWh (year-on-year percentage improvement)	(0,4)	n/a	n/a	**n/a**	n/a
Operating cost per Mℓ.m (a)	R/Mℓ.km	119	135	168	**139**	167
Gas (actual usage: capacity)	million m^3/month	50:57	40:57	42:57	**43:57**	42:57
Service delivery						
'Off spec' volumes	litres per billion delivered	253 022	162 519	228 271	**2 043 187**	216 952
Number 'off spec' delivery events per thousand dockets	number	0,3	0,4	0,3	**0,3**	0,3
Ordered vs delivered volume	%	96	93	95	**97**	95
Planned vs actual delivery time	%	86	86	88	**91**	90
Sustainable developmental outcomes						
Employment (human capital)						
Training spend	% of personnel cost	3,3	3,0	n/a	**n/a**	n/a
Employee turnover	%	4,8	n/a	n/a	**n/a**	n/a
Employment equity	% of black employees	88	n/a	n/a	**n/a**	n/a
Employee headcount	number	642	639	684	**672**	709
Female employees	% of headcount	33	n/a	n/a	**n/a**	n/a
People with disabilities	% of headcount	3,0	n/a	n/a	**n/a**	n/a
Risk, safety and health						
DIFR	rate	0,37	0,09	0,65	**0,18**	0,60

Financial performance review

Salient features		Year ended 31 March 2019 R million	Year ended 31 March 2018 R million	% change
Revenue	R million	**5 262**	4 488	17,2
– Refined	R million	**2 941**	2 502	17,5
– Aviation fuel	R million	**62**	66	(6,1)
– Crude	R million	**2 056**	1 445	42,3
– Gas	R million	**107**	96	11,5
– Handling	R million	**37**	19	94,7
– Other	R million	**6**	(31)	119,4
– Clawback and levy	R million	**53**	391	(86,4)
Operating expenses	R million	**(1 266)**	1 296	(2,3)
– Energy costs	R million	**(298)**	(264)	12,9
– Maintenance	R million	**(112)**	(98)	14,3
– Materials	R million	**(9)**	(305)	(97)
– Personnel costs	R million	**(438)**	(427)	2,6
– Other	R million	**(409)**	(202)	102,5
Profit from operations before depreciation, derecognition, amortisation and items listed below (EBITDA)		**3 996**	3 192	25,2
Depreciation, derecognition and amortisation	R million	**(1 283)**	(1 026)	25,0
Profit from operations before items listed below	R million	**2 713**	2 166	25,3
Impairments and fair value adjustments	R million	**24**	(20)	220
Net finance costs	R million	**(1 125)**	(233)	382,8
Profit before taxation	R million	**1 612**	1 913	(15,7)
Total assets (excluding CWIP)	R million	**39 004**	38 000	2,6
Profitability measures				
EBITDA margin[1]	%	**75,9**	71,1	4,8
Operating margin[2]	%	**51,6**	48,3	3,3
Return on average total assets (excluding CWIP)[3]	%	**7,0**	7,0	0
Asset turnover (excluding CWIP)[4]	times	**0,1**	0,1	0
Capital investments[5]	R million	**326**	1 544	(78,9)
Employees				
Number of employees (permanent)	number	**672**	639	5,2
Revenue per employee	R million	**7,83**	7,02	11,5

1 *EBITDA expressed as a percentage of revenue.*
2 *Profit from operations before impairment of assets, fair value adjustments, net finance costs and taxation expressed as a percentage of revenue.*
3 *Profit from operations before impairment of assets, fair value adjustments, net finance costs and taxation expressed as a percentage of average total assets, excluding CWIP.*
4 *Revenue divided by average total assets, excluding CWIP.*
5 *Actual capital expenditure (replacement plus expansion), excluding borrowing costs and including capitalised finance leases.*

Performance commentary

Financial sustainability

- Revenue increased by 17,2% to R5,3 billion (2018: R4,5 billion). This is mainly attributable to the 25,96% increase in petroleum allowable revenue granted by NERSA for the financial year.
- Net operating expenses decreased by 2,3% to R1,27 billion (2018: R1,3 billion). The decrease is due to the inclusion of an inventory write-off of R292 million in the 2018 financial year.
- EBITDA, of R4,0 billion is 25,2% higher than the prior year (2018: R3,2 billion).
- Revenue per employee increased by 11,5% to R7,8 million (2018: R7,0 million).

Looking ahead

- Pipelines intends to minimise the impact of the 2020 petroleum tariff determination on EBITDA and other key financial ratios.
- Pipelines plans to engage with Nersa on the NMPP prudency review.
- The division will continue with the Total and Sasol litigation resolution.
- Pipelines' will review tariffs at Kroonstad and Tarlton to ensure cost effectiveness.

Capacity creation and maintenance

- The division's spend on capital for the year was R326 million compared to a target of R1,3 billion. This is mainly due to revision of project schedules and delays in certain projects.
- The decommissioning of the southern section of the Durban to Johannesburg Pipeline has commenced.
- The prefeasibility exercise for the PL5 (Sasolburg to Kroonstad pipeline) and PL6 (Jameson Park to OR Tambo International Airport pipeline) continued in the 2019 financial year and is planned to be finalised in the 2019/20 financial year.

Looking ahead

- Transnet Pipelines will execute the following major projects in the next financial year:
  - Construction of the Sapref replacement tanks;
  - Upgrade of the fire protection system at its various sites; and
  - Control system development and crude deployment.
- Pipelines will finalise the business case for the Coastal Terminal (TM1) accumulator tanks.

Operational performance

Volumes

- The petroleum volumes transported for the period increased by 9,1% to 17,825 billion litres (2018: 16,345 billion litres). This increase is predominantly due to higher crude volumes transported as there was no Natref shutdown in the current year.
- Tarlton storage and handling volumes increased by 72,5% to 596,531 million litres (2018: 345,745 million litres). This is attributable mainly to new clients, certain fuel majors recommencing use of the Tarlton facility and increased volumes from certain customers.
- Gas volumes compared to the preceding year showed a slight increase of 4,4% to 511 million cubic metres (2018: 489 million cubic metres).

Capacity utilisation

Combined capacity utilisation for the NMPP 24" and DJP (actual usage: capacity) of 110:148 Mℓ per week (2018: 115:148 Mℓ per week) is lower than the target of 128:148 Mℓ as a result of commercial agreements that the customers entered into with the inland refineries.

Service delivery

- Pipelines' customer satisfaction declined to 65,7% from 75% in 2018. This was mainly due to customer concerns regarding the conveyance agreement.
- Service delivery measures relating to ordered versus delivered volumes and planned versus actual delivery times were 97% and 90% respectively compared to 93% and 86% in the prior year. The results were attributed to full operation of the terminal at Jameson Park giving flexibility while reducing delays.
- Pipelines' operational cost per megalitre kilometre (Mℓ.km) of R139 per Mℓ.km is lower than the target of R168 per Mℓ.km due to cost-saving initiatives being implemented.

Looking ahead

- The division aims to achieve petroleum volume of 17,204 billion litres, which is lower than 2019 due to a planned Natref shutdown.
- Pipelines will continue to improve Tarlton volumes and efficiencies by focusing on process automation, rail and road turnaround times.
- With the availability and optimisation of TM2 (Jameson Park), Pipelines will continue to improve the availability of product at the main areas of supply.

Sustainable developmental outcomes

Human capital (employment and transformation)

- Pipelines achieved a permanent employee headcount of 672 (target: 684). The filling of vacancies was curtailed during the year due to the current moratorium on filling vacancies.
- Black employees represented 89,58% of the total employee base against a target of 89,0%.
- Female employees represented 34% of the total employee base against a target of 34,08%.
- People with disabilities represented 1,98% of the total employee base against a target of 3,2%.
- The employee turnover rate is 5,17% compared to a target of 5,0%.
- The Absenteeism Index of 1,78% is lower than the target of 2,5%.

Skills development

- Pipelines achieved a training spend of 1,1% compared to a target of 3,5%.
- The division will focus on:
  - People Living with Disability Learnership programme;
  - People in Pipeline training programme;
  - Lean 6 Sigma White Belt training for all employees;
  - Supervisory Development Training for all supervisors; and
  - Building a Gas Skills Competency Framework in preparation for the new business initiatives.

Health and safety

- A DIFR of 0,18 (2018: 0,09) was achieved for the year compared to a threshold of 0,65.
- Pipelines continues to implement the Transnet Integrated Management Approach and is aiming for certification on the safety system in the next financial year.

Quality assurance

- Pipelines achieved the ISO 9001:2015 certification.

Environmental stewardship

- Pipelines continued to implement a comprehensive Environmental Management System based on the ISO 14001 standard. We managed to maintain certification in line with the ISO14001:2015 standard.
- As part of sustainable initiatives Pipelines conducted a very successful coastal clean-up in partnership with National Ports Authority in September 2018, in commemoration of the International Coastal Clean-up Day.

Social accountability

- Enterprise Development (ED) initiatives amounted to R10,2 million for the year, including the following highlights:
  - Pipelines entered into partnerships with third-party/conduit ED companies to implement enterprise and supplier development (ESD) initiatives for the purpose of developing and sustaining small, medium and micro enterprises (SMMEs) that have the potential to become suppliers.
  - ESD resources continued to focus on the needs of SMMEs within Transnet's supply chain and provided them with support and early payment terms.

Key risks and mitigating activities

The following table details Pipelines' top five risks and the key mitigations activities.

Key risks	Mitigating activities
Material pay-out in terms of Natref neutrality principle	• Termination of the letter agreement • Commercial case management process is currently in progress
Delay in the completion of the Sapref R-tanks as part of the NMPP	• Proactive management and monitoring of key milestone dates and activities as per the execution schedule
Negative financial impact of Nersa NMPP Prudency Review	• Compilation of position papers and sourcing of supporting documentation to mitigate prudency risks on TM1, TM2 and Engineering Procurement and Construction Management (EPCM) costs • Prudency assurance team in place • Engagement with Nersa on the Nersa NMPP Prudency Review
Non-completion of the TM1 accumulator tanks in time to meet demand	• Timeous approval of business case • Appointment of EPCM to complete FEL 3 validation and assist with the business case
Loss of revenue due to the high cost of doing business with Pipelines	• Capital optimisation programme • Various initiatives to increase volumes • Review of tariffs at Kroonstad and Tarlton
DJP Pipeline Integrity (SBG – KRO and ALR – APT)	• Replacement of DJP sections with PL5 and PL6
Increase in safety, health and environmental incidents	• Behaviour-based safety programme • Internal and external assurance testing • Planned job observations • Implement and monitor corrective action from previous incidents

Opportunities

Gas

- Exploring opportunities to diversify into the LNG market

Terminal

- Creating import capability for new users at Island View, Durban
- Terminal operations at Island View and Ambrose Park, Durban

Pipelines

- Feasibility study – new jet pipeline from Chevref or from Port to Cape Town International Airport
- Feasibility study – new pipeline from South Africa to Botswana
- Investigating alternative uses of the DJP after its decommissioning from petroleum product use

Africa

- Via Transnet International Holdings, Pipelines will focus on the success of the Africa strategy. The division intends to grow the non-regulated business by sharing skills, knowledge, pipeline training, and operational services with other African pipeline companies in the Southern Africa Development Community (SADC), including Kenya
- Focus on efficient supply chain to Botswana

Integration of Transnet business units

- Intermodal integration of Freight Rail and Pipelines service offering for liquid fuel.

Abbreviations and acronyms

CWIP	Capital work in progress
DIFR	Disabling injury frequency rate
DJP	Durban-Johannesburg Pipeline
EBITDA	Earnings before interest, taxation, depreciation and amortisation
LNG	Liquefied natural gas
NMPP	New Multi-Product Pipeline
Nersa	National Energy Regulator of South Africa
SOC	State-owned company
TVCC	Transnet Value Chain Coordinator

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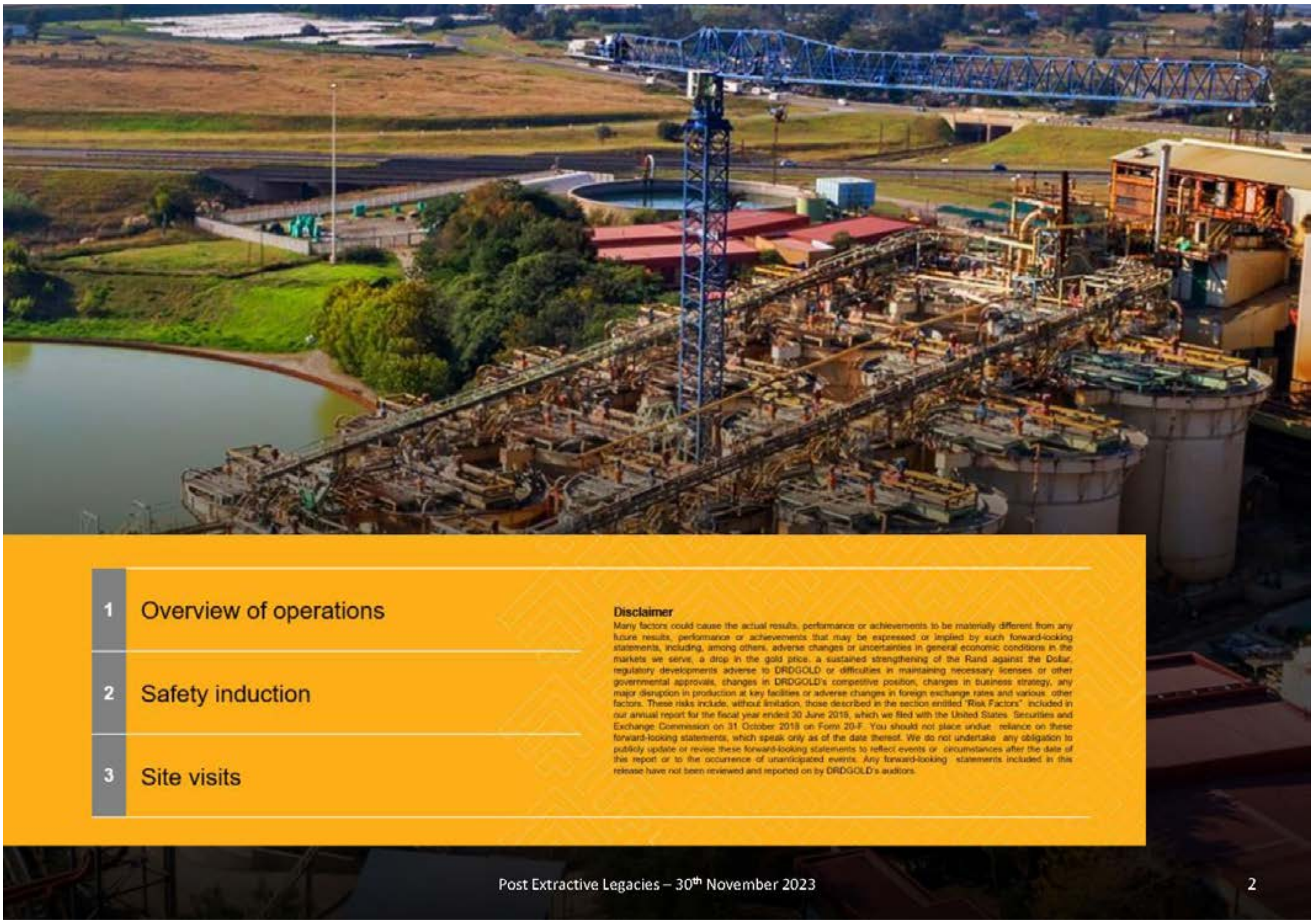
DRD GOLD


TEAM VISIT FROM POST EXTRACTIVE LEGACIES
30th November 2023
Post Extractive Legacies – 30th November 2023
1



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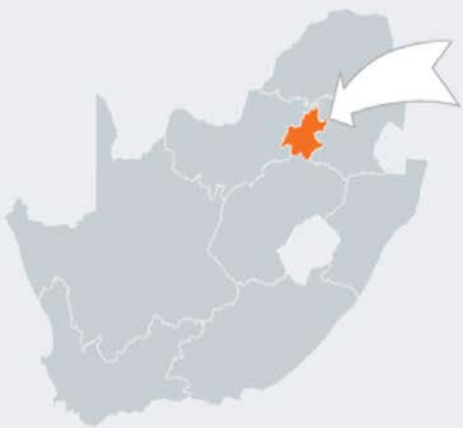
WHERE WE OPERATE



GAUTENG PROVINCE
SOUTH AFRICA

FWGR

Mineral Reserves of 2.46Moz

- 1 processing plant with a capacity of 500 000tpm (Driefontein 2)
- 1 tailings Storage facility with a capacity of 525 000tpm (Driefontein 4)

ERGO

Mineral Reserves of 3,58Moz

- 1 processing plant with a capacity of 1.80Mtpm (Ergo)
- 2 Milling Plants (City and Knights)
- 1 tailings Storage facility with a capacity 2.0Mtpm (Brakpan/Withok)

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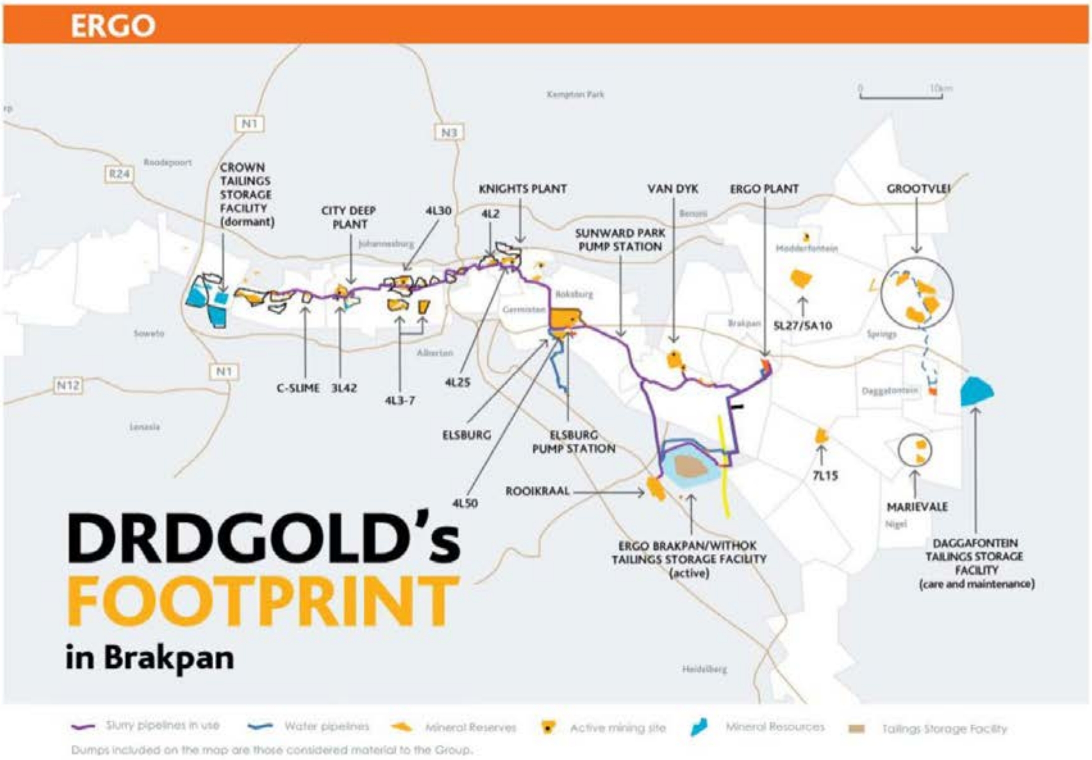

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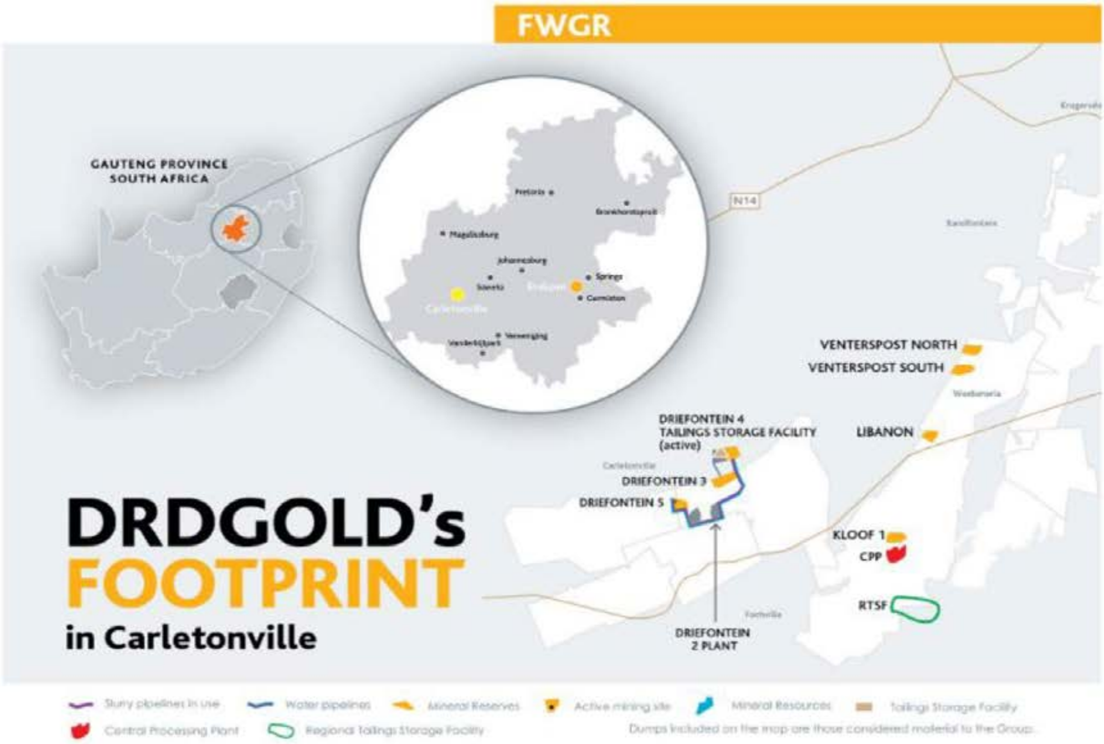
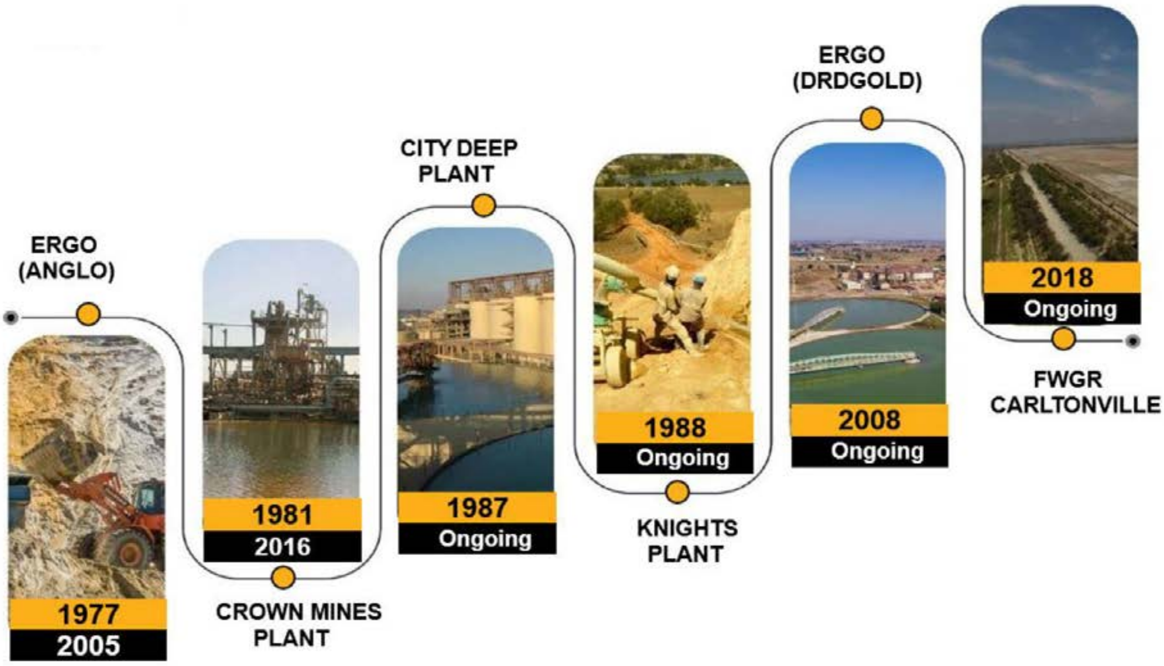
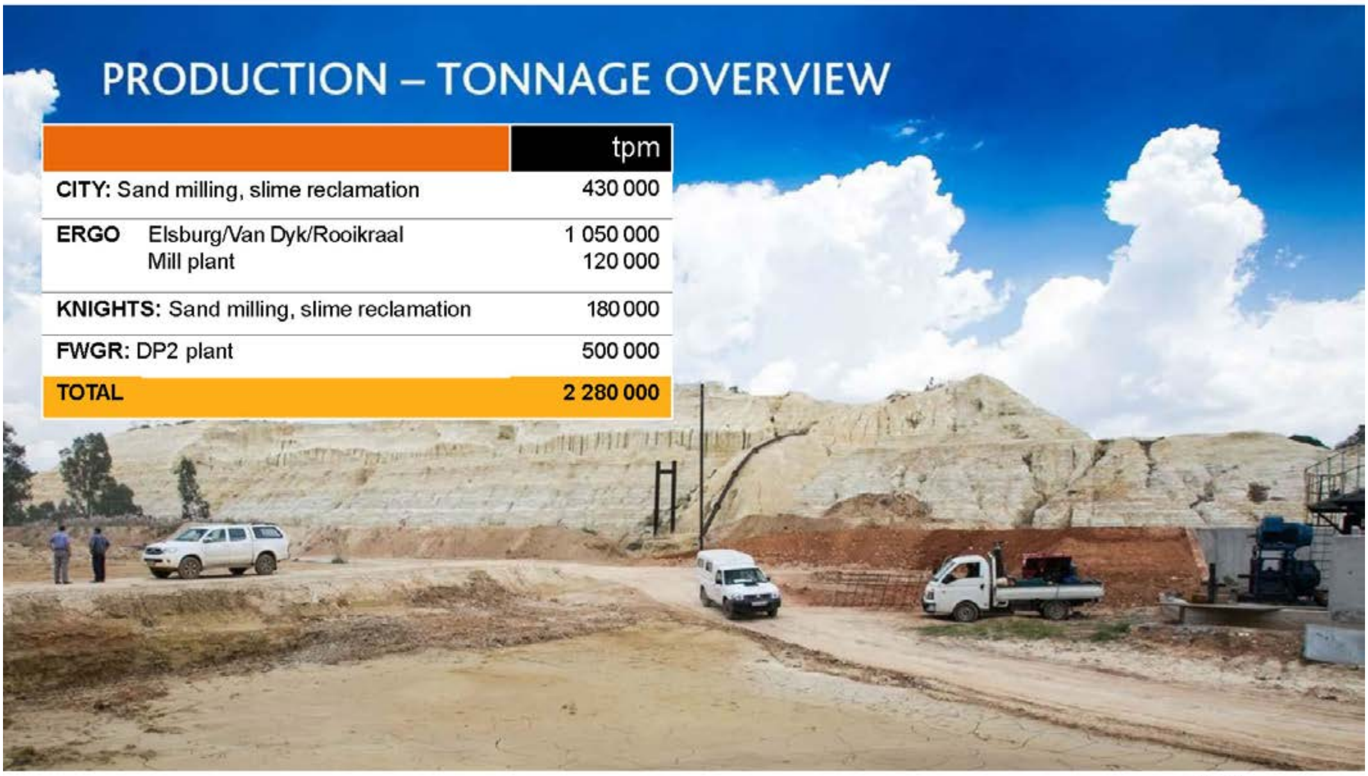


HISTORY



PRODUCTION – TONNAGE OVERVIEW

	tpm
CITY: Sand milling, slime reclamation	430 000
ERGO Elsburg/Van Dyk/Rooikraal	1 050 000
Mill plant	120 000
KNIGHTS: Sand milling, slime reclamation	180 000
FWGR: DP2 plant	500 000
TOTAL	**2 280 000**



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MONTHLY GOLD PRODUCTION

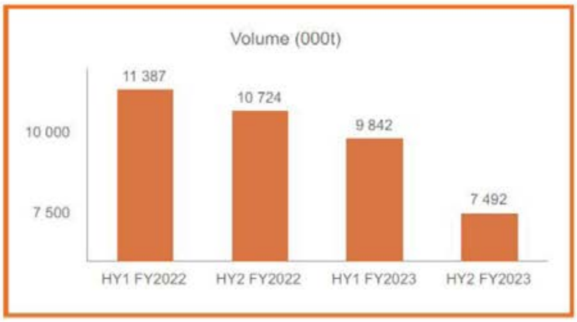
	kg
Knights	60
City	120
Ergo	170
FWGR	130
Total	**480**

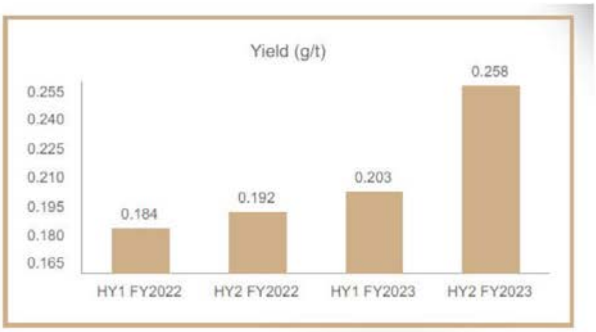
DRDGOLD LIMITED

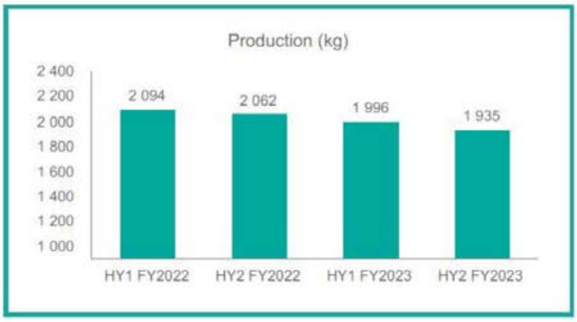
ERGO MINING OPERATIONS BREAK-EVEN ANALYSIS

ITEM		Break-even grade	Break-even gold price
Combined plant throughput	tpm	1 841 000	1 841 000
Gold price	$/oz	1 862	1 507
Exchange rate	R/$	15.15	15.15
Conversion	g/oz	32.1507	32.1507
Gold price	R/g	907	734
Operating costs	Rm/month	254	254
Operating costs	R/t	137.97	137.97
Yield	g/t	0.152	0.188
Combined gold production	kg/month	280	346
Combined residue grade	g/t	0.197	0.197
Combined feed grade	g/t	0.349	0.385

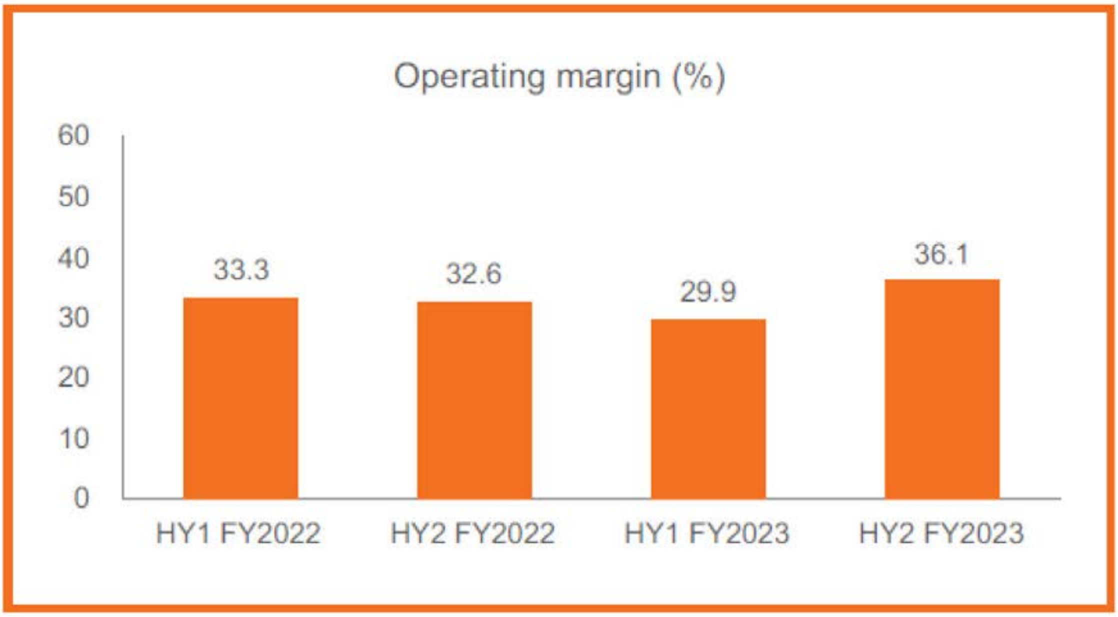
GROUP OPERATING TRENDS





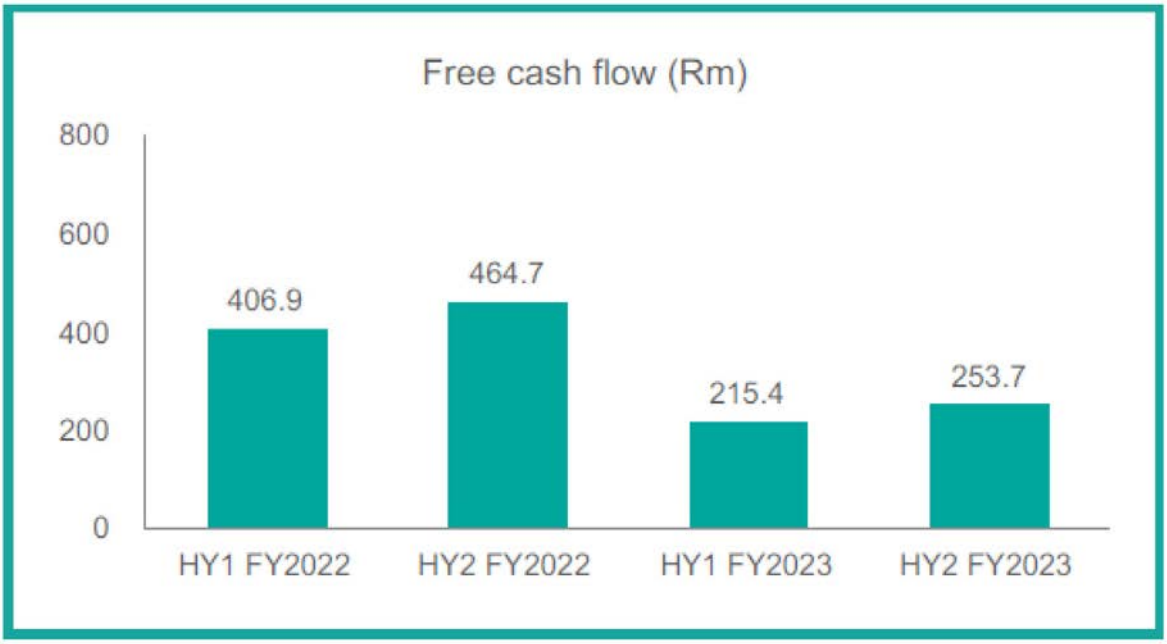


GROUP FINANCIAL TRENDS



GROUP FINANCIAL TRENDS

DRDGOLD LIMITED



EMPLOYEE OVERVIEW

DRDGOLD LIMITED

It is our desire to develop an engaged, knowledge-based workforce that increasingly represents the demography of South Africa and that provides fair opportunity for advancement to all. We aspire to create an environment where employees are safe and content and are provided with every opportunity to develop as individuals.

EMPLOYEE RELATIONS AT A GLANCE

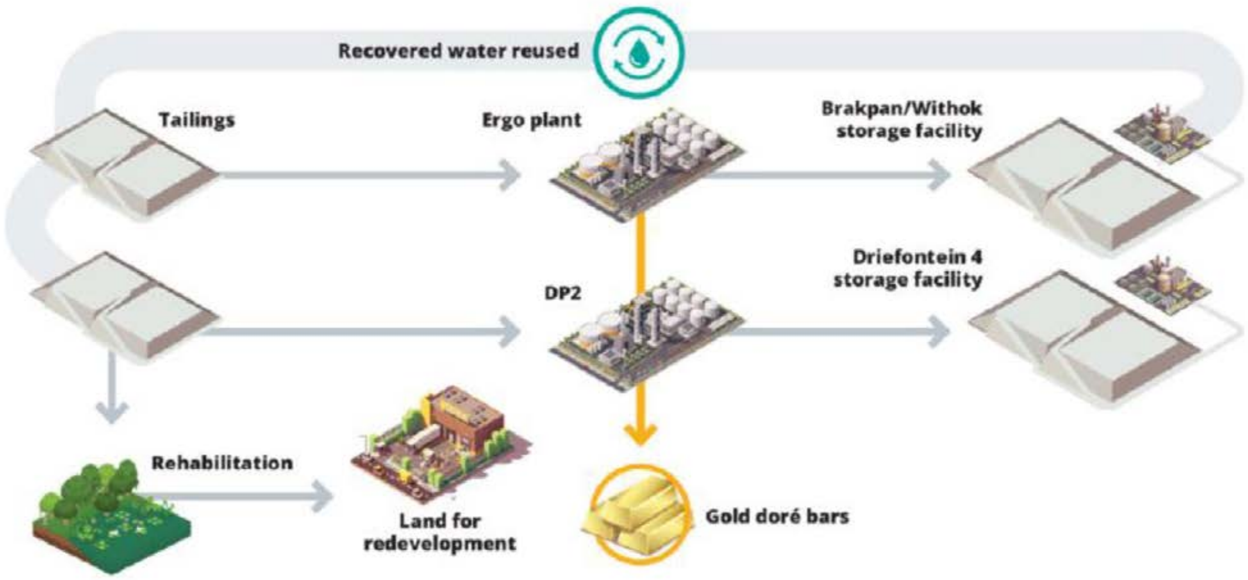
927	2 155	25%	75%	R16.6m
employees	specialist providers	women in mining	HDPs	training spend

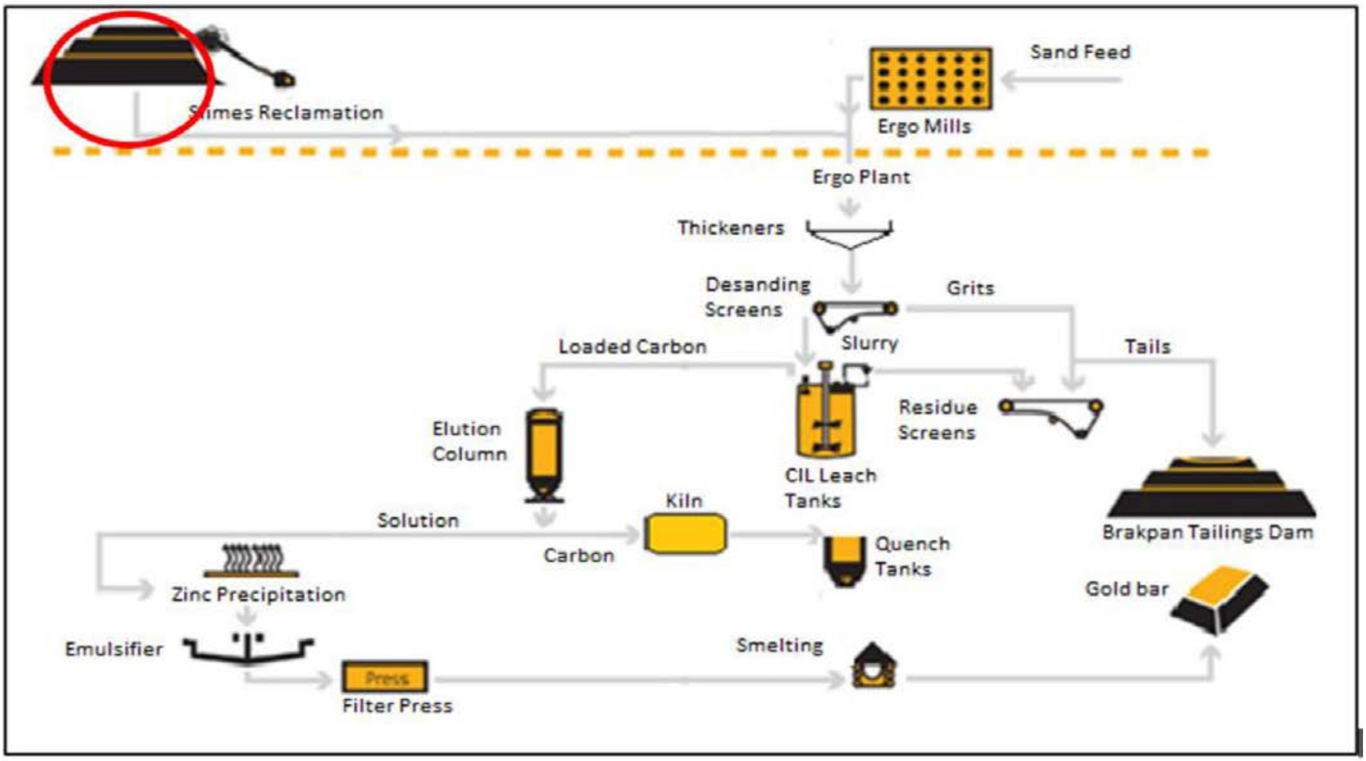
Value distributed to employees – salaries, wages and other benefits

R663m

(2022: R650m)

OPERATIONAL OVERVIEW



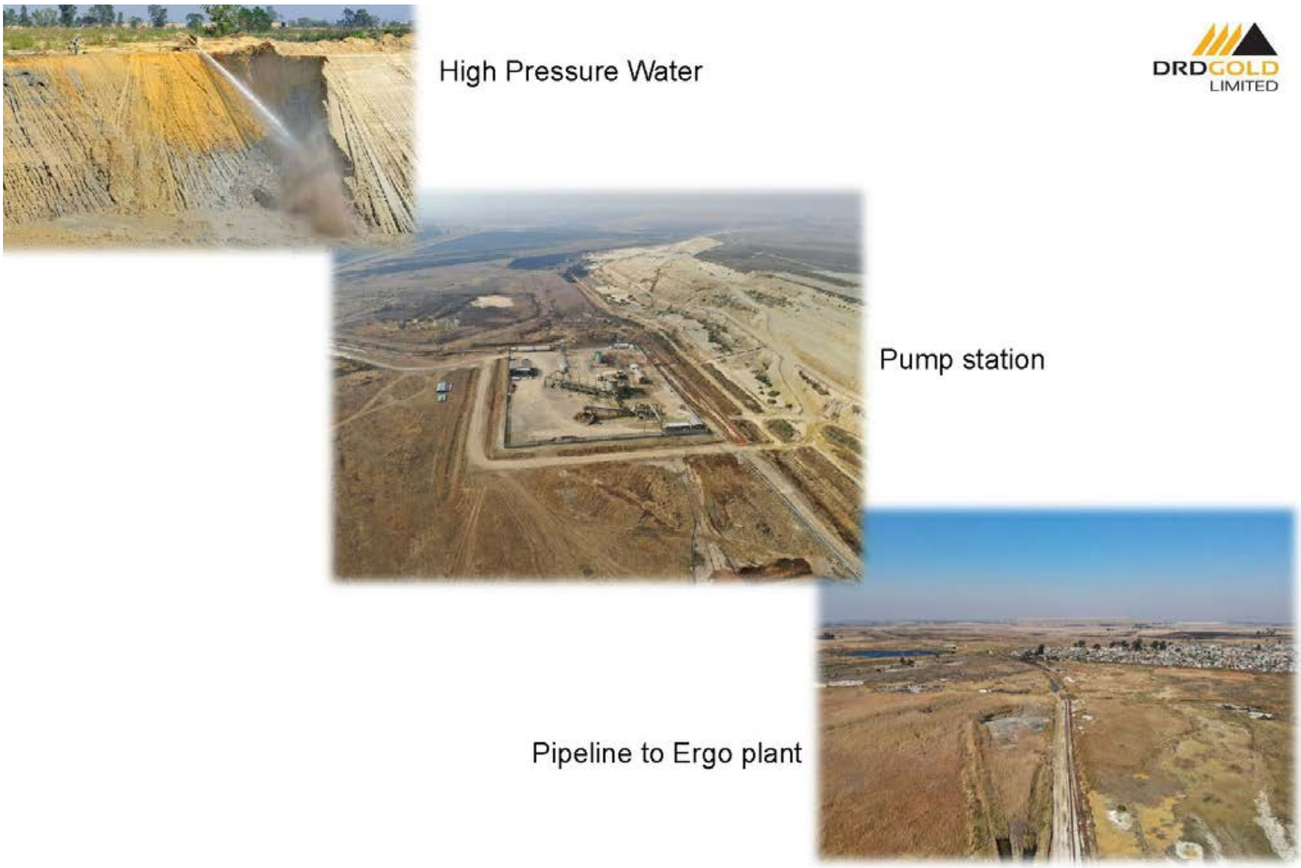


Reclamation Sites

DRDGOLD LIMITED

Current Active Reclamation Sites:

1. **4L25/ 4L2**
2. **5050**
3. **4L30**
4. **4A18**
5. **Satellite 3**
6. **4L50**
7. **Benoni**
8. **Rooikraal**



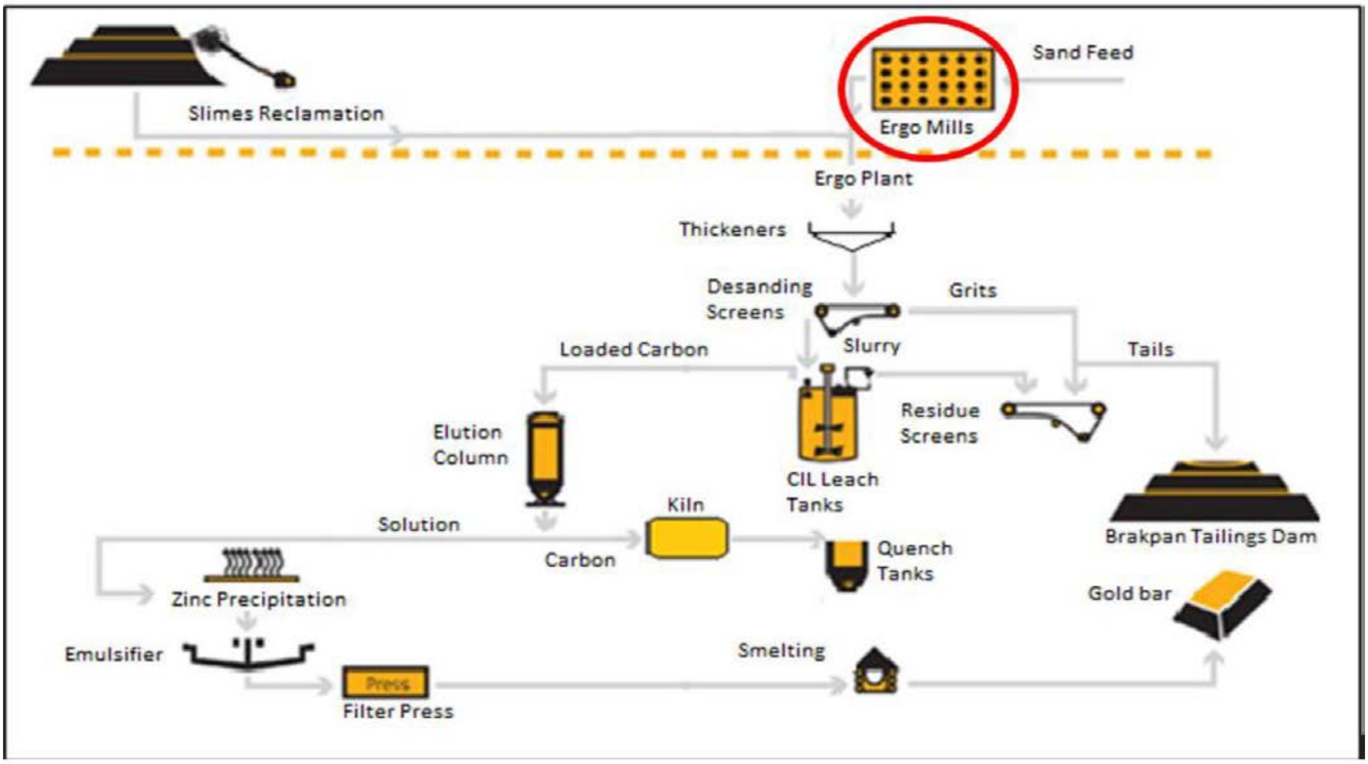
High Pressure Water

DRDGOLD LIMITED

Pump station

Pipeline to Ergo plant

DRDGOLD LIMITED



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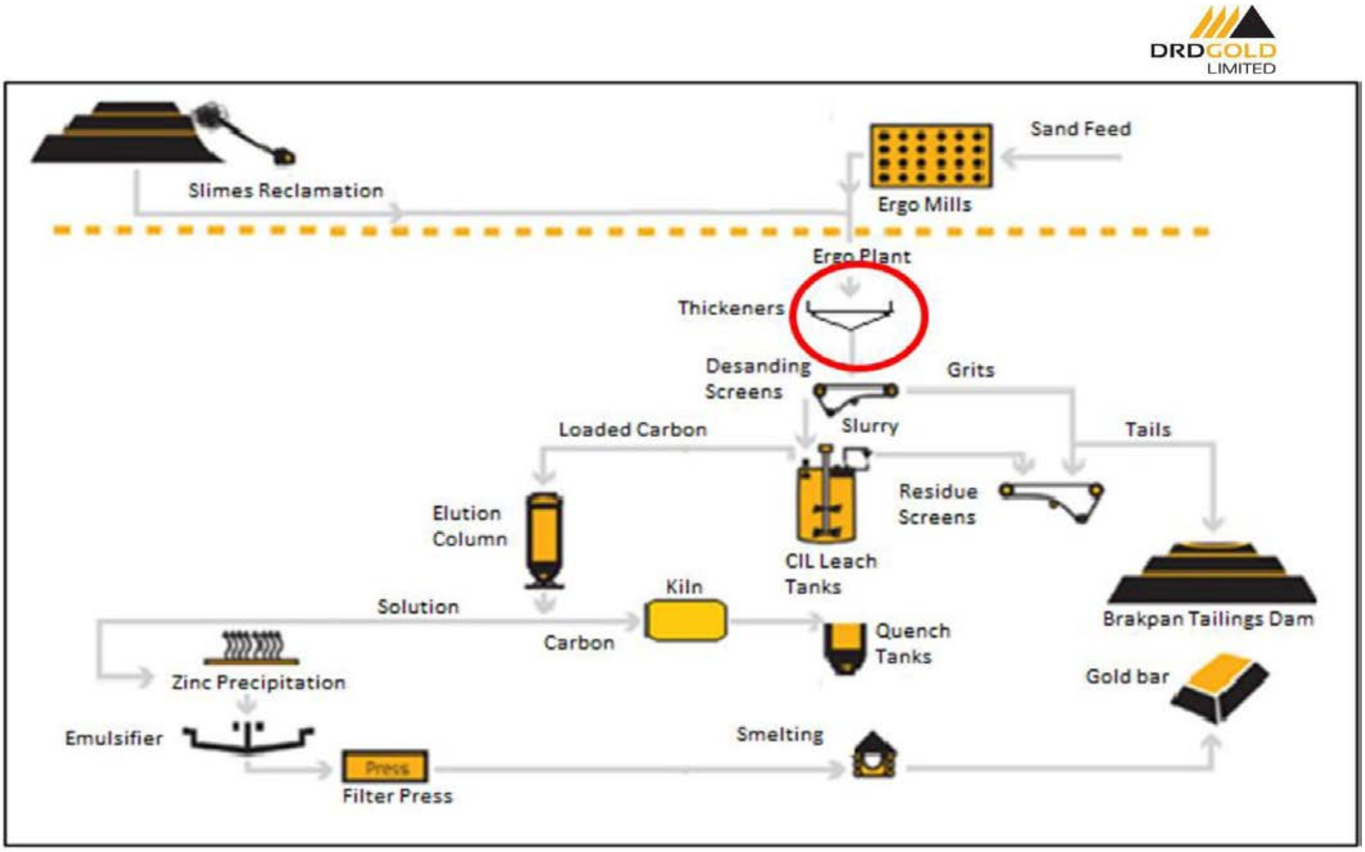
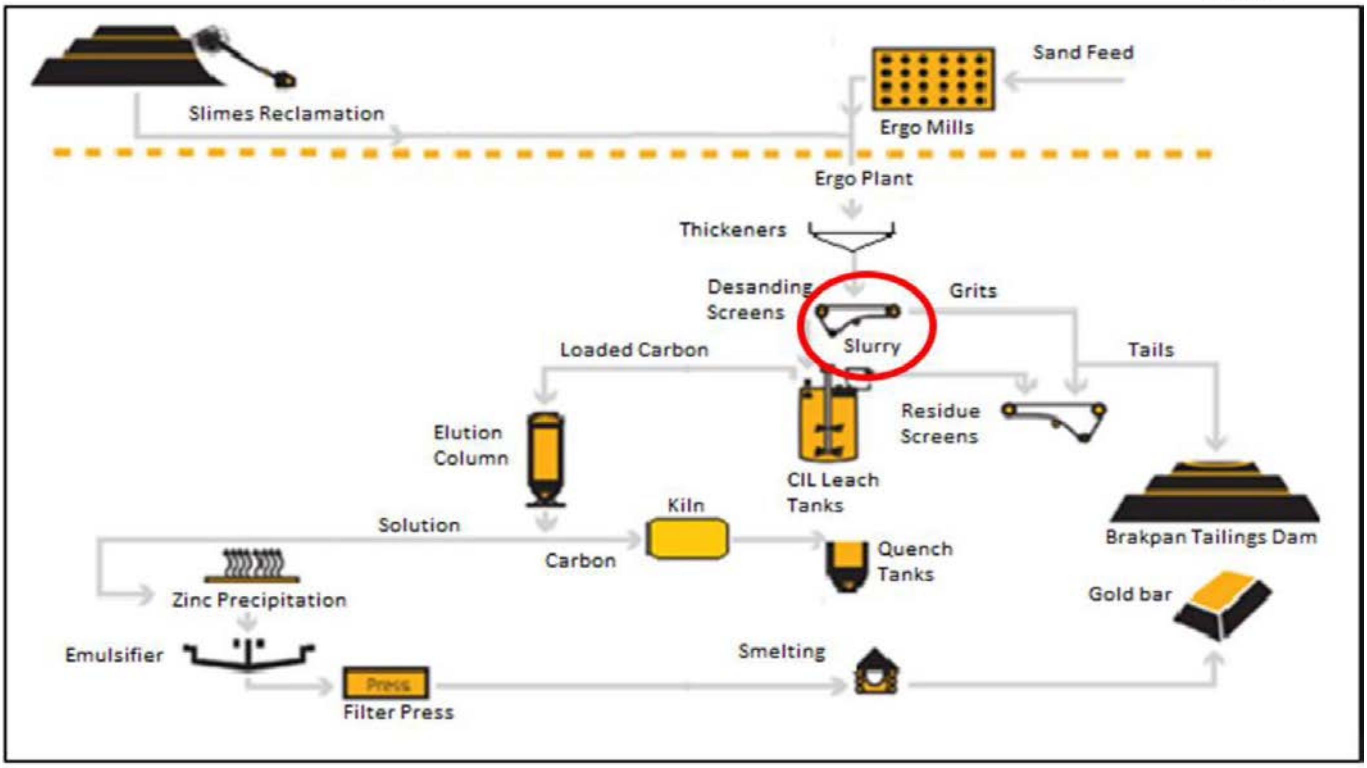


DRDGOLD LIMITED
Slimes Reclamation
Sand Feed
Ergo Mills
Ergo Plant
Thickeners
Desanding Screens
Grits
Slurry
Tails
Loaded Carbon
Elution Column
CIL Leach Tanks
Residue Screens
Brakpan Tailings Dam
Kiln
Solution
Carbon
Quench Tanks
Zinc Precipitation
Gold bar
Emulsifier
Press
Filter Press
Smelting

70

DRDGOLD LIMITED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Filter Press

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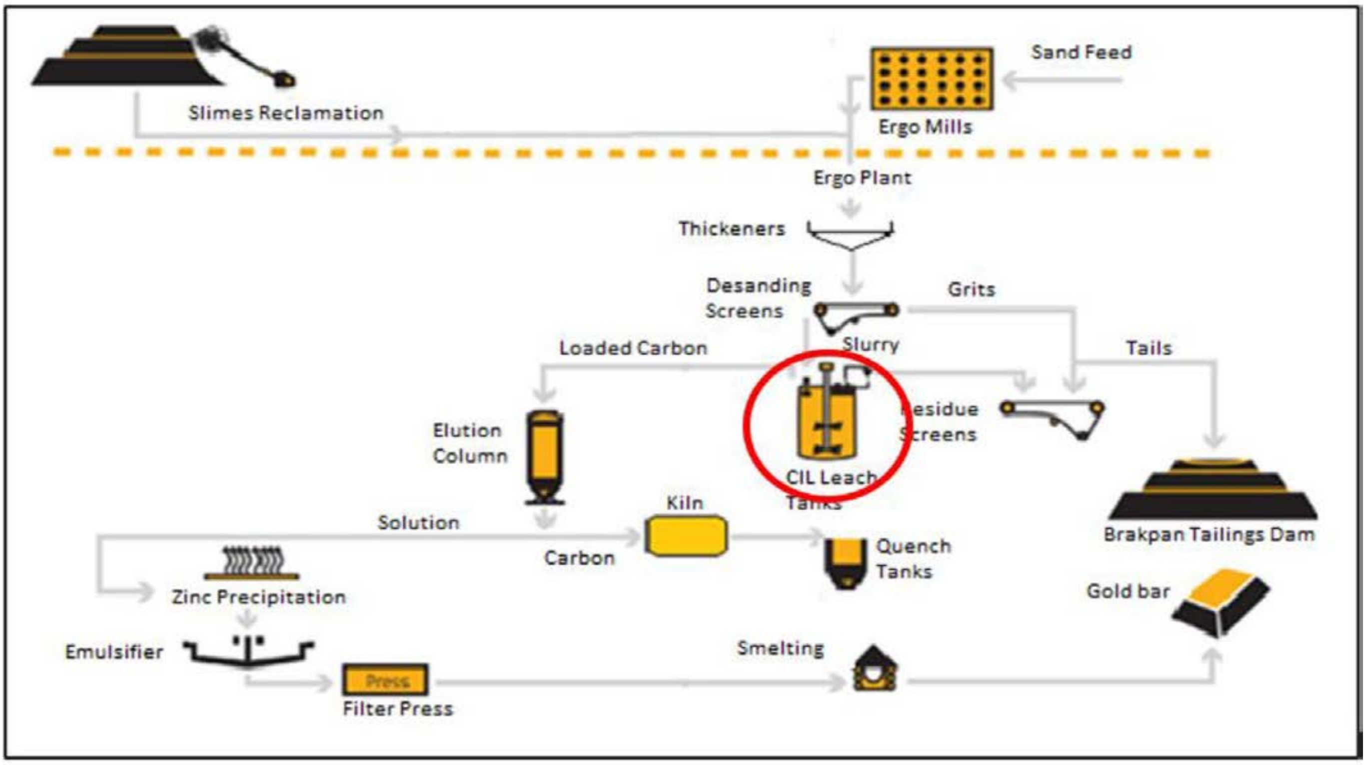

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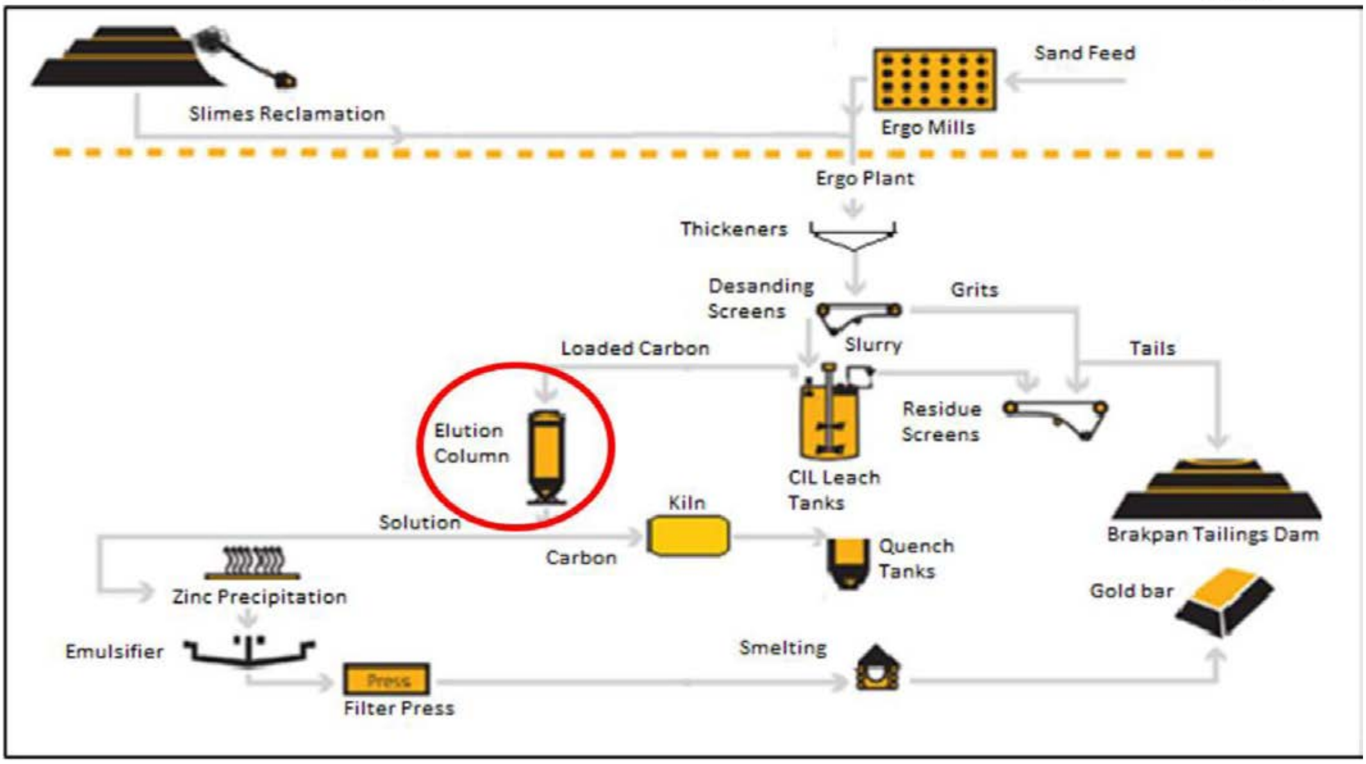

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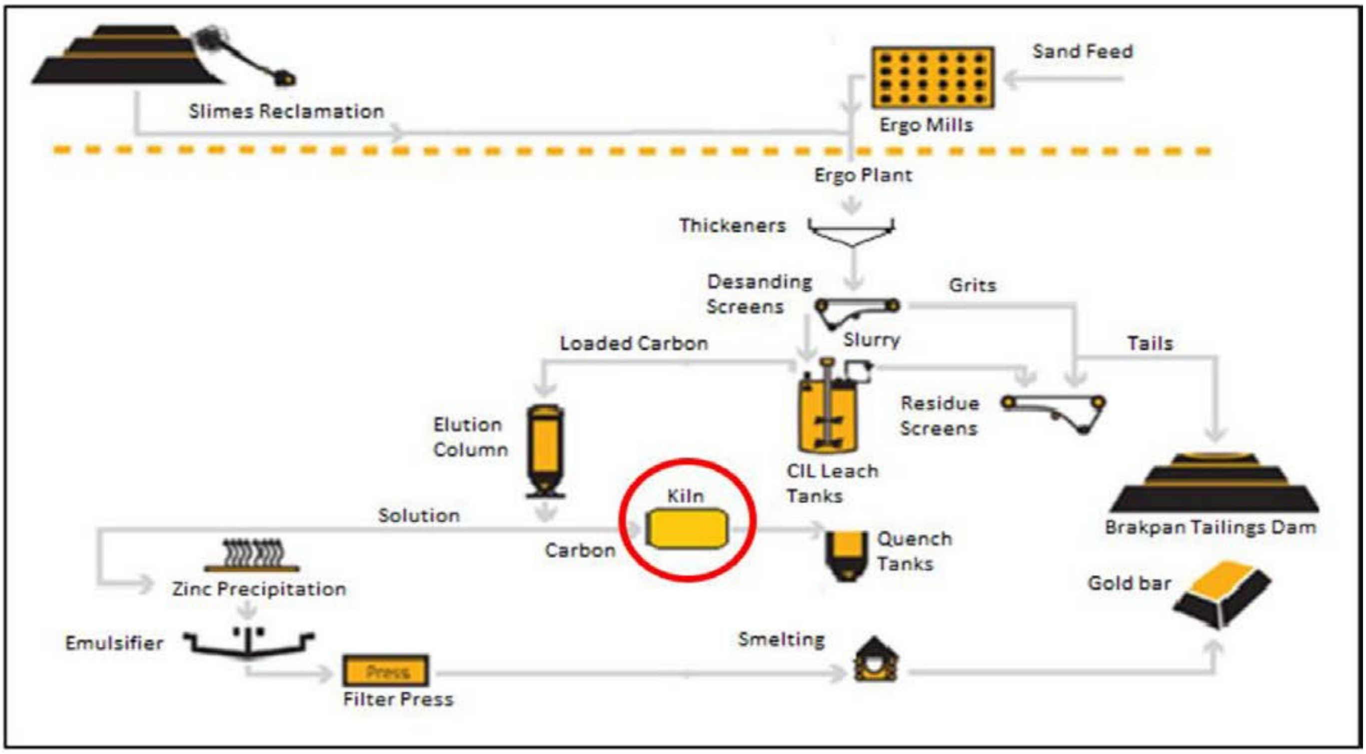
DRDGOLD LIMITED



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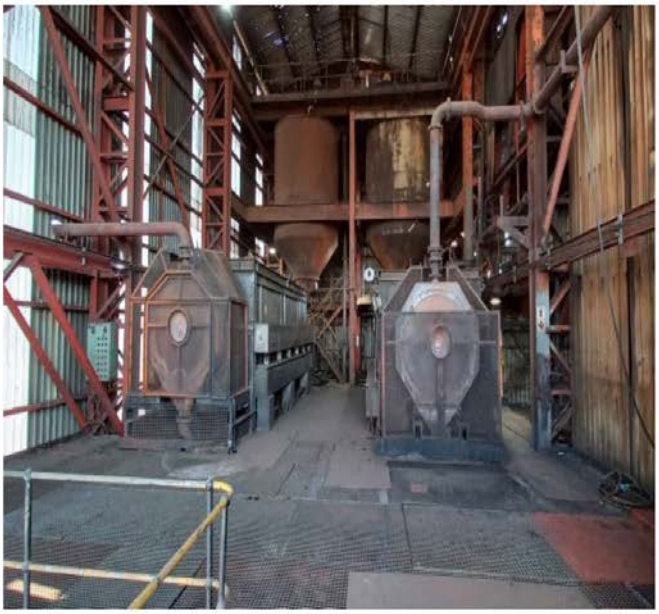
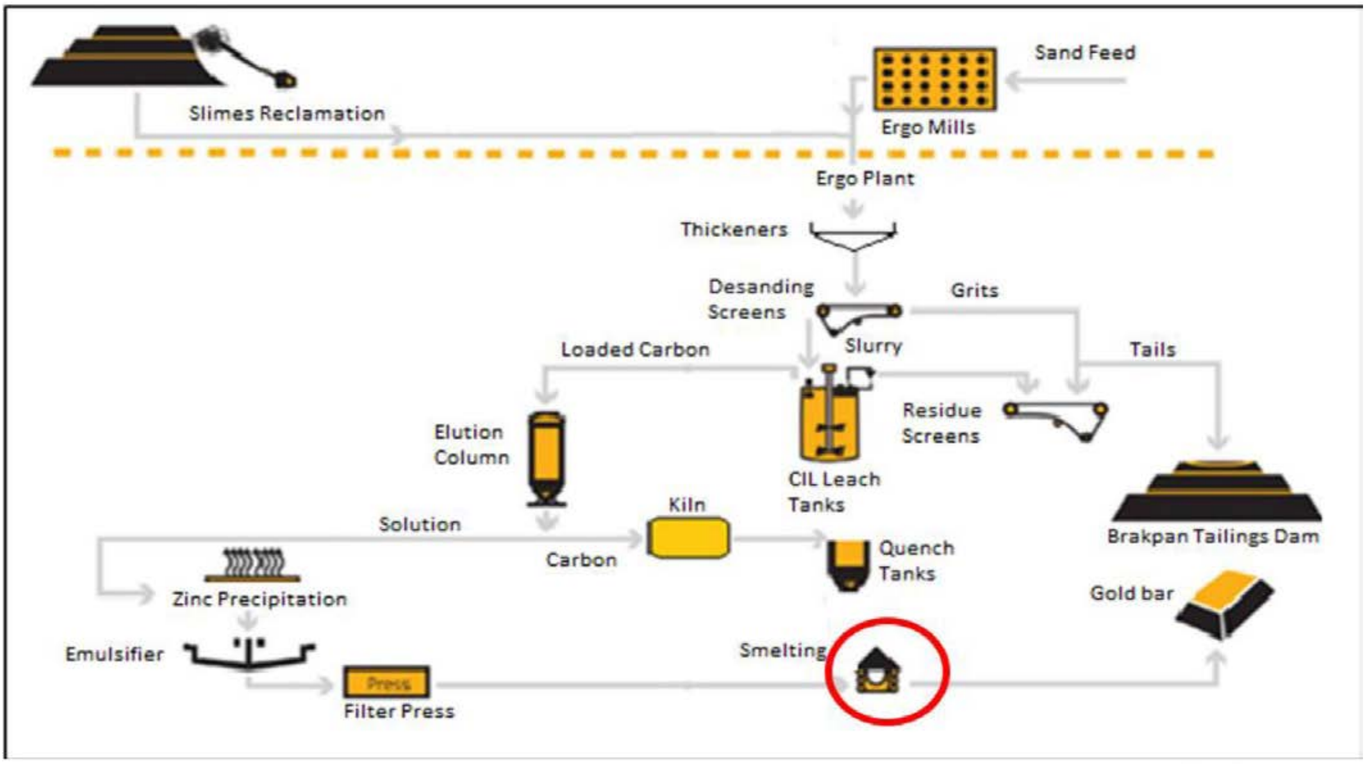
2 x Electric Kilns



Gas Kiln

DRDGOLD LIMITED



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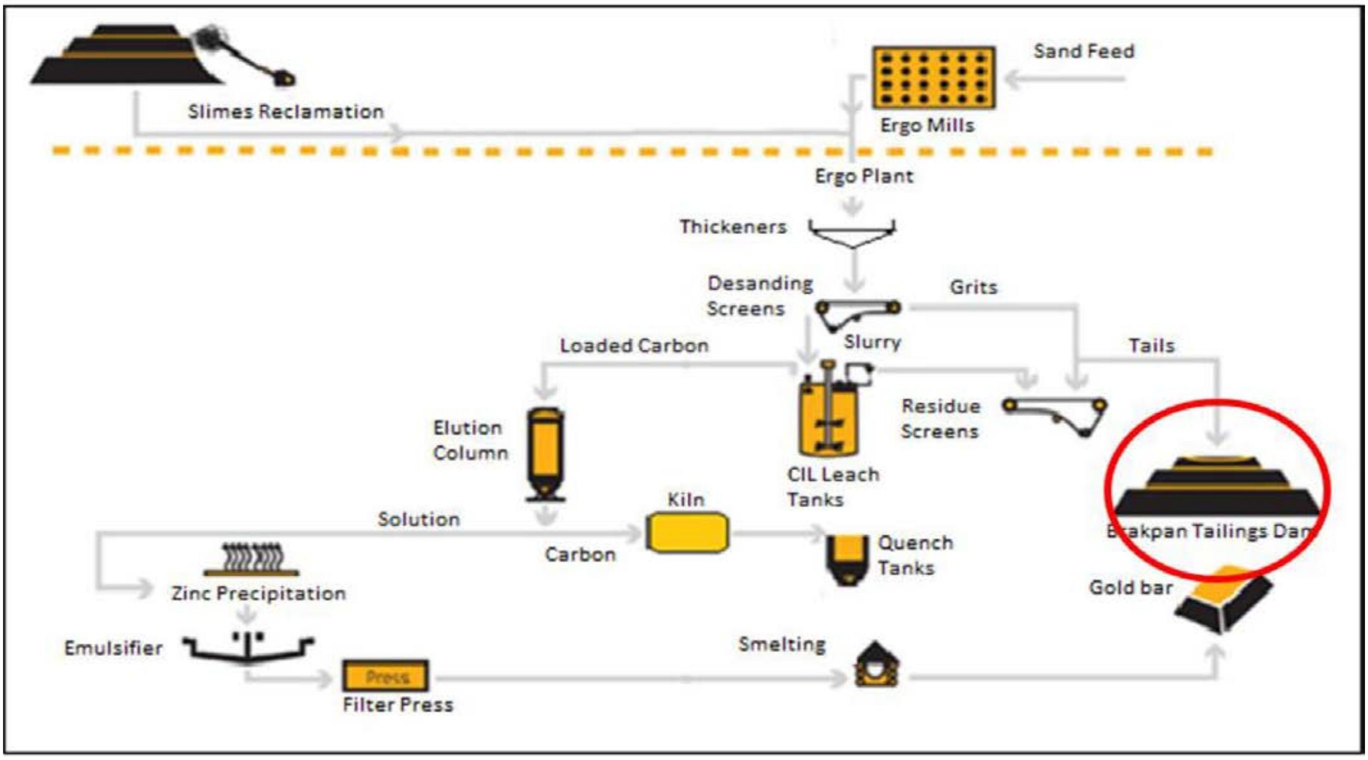
DRDGOLD LIMITED



Tailings Facility

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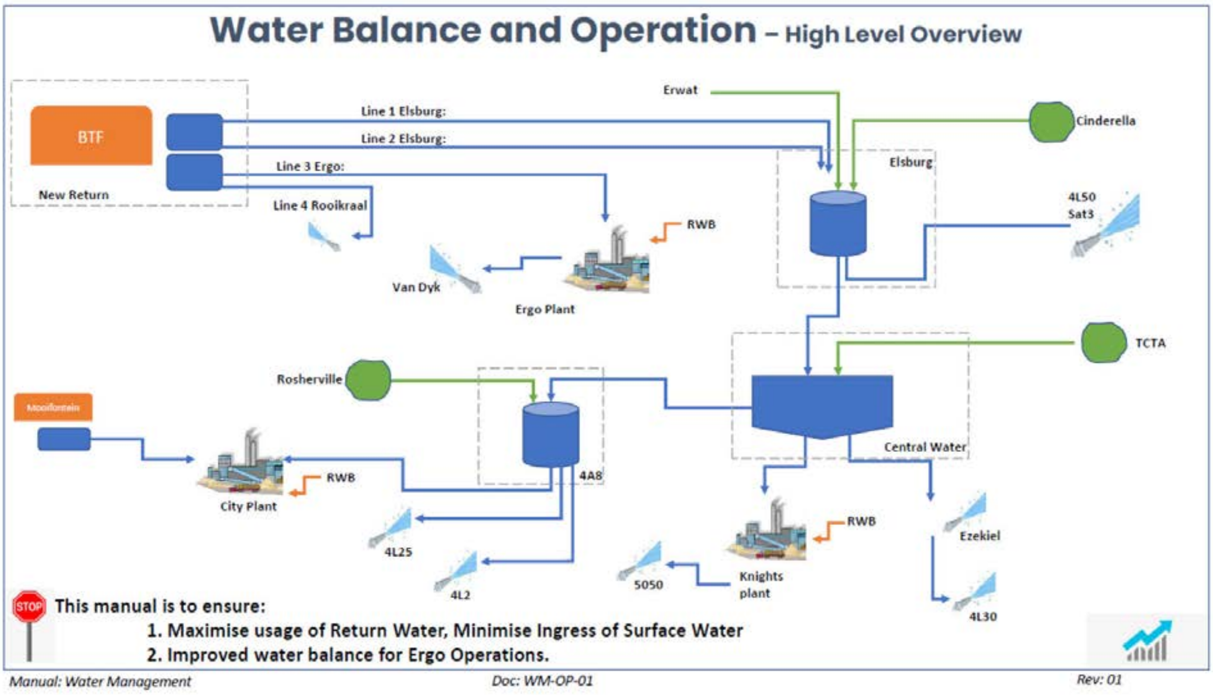
Deposition using 250 cyclones

DRDGOLD LIMITED

Brakpan Tailings Pond

Return Water Dams

Recycling of Process Water



ENVIRONMENTAL VALUE ADD

DRDGOLD LIMITED

		2023	2022	2021
Hectares of TSFs vegetated	Ha	**25**	58	115
Potable water consumption	Mℓ	**2 380**	2 642	2 968
Dust emission exceedances	%	**0.87 %**	1.98 %	0.27 %
Electricity consumption	Mwh	**333 249**	376 513	381 707
Carbon emissions	CO_2e (t)	**368 581**	414 835	412 145

Environmental spend
R41.9m
2022: R60.3m
2021: R105.0m

DRDGOLD LIMITED

E OUR PERFORMANCE FOR THE YEAR ENDED 30 JUNE 2023

1 decrease in externally sourced potable water	2 dust emissions exceedances	3 spent on rehabilitation	4 tailings deposition facilities vegetated	5 Potable water consumption
10%	**0.87%**	**R41.9m**	**25ha**	**2 380Mℓ**

TAILINGS MANAGEMENT

- External Tailings Review Panel
- Internal Tailings Performance Management System (TPMS) implemented for dedicated data collection, storage and processing. Ensures integrity of data for day-to-day management and oversight
- Review of Historical Interferometric Synthetic Aperture Radar (InSAR) imagery for mapping ground deformation over large areas
- Quarterly drone surveillance

REVERSING THE LEGACY OF MINING

DRDGOLD LIMITED

Redesign and Post Mining Landscape Team visit, 08 July 2022 40 www.drdgold.com

LOOKING AHEAD

DRDGOLD LIMITED

FY2023 GUIDANCE

- Achieve a gold production of between 160 000oz and 180 000oz
- @ cash operating cost of R685 000/kg
- Expected capital investment of R1.4 billion

ERGO

- Completion of 20MW solar power project
- Plans to mine east of the Ergo Plant

FAR WEST GOLD RECOVERIES

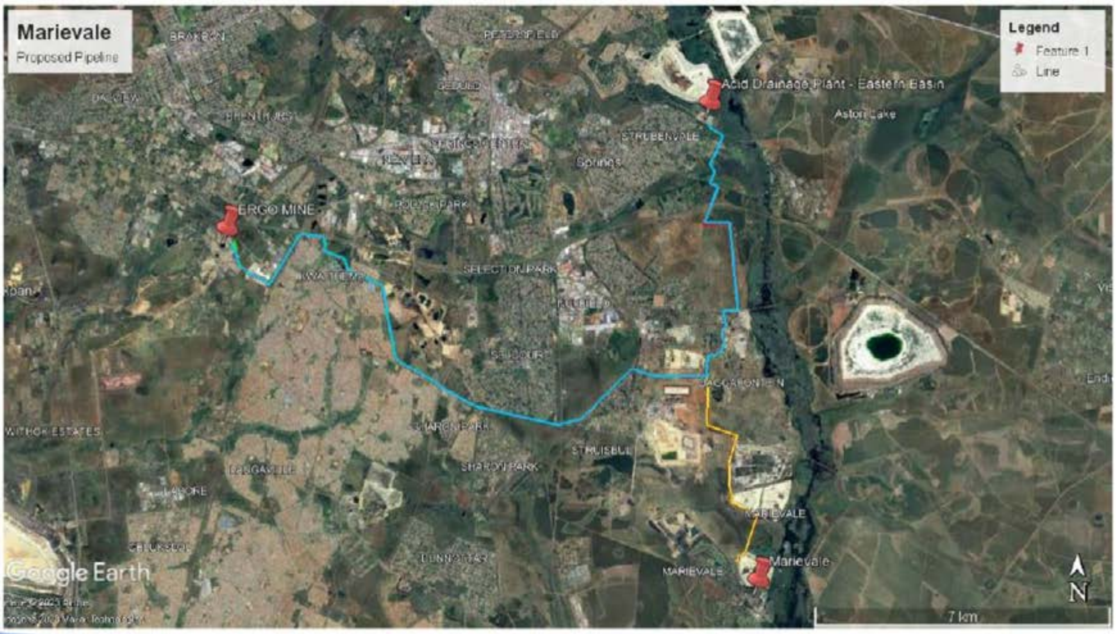
- Commissioning of Driefontein 3 for mining

Post Extractive Legacies – 30th November 2023 41 www.drdgold.com

LOOKING AHEAD

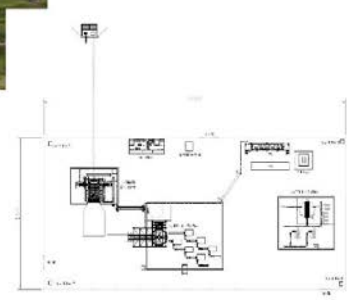
DRDGOLD LIMITED

Proposed Pipeline – Marievale



LOOKING AHEAD

DRDGOLD LIMITED



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CONTACT DETAILS

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Maraisburg
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JSE share code: DRD
ISIN: ZAE 000058723

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Articles

Bad Earth

Hannah le Roux and Gabrielle Hecht

A boy in Orlando West, Soweto shields his eyes from dust from a nearby mine. As South African mines close, they increase pollution from mine dust and acid mine drainage, harming the surrounding majority-black communities that were established near mines to provide cheap labor. Photo by Samantha Reinders, 2011.

A boy in Orlando West, Soweto shields his eyes from dust from a nearby mine. As South African mines close, they increase pollution from mine dust and acid mine drainage, harming the surrounding majority-black communities that were established near mines to provide cheap labor. Photo by Samantha Reinders, 2011.

Accumulation
August 2020

Every year, humans move more earth, and more rock. More than what rivers carry with them as they rush to oceans and lakes. More than what is eroded by wind, or rain, or seasonal frictions. More than what is hurled out as lava by volcanoes. More, in fact, than all planetary forces combined. And faster, too—a few decades of human activity have displaced more materials than the planet could over millennia. This is what it means to say that humans have become a geological force, that the Earth has entered the era of the Anthropocene.

"Humans," of course, is far too broad a descriptor to capture the causes, mechanisms, and effects of all this earthly displacement. The generic category of "human" as an agent of change only makes sense if you're a planet. We all know that some humans—bolstered by the political systems in which they live and the institutions for which they work—are far more powerful than others.[1] The quantity of rock moved by Anglo American in its century-plus of metal mining completely overwhelms that displaced by a migrant scraping the walls of abandoned mine shafts. But the difference is not just a matter of magnitude. More fundamentally, it's about the inequities that enabled and conditioned this massive scalar difference, and that continue to be amplified by it. The apparent incommensurability of these scales must not blind us to their deep interdependence. This is especially evident in the use of mine waste as building material, which involves a triple extraction: of minerals, of waste, and of human health.

The increasing precarity of life on our planet may dispose us to see this use of discarded matter as an unalloyed good. Surely it's better than removing yet more of the planet's matter? Billions of people lack adequate shelter, after all. The need for large-scale, low-cost housing constantly outpaces its construction, as well as the availability of land to build on. The vast growth of mineral extraction since the 1940s has been accompanied by a proliferation of experiments in the re-mining of their waste products. These approaches, in turn, have relied upon—and also generated—a patchwork of modular building materials, framed by modernity's perpetual penchant for scalability, while simultaneously containing its dark consequences. The promises of postcolonial modernity—housing, health, prosperity—tacitly assumed that these materials would be clean, abundant, and neutral: the unremarked and unremarkable means to a greater end, not sources of trouble in and of themselves. Put differently, the assumption was that the materials of postcolonial modernity were "raw": in a state of nature, there for the taking, ready to be molded, unsullied and unaffected by previous use.

Yet many of the materials of modernity were not, in fact, inherently neutral. This was not—is not—merely a political statement. It also reflects material reality: runoff from abandoned mines, produced by the chemical reaction of exposed pyrites with oxygen, acidifies soil and water. As the ruins of mining and other industrial activity continue to spread, unchecked acid mine drainage renders ever-larger plots of land unfarmable, and ultimately unlivable. Bauxite, gold, uranium, asbestos, iron, copper, and especially coal: all generate gigantic footprints and piles of waste. No surprise, then, that these materials seduced builders, engineers, and architects. Using mine waste as a construction resource appears to address two problems at once: what to do with the waste material and land, and how to build low-cost shelter for the many thousands of workers required to run extractive processes.

Transvaal minefields photographed from hot air balloon. Photo by Eduard Spelterini, 1911. Schweizerische Nationalbibliothek, Eidgenössisches Archiv für Denkmalpflege (EAD): Sammlung Eduard Spelterini.

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Archaeologists have found evidence that Spanish settlers in seventeenth and eighteenth century Mexico used tailings from silver mines in building the adobe haciendas that constituted the loci of their colonial power.[2] These buildings bear traces of the mercury used in silver amalgamation, suggesting that their erosion may have released toxins to their inhabitants. Even earlier antecedents surely exist. The reuse of mine waste is nothing new.

What *has* changed, however, is the scale and shape of such reuse, along with the intensity, spread, and characteristics of contamination it can generate. By 1968, when the US Bureau of Mines began sponsoring national symposia on the use of mine waste in construction, researchers and industrialists were exploring the use of waste from iron, copper, and phosphate mining, as well as fly ash (from coal), ferrous and non-ferrous scrap, and more.[3] As one meeting chairman explained, the symposia were built on the premise that pollution and waste offered "opportunities," whose technical and economic feasibility could be explored: "Incentives, rather than hysteria, offer a sound path toward eliminating the pollution problems of air, water, and land."[4] Turning waste into resource certainly seemed like the perfect industry response to the burgeoning environmental movement. Indeed, with this effort originating two years before the creation of the US Environmental Protection Agency, the mining sector appeared positively proactive.

By 1979, RILEM (now the International Union of Laboratories and Experts in Construction Materials, Systems, and Structures) reported on some twenty countries where mineral wastes supplied the formal construction industry. The largest proportion of these materials consisted of metallurgical slags and fly ash. But mine and quarry waste also contributed significantly to road construction, fill, concrete aggregates, and—in a few instances—the manufacture of bricks and plaster. The US dominated RILEM's list, though as symposium reporters noted, this could simply be the result of more information; "in most other countries… [mine] wastes are often produced in remote areas where little attention is paid to them." The authors noted, in passing, that "some of the mine tailings, e.g. those containing heavy metals, uranium, or asbestos may present problems of toxicity and their disposal will accordingly need to be carefully controlled." Nevertheless, in 1979 the authors estimated that the annual production of waste rock from uranium extraction produced some 155 million tons of waste rock in the US, where some of it fed bituminous concrete aggregate. "There have been problems of radioactivity," the authors remarked, in bloodless prose. Overall, however, they concluded that raw mine waste saw less uptake than other mineral discards, primarily because in most countries, mines "tend to occur away from populated areas and the cost of transport makes them uneconomic in comparison with competing materials."[5]

Mounana, Gabon, 1970s. Courtesy of Cogéma.

Construction projects located near mines and their wastes, however, don't face the problem of transportation costs. In such instances, the economy of waste reuse could seem attractive—particularly in postcolonial states seeking a fast track to modernity. This undoubtedly drove decisions about building materials for the mining town of Mounana, Gabon, shortly after its erection in the 1970s. Each house, complete with electricity and running water, sheltered a mineworker and his family according to European nuclear family norms (no polygamists, no extended kin) and lifestyles (no chickens, no goats). In the center of town, residents could shop at the marketplace. Women delivered their babies at the maternity clinic. Children attended school. In the late 1970s, Mounana represented Gabonese "expectations of modernity" via national and corporate projects. In what appeared as a model of efficiency, waste rock from the nearby mines served as the basis for the gravel, cement, and concrete in these structures and in the paved roads that connected it with the town.[6]

This rock, however, was not inactive. It came from the uranium shafts that powered economic activity in postcolonial eastern Gabon. The uranium content in the discarded rock was too low to extract profitably. But it was still there, and it did what uranium always does: it decayed, releasing radioactivity along the way, gradually turning into radon gas. Three decades later, and years after the mine had shut down, local activists and French NGOs found radon levels in these structures well in excess of internationally recommended limits. In the end, the mining town—which continued to lodge people after the company's departure—had found a surefire way to make families nuclear.[7] The materials of modernity had become instruments of slow violence.

This outcome shouldn't have surprised the French-owned Compagnie Minière d'Uranium de Franceville (COMUF). In 1971, revelations broke that one-third of the houses in Grand Junction, Colorado were bursting with radon because they'd been built with tailings from the uranium mills that powered that town's growth. Ninety miles further south, some homes in Uravan had radon levels over 700 times regulatory limits; subsequently abandoned, the town became a superfund site. In 1975, a survey demanded by the Navajo Tribal Council found radioactive buildings strung out from Shiprock to Tuba City. Many of these sites in the Navajo Nation remain unremediated, potent reminders of the everyday violence of the white settler state.

View of street in Manhessim (old Fanti capital) in the Gold Coast (now Ghana), with earth and colonial building. Unknown photographer, 1901. Colonial Office collection, National Archives, UK.

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During the nineteenth century, hard core building—what French colonial officials called "construction *en dur*"—constituted a key element of the "civilizing mission." In the colonial imagination, modernity required stone, or at least stone-based materials such as concrete or fired clay bricks. Buildings that needed seasonal maintenance to maintain their structure were coded as *indigène*, inferior. Europeans built solid homes in the tropics, and they assumed that their colonial subjects held the same aspirations. Throughout the mid twentieth century—including during the times of imperial decline, independence, and postcolonial possibility—the trope of the "solid house" remained a symbol of concrete modernity for many postcolonial societies seeking to build new nations.

Yet the material and economic conditions of postcolonial state-building undermined these ambitions. The ingredients of modern building were themselves exported, or taken up in the infrastructure needed for resource extraction. In making concrete, grand projects extract selected grades of sand and aggregate, quarrying them from the sum total of earthly resources. The remnants—typically degraded soils—serve as both sites and building materials for housing the global poor.

In response, new taxonomies of earthly materials and building elements emerged. Political and chemical forces concretized these taxonomies by bringing them into relation. Wartime scarcities of the 1940s coincided with experiments in sand, earth, or mud blocks, all stabilized by the addition of cement, with hybrid names such as sandcrete, landcrete, and swishcrete. Some technologies emerged from trials in American agricultural research centers, including the Tuskegee Institute, and were tested in Africa at research stations.[8] Cement additives circumvented the need for skilled local builders and their ability to create durable structures by combining earths and organic render mixes with materials such as cow blood, urine, dung, chicken feathers, and plant fibers.[9]

In the flush of early independences, the biggest challenges seemed to revolve around cost and scale: how to build large numbers of solid houses in which the newly franchised poor—particularly in the tropics—could live, and perhaps even thrive. The need for new houses that met acceptable standards, in the UN's 1952 account, was staggering: 25 million homes in Latin America, homes for 100–150 million families in Asia, and enough for "just about" all the people in Africa.[10] Rejecting Third World requests for more money—or anything that might resemble a Marshall Plan for decolonizing territories—UN experts, many of whom had previously worked for colonial governments, instead emphasized the importance of low-cost techniques and individual self-financing.[11] Cement-stabilized earth blocks fell neatly into this austere approach: since as much as 95% of the block volume consisted of nominally free, local, earthly material, capital reserves could be channeled to infrastructural elements such as sanitation, sheet roofing, and cement.

Korean laborers using South African "Landcrete" machines for blockmaking in Pusan, Korea, 1953, for the U.N. Korean Reconstruction Agency. UN News & Media Photo.

But there's no such thing as a free block, and development aid always comes at a price. Consider the Landcrete press, designed in the early 1940s in South Africa by Landsborough Findlay, a company specializing in earth-moving equipment for mines and farming land. The company's international marketing efforts succeeded: in 1953, the United Nations Korean Reconstruction Agency bought one hundred presses to help build a million homes for war refugees.[12] As modular elements, landcrete blocks could be traded ubiquitously, from very basic production yards to housing sites. UN sponsorship of block making machines did much to displace indigenous earth building with a fragmented and interchangeable vision of building, couched in the idea of "self-help" in international "development."[13] And as M. Ijlal Muzaffar documents, the "participating native" was a central figure in this discourse, which unabashedly celebrated "traditional" building techniques and indigenous "ingenuity"—even as it worked to supersede local expertise—all the while claiming to represent "the demands and desires of populations already in transition to modernity."[14] As presses such as the Landcrete (which had many successors and spin-offs) gained traction in international development circles, blocks replaced solid earth in the building envelope.[15] In the same years that Western photographers began training their cameras on the marvels of indigenous earth architectures, "development" agencies and technical experts worked to fracture their integrity.[16]

Cheap blocks complemented the "roof loan" approach, conceived by UN technical advisors on housing. Working in the Gold Coast, the American housing advocate Charles Abrams, along with Vladimir Bodiansky and Otto Koenigsberger imagined that community savings groups would share loans to buy industrially produced materials to roof the houses with already completed walls, which they had built with cheap or personal labor from locally made earth blocks. Rather than evolving together, then, roofs and blocks were recombined in the "self-help" house as elements with diverse procurement paths. Block fabrication could now take place before or beyond the oversight of technical experts, while the roof materials were locked in place through debt.

Left: extract from report on the Ghana Roof Loan Scheme, presented by Otto Koenigsberger in Addis Ababa, 1969. RIght: molding with a hand press, by Nancy Bergau. From Peter Gallant, *Self-Help Construction of 1-Story Buildings* 6 (Washington, D.C.: Peace Corps, 1977). Courtesy of the Peace Corps.

In this plan, good roofs allowed for bad walls. Protected by the overhang of a relatively durable roof, supported by a sanitary core and pillars, stabilized earth blocks did not have to meet any standards of longevity, size, material, or even delivery timelines. By the 1960s, the roof loan scheme—originally designed to conclude the self-housing process—became instead its starting point. This inversion allowed experts to abandon recipients, leaving them to finish their homes entirely by themselves, while repaying the roof loan to their community savings group.[17]

Roof loans also opened the market for both asbestos cement and corrugated aluminum roofs, along with corrugated iron.[18] Their specification related to the availability of raw materials, all of which generated potentially toxic residues and landscapes. In Ghana, for instance, the Volta Aluminium Company began construction on an aluminum smelter in 1964, with the view to make construction products from its bauxite ore mines.[19] In South Africa—with its rich reserves of asbestos, iron ore, and strip-mined coal—asbestos-cement roofs and corrugated iron split the market. In both countries, such beneficiation of raw materials made some economic sense. But for countries without minerals, importing any of these materials represented a burden.

In this assemblage of debt, roof, and unfinished walls, waste served as a basic material for cheap, locally made blocks. Discarded material could substitute for good earth, ideally leaving it as soil for farming. Co-locating housing with borrow pits and other “drosscapes” made discards readily available as construction material.[20] In countries with mineral resources, low cost housing near mines and mills would use materials created as by-products in industrial processes, including red mud from bauxite tailings from alumina extraction, as well as tailings from zinc, copper, gold, asbestos, uranium, and iron mines.[21] Portland cement, the ubiquitous stabilizing material, itself was mixed with wastes, including lime sludges, slags, and fly ash.

The consequences of this regulatory arbitrage around mining wastes in building materials are rarely documented. One exceptional study, however, assessed the risk of exposure to dangerous fibers around former asbestos mining sites in South Africa, and then trained villagers to collect samples from houses and schools built from local blocks. Their focus was on those structures that might contain materials gleaned from nearby tailings in the blocks, floors, and plaster.[22] Of thirty-one sites surveyed in the village of Sedibeng, near the mining center of Kuruman, 88% of blocks, 94% of houses, and the only school contained asbestos containing building materials (ACBM), some in friable blocks that could release fibers into their surroundings.[23] In impoverished communities where many elders had contracted fatal mesotheliomas working in now abandoned mines and closed mills, this risk lingers for another generation.[24] Another brick in the crumbling wall of wasted modernity.

Asbestos waste in locally made blocks used for a house in Sedibeng village, near Kuruman, South Africa. Photo by Asbestos Interest Group community monitors, 2019.

***

In 2019, we travelled the length of the Main Reef Road, which stretches both east and westwards from Johannesburg. Built to serve the industrial gold mines that spawned the city, the road spans much of South Africa's Witwatersrand plateau, known by the same moniker as its currency: the Rand. We wanted to sample the range of blocks—along with their constituent materials—that people can buy to build or expand their homes. How, we wondered, do current residents of the Rand create homes in toxic wastelands, especially in the absence of adequate state housing and land remediation programs?

Launched in 1886, the Rand's mines rapidly became the deepest in the world. Removing "overburden" to reach gold seams, miners extracted billions of tons of rock, formed into gigantic tailing piles and vast slime dams that comprehensively transformed the region's topography in just a few decades.[25] By 1911, fifty-two mines formed a nearly 100-kilometer band from Randfontein to Nigel. As their tailings dumps continued to grow, they also became more dangerous. The cyanide leaching of ore to recover gold required milling the ore more finely, which produced smaller dust particles that were even more mobile and inhalable.[26] The leaching itself produced vast quantities of sludge that was dumped into the seasonal waterpans of the lowest-lying areas, whence it leaked into streams and groundwater.

Today, some 1.6 million people live on or very near toxic mine dumps, mostly in former black townships and informal settlements, often in precarious conditions.[27] Heavy metals—in no short supply thanks to the dumps and their dust—dissolve readily in the highly acidic water that decants from mine shafts, transporting toxicants such as mercury, arsenic, and lead into groundwater, streams, and farmland. Uranium-laced dust whips into homes and settles on the vegetable patches that residents rely on for sustenance.[28] Over the course of recent decades, mining companies (ever-morphing into new ownership structures) have moved this patchwork of tailings, reprocessing them for gold and/or uranium before reassembling remaining waste into three superdumps. Water and surface damage form the residual footprints of removed dumps.

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Reinstating water, resurrecting the Witwatersrand

Tahira Natasha Toffah

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To link to this article: https://doi.org/10.1080/18626033.2013.864088

Published online: 29 Nov 2013.

Reinstating water, resurrecting the Witwatersrand [1]

Tahira Natasha Toffah University of the Witwatersrand, South Africa

The Witwatersrand mining belt of South Africa, bisecting Johannesburg, the country's economic capital, played a central role in the formation of the region. When most mining operations in the region ceased in the 1970s, its role shifted from a productive space to one of environmental crisis. Through an exploration of various solutions, and the crucial role of water systems within these processes, the paper proposes an alternative vision for the mining belt that recognizes its potential to once again be a 'productive' space. A critique of current attitudes among authorities and major land developers toward the mining belt, their ability to deal with the acid mine water crisis and the redevelopment of mining land is offered. More broadly, the paper explores the potential contribution of landscape urbanism's ecological perspectives toward the rapid urbanization in cities of the so-called 'Global South', its engagement with territorial scale, and its potential for integrative thinking across disciplines.

Acid mine water / landscape urbanism / remediation / water urbanism / Witwatersrand gold mines

The majority of South Africa's gold mines are concentrated in the Witwatersrand region [2], especially around the conurbation known as Johannesburg, forming a mining belt 100 km long. This belt played a central role in the socio-economic and spatial formation of the region. However, this role changed when most mining operations in the region ceased in the 1970s [3] and transformed the mining belt from the city's industrial engine to an almost sterile wasteland.

Spatially, the mining belt is an iconic physical barrier between a mostly white and affluent north and a more impoverished, predominantly black south [4]. Since the dismantling of apartheid, the mining belt has posed both possibilities and problems. The post-apartheid period brought the mining belt to the fore as a space that offers significant potential to reunite the two still unequal parts of the region. At the same time, there is an acceleration of laissez-faire redevelopment of land previously used for mining purposes. The significance of the mining belt was accelerated in the last decade by the severely polluted state of surface and water systems, which has both local and broader regional consequences [5].

'Landscape', 'city', and mining

Johannesburg is one of the few large cities in the world not built adjacent to a significant water body, a fact frequently referred to in popular histories. Yet the name given to the region, the Witwatersrand, a word in Afrikaans that means 'the ridge of white waters', speaks of a much forgotten aspect of the land's past, referring to its natural springs as they once appeared to glisten in the sun along the range of rocky hills that runs through the region. This idea of the land strikes a counterpart to another

GOOGLE EARTH 2012, GAUTENG DEPARTMENT OF AGRICULTURE AND RURAL DEVELOPMENT 2012

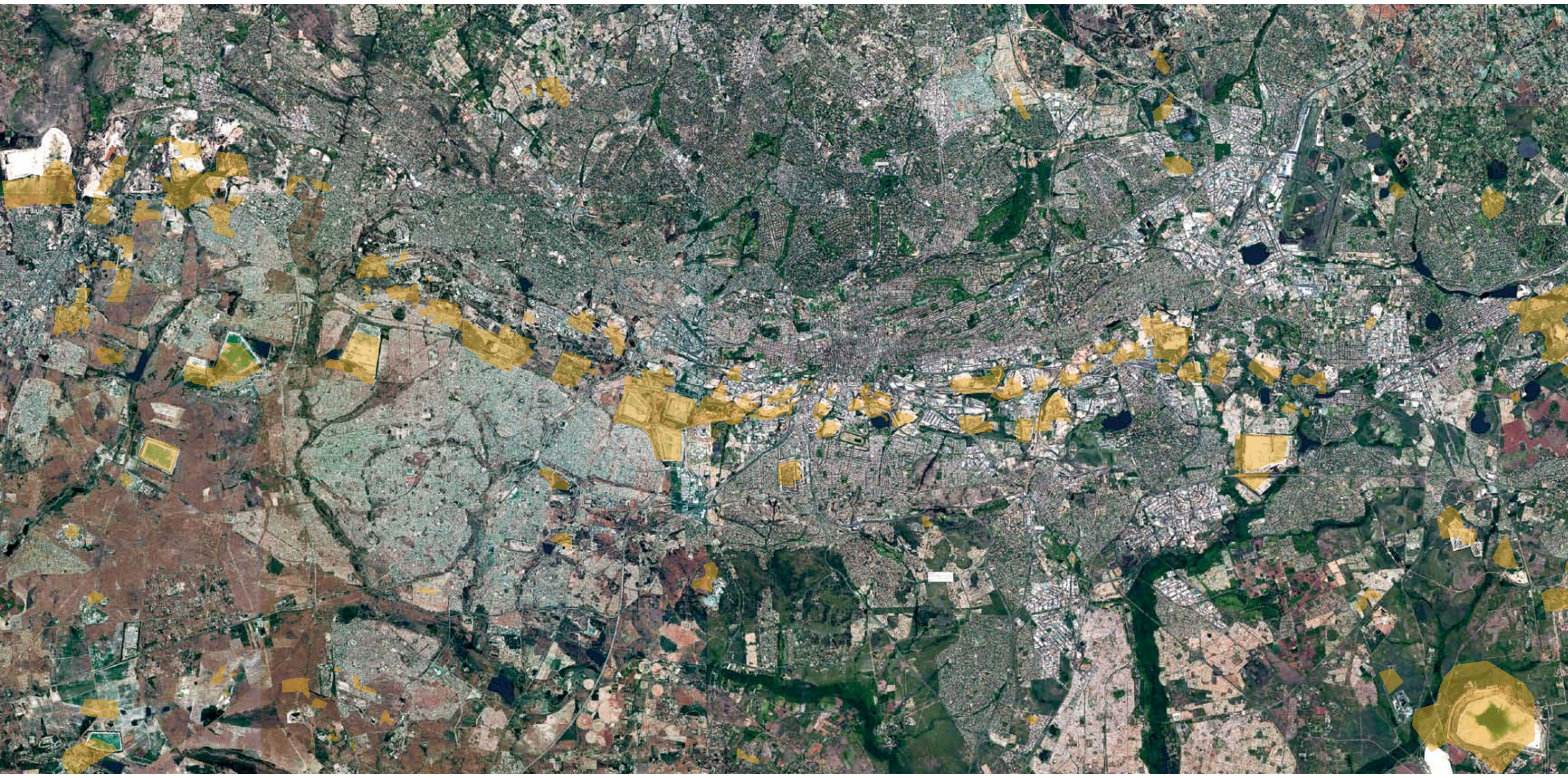

Figure 1 The majority of South Africa's gold mines are concentrated in the Witwatersrand region, especially around the conurbation known as Johannesburg, forming a mining belt 100km in length. Highlighted in yellow are Mine Residue Areas, which make up an area of approximately 400 km².

South African idea of the land, that of the 'veld'. Like the 'rand', the veld was also originally derived from a Dutch word meaning field, country, or countryside (*Beningfield 2006: 17*). [6] Thus, the Witwatersrand–a place of ridges and water springs–could be understood in contradistinction to the broad expanses of open veld landscapes of grasses, trees, and shrubs; similarly, 'Johannesburg' evokes the urbanized 'citiness' of the region, while 'Witwatersrand' recalls and highlights its much forgotten and much neglected topographical and ecological underpinnings.

The natural water systems of the Witwatersrand are comprised of small rivers and streams, emanating from springs fed by large quantities of groundwater located in the dolomitic rocks underlying the region. Mining and the making of 'city' in the urbanization of the territory have for over a century severely altered the water systems: dams were built to supplement the early mining operations, source springs have dried up due to extensive subsurface pumping operations, and many rivers and streams have been canalized. In conjunction with severe pollution, the most detrimental manipulation of these integral systems was the extensive and subsurface pumping of water to sustain the mining industry.

The extensive mining operations in the Witwatersrand have carved out a huge underground void, connected by a network of tunnels and shafts, thus allowing water to migrate from one mine to another. Water from surrounding groundwater sources filters continuously into this underground void and when mining in the region was more active, the water was constantly pumped out to prevent flooding. However, as mining operations in the Witwatersrand basins declined, so did the extensive pumping operations, resulting in the gradual filling of the void with acid mine drainage (AMD) water [7]. Once a hydraulically independent void or basin fills completely, decant or overflow of this polluted water commences. The Western Basin, the smallest basin, already filled and began to decant in 2002. Hence authorities have a short-term solution in place to pump from a central point in each basin and partially treat the polluted water (*Durand 2012; McCarthy 2010*). [8]

The mine dumps and tailings dams scattered across the mining belt are one the biggest sources of pollution in the region and also contribute significantly to the AMD situation. Experts estimate that one third of the pollution in the AMD water rising in the Witwatersrand void is a result of the surface pollution from mine residue areas (MRAs). Therefore if these footprints are cleaned, the polluted state of the water that flows out of the mine void would be significantly reduced, decreasing the costs for treating the mine water and simultaneously improving living conditions for the estimated 1.6 million people that live adjacent to MRAs. Many communities are affected by the water and dust pollution from MRAs and because of the undesirable nature of the mining belt, it tends to be poorer and more marginalized communities who live in close proximity to and within the mining belt. In some instances, informal dwellings have been built directly onto inactive slimes dams, exposing inhabitants to an array of potential health risks including radon exhalation, radiation, dust inhalation, and other tailings-related hazards Furthermore, people living in the rural areas adjacent to the mines and downstream of the mines, without access to municipal services, use groundwater for drinking purposes, to water their cattle, and to irrigate their crops (*Winde & Stoch, 2010*).

Figure 2 The Top Star tailings dump was an icon of Johannesburg up until 2006 when it was shut down by a tailings reclamation company to extract latent gold from its belly.

Waterscapes, landscape, and city: between 'north' and 'south'

While scholarly attention within the spatial disciplines in post-apartheid South Africa has understandably concentrated more on the deliberate manipulation of the built environment and organization of urban space as coercive instruments for social control (*Jackson 2005: 39*), as well as its concomitant socio-economic realities, the destruction and distortion of the natural landscape has been largely absent in the discourse. The mining belt of the Witwatersrand, as a regional element, and in its key role in structuring the broader urban landscape, demands a redress and rebalancing within the discourse. Thus the proposed vision and strategies draw from the discourse of landscape urbanism, particularly with regard to its engagement of the territorial scale, the remediation of post-industrial sites with ecological function, and its potential for integrative thinking across professional boundaries.

Both the sheer volume of rising water and the extensive surface transformation of the mining belt are opening up a critical space to imagine a new future for the region. A vision for the territory shaped by its most pressing forces as well as for its most compelling opportunities is proposed. Through an analysis of mining-related problems of immediate environmental necessity, which the city and other role players have largely sought to address via engineering solutions of a short-term nature, together with an exploration of more sustainable environmental solutions crucially related to a revitalized role for the region's polluted natural water systems, the study proposes a regional-scale landscape figure that utilizes water as a key structuring element and simultaneously offers to generate a response to both environmental and urban conditions. Despite the scale of the problems being addressed–regional, environmental, social, and economic–the proposal is one that nonetheless attempts to provide a feasibility and workability due to the flexibility and capacity for implementation in episodic interventions (especially at critical emergency sites) and phased interventions (at other sites). The following three primary approaches/proposals are suggested:

The city-nature landscape

Johannesburg-Witwatersrand emerged, as with many regions, with two primary spatial aspects: the 'figure/urban' versus the 'counter-figure/landscape'. However, since the region's counter-figure/landscape consisted of heavily polluting processes of resource extraction, its ecological state is compromised. The cessation of mining has left a degraded, poisoned, and largely abandoned wasteland rather than a cohesive counter-figure/landscape.

The vision for the region proposed here confronts the probable reality that if current patterns continue the mining land will ultimately be consumed by real estate developers and authorities, or at least be distorted beyond recognition. It is suggested that nature be coherently (re)constructed alongside urban development and that, through this interaction, relations in the region can be 're-edited'. This vision measures, maintains, and constructs the mining belt as an open space or 'counter-figure' in the urban region. However, it should not be understood as a type of open-space green belt but, rather, as a hybrid landscape that mediates relations between segmented areas (social, economic, as well as spatial) in the region, while creating new urban-natural areas that would provide the ground for new urbanization strategies.

Natural-engineered landscape structures

The hybrid nature and conditions of sites such as the mining belt necessitate an approach that is able to accommodate and synthesize multiple perspectives and considerations. A soft engineering solution is proposed to address the rising AMD water crisis and work with, rather than against, the forces of nature. In a region where water is a scarce resource the rising water is seen as an opportunity. Instead of further suppressing its natural course, the water could be allowed to rise up and decant, and then be directed to a new canal system, follow the existing railway line–a 'horizontal landscraper'–be cleaned and then distributed into the north-south flowing rivers.

HUGH FRASER 2011

Figure 3 Contaminated water flowing from a pipe at the base of a tailings dam in the Witwatersrand

Figure 4 Experts estimate that one third of the pollution in the water rising in the Witwatersrand void is a result of the surface pollution from mine residue areas.

YAD TABENKIN ARCHIVE, RAMAT GAN

Figure 5 Tudor Shaft is an informal settlement located within a mine residue area.

Figure 6 A vision for the AMD water purification—a hybrid canal that follows the line of the railway

Figure 7 A soft engineered solution

In this natural-engineered landscape scheme, new and existing man-made systems and natural systems cooperate in addressing critical and other environmental problems. These combined landscape structures would become the basis for a new regional and urban form (*De Meulder & Shannon 2010*). Here the patterns of landscape urbanism clearly provide fertile ground for the possibilities of such issues, with an emphasis on 'process' rather than the resolution of 'plan', a subsequent foregrounding of infrastructure as landscape structure, and the interest in the positive use of waste materials.

Productive spaces

In the third strategy the mining belt is approached as a 'productive' space of two different orders: constructing nature and redefining the urban. In the first, the mining belt is envisioned as a mosaic of landscapes, some of which require no remediation and are either cultivated or preserved, and others that require remediation to mitigate the pollution both on the surface and in the water. Phytoremediation would facilitate the making of a landscape that not only cleans heavily polluted soils, but also contributes to the landscape's productive nature.

Locating such 'scientific' discourses of land, namely in terms of its purely spatial and environmental coordinates, within that of another–the post-colonial, post-apartheid, and that of the Global South generally–and joining the ecological coordinates of landscape with the social conditions of city, remediation is imagined and developed together with socio-economic opportunity. Thus, the strategy proposes a space that reconstructs, reinstates, and recontextualizes the historically productive nature of the mining belt, where 'production' is understood as both a social and an ecological function. In the South African context of high poverty and unemployment, this provides a potential model for alternative economic opportunities to the retail-dominated informal sector (the 'second economy').

Conclusion

The critical environmental situation around the issue of the Witwatersrand's toxic mining water is one of the most pressing and immediate forces shaping the direction of this study's vision and proposals. The challenge has been to re-imagine this issue beyond the largely utilitarian approach in current practice, which addresses it as a problem of engineering and an opportunity for a new form of private profit-taking, rather than as a public environmental crisis that could be managed creatively, along with possibilities of broader social benefit.

The vision and strategies proposed regard the moment as a crucial opportunity. With the three approaches proposed in the paper taken together ('counter-figure', 'structure', and 'production'), the formidable and challenging scale and complexity of the mining belt begins to be engaged, shaped, and synthesized through a 'landscape' or 'water' urbanism (*Shannon et al. 2008*) that generates a water-structured counter-figure territory; this in turn is also generative of life in its social dimensions, wherein the mining belt is envisaged as a self-sustaining and productive system. The approach addresses multiple concerns and introduces many new possibilities: for interaction between the built vs. 'natural' landscape, and in the natural systems that interlace them; in offering more coherency and regional form to the agglomerations of laissez-faire urbanization; in exploring responses to environmental urgency and alternative economic development opportunity and for general social well-being.

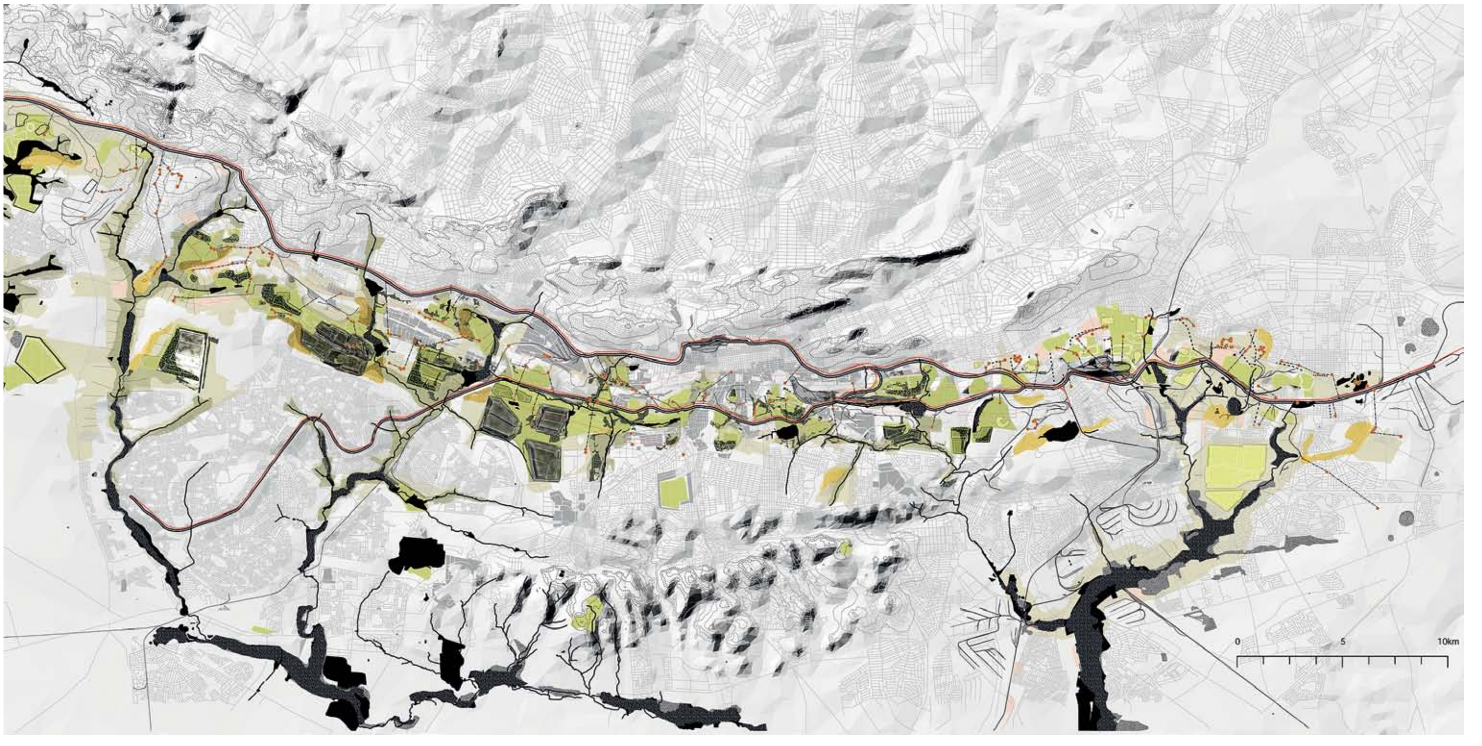

Figure 8 The mining belt envisioned as a regional open space and hybrid water system

More broadly, in drawing from and engaging the discourse of landscape urbanism, the paper also attempts to contribute to the debate of the potential roles of such forms of urbanisms, from the perspective of what has come to be termed as the Global South (that is, an area of research and practice that addresses cities of unprecedented urban growth, the resulting urbanization of poverty, and the increasing inequalities in the distribution of resources). The ways in which landscape urbanism, particularly in its recent transformation to 'ecological urbanism' (*Mostafavi & Doherty 2010*), does not adequately engage the social and economic structure of the city has been one of the most important critiques of the discourse [9]. The problems and tensions between the primacy of Johannesburg as a 'city' of agglomerating urbanization vs. the neglect of the Witwatersrand as a landscape of natural systems, thus echoes a kind of inverse critique of landscape urbanism. In this regard, perhaps paradoxically, landscape and water urbanisms are particularly relevant in rapidly urbanizing contexts such as Johannesburg, precisely because of the latter's neglect of its topographical and ecological underpinnings within these processes. The discussion concerns the encounters of the 'landscapes of the North' (that is, the contexts in which the landscape urbanism discourse emerged) with the 'cities of the Global South', and begins to mould a definition of landscape urbanisms in the contexts of the Global South. In this complex and imaginative task, many questions are still left unanswered or insufficiently developed. In this regard the trajectory of this paper should be considered not as a resolution of such complexity, but more as the beginnings of an overdue–indeed urgent–dialogue that opens up and engages multiple aspects of the mining landscape to which future research and design approaches may contribute.

Acknowledgements

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NOTES

1 This paper is based on a Master's thesis, completed under the guidance of Prof. Bruno De Meulder and submitted in partial fulfilment of the Master's degree in Urbanism and Strategic Planning, Katholieke Universiteit Leuven, Department of Architecture, Urbanism and Planning, August 2012.

2 In this study the conurbation of Johannesburg and its mining belt are collectively known under the territorial term Witwatersrand, a 350 km arcuate basin comprising seven major discrete gold fields.

3 The Witwatersrand Basin still holds an estimated 45% of the world's known gold resources, but the costs and difficulties of increasingly deep-level mining, coupled with increasing labour costs, have prevented the expansion of the industry to its former glory (*Viljoen 2009*).

4 In this paper, as in any South African history research, racial and ethnic terms are unavoidable. In this study they have been used as far as possible as they may be self-identifying terms, such as 'black' or 'white'.

5 The Witwatersrand is a continental watershed; rivers and streams that flow down its northern slopes into the Crocodile River ultimately flow to the Indian Ocean on the east of southern Africa.

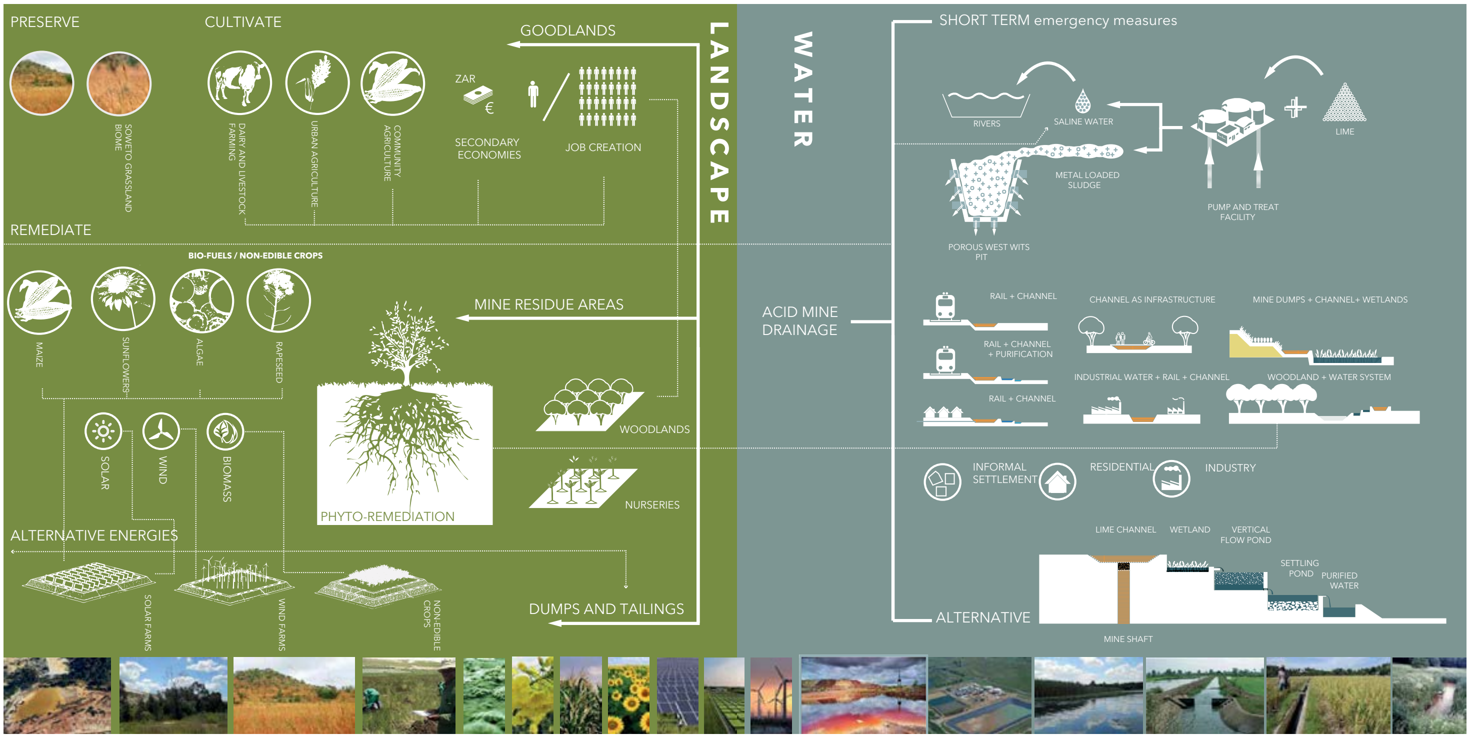

Figure 9 Productive space and water system matrix

6 In the South African context, however, it would technically be used in botany to refer to different types of southern African vegetation, but more popularly in contemporary usage it would come to refer to a kind of landscape, to vast terrains made up of broad botanical veld types such as Karoo, fynbos, lowveld, highveld, and bushveld.

7 Acid mine drainage (AMD) refers to the outflow of highly toxic and acidic water usually from abandoned mines. AMD occurs primarily when water in mines comes into contact with oxygen and the mineral iron pyrite ('fool's gold') to create sulphuric acid (McCarthy 2010).

8 The water is neutralized by adding huge quantities of lime to increase the pH of the water, causing hidden metals to dissolve and separate from the water into a toxic sludge, which is disposed of in a disused mining pit. The water that is discharged into local water systems is very high in sulphates and has detrimental impacts on the surrounding ecosystems. This venture capital /engineering solution is highly contested by scientists and NGOs.

9 For example, see the critique of Thompson 2012.

REFERENCES

Armstrong, P., Lekezwa, B. and Siebrits, K. (2009), 'Poverty Remains the Priority for SA'. [online text] www.ngopulse.org/article/poverty-remains-priority-sa, accessed 29 June 2013.

Beningfield, J. (2006), *The Frightened Land* (London: Routledge).

De Meulder, B., Shannon, K. (2010), 'Orchestration of Nature in Urbanism', in S. Witzgall, F. Matzner, I. Meder I. (eds.), *(re)Designed Nature* (Ostfildern: Hatje Cantz), 20–37.

Gauteng Provincial Government (2012), 'Gauteng Intensifies Calls for Review of Division of Revenue' [website], www.info.gov.za/speech/DynamicAction?pageid=461&sid=32208&tid=90260, accessed 29 June 2013.

Jackson, S. M. (2005), 'Cape Colonial Architecture, Town Planning, and the Crafting of Modern Space in South Africa', *Africa Today* 51 (Summer): 33–54. www.jstor.org/stable/4187686, accessed 26 June 2013.

Kyrou, E. et al. (2010), 'Assessing and Exploring the State of Knowledge: Its Production, Use, and Dissemination in Cities of the South', in Brunfaut, V. et al. (eds.), *Urban Knowledge & the Cities in the South. Proceedings of the XIth N-Aerus Conference, Brussels, 28–30 October 2010* (Brussels/Leuven: LaCambreHorta/ULB/ASRO/KU Leuven.), vii–xi.

McCarthy, T. (2010), *The decanting of acid mine water in the Gauteng city-region: Analysis, prognosis and solution* (Johannesburg: University of the Witwatersrand, School of Geosciences, Provocations Series).

Mostafavi, M., Doherty, G. (2010), *Ecological Urbanism* (Zurich: Lars Muller Publishers).

Shannon, K., De Meulder, B., D' Auria, V., Gosseye, J. (eds.) (2008), *Water Urbanisms* (Amsterdam: Sun).

Thompson, I. H. (2012), 'Ten Tenets and Six Questions for Landscape Urbanism', *Landscape Research* 37/1: 7–26.

Vijoen, M. (2009), 'The Life, Death and Revival of the Central Rand Goldfield', in *World Gold Conference, Gauteng, 26–30 October 2009* (Johannesburg: The Southern African Institute of Mining and Metallurgy).

Winde, F., Stoch, E. (2010), 'Threats and opportunities for post-closure development in dolomitic gold mining areas of the West Rand and Far West Rand (South Africa)—a hydraulic view, Part 1: Mining legacy and future threats', *Water SA* (36) 1: 69–74.

BIOGRAPHICAL NOTES

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The legacy and prospects of the Gauteng City-Region's mining landscapes

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Abstract

Mine Residue Areas (MRAs) describe general mine waste associated mainly with gold-mining. In a recent study compiled by the Gauteng Department of Agricultural and Rural Development (GDARD), 374 Mine Residue Areas were identified in the Gauteng City-Region (GCR) of South Africa (SA). Of these, only 25km^2 of the total 321km^2 covered by MRAs can be rehabilitated at a low cost. Insufficient mine closure plans have created a mining landscape legacy that is scattered across the GCR, serving as a constant reminder of how concepts of sustainability were not part of past mining responsibilities and still appear to slip through the cracks of SA's environmental and mining legislation. MRAs affect air and water quality, present geo-technical safety concerns for communities and create physical barriers to the movement of people, presenting challenges for spatial redevelopment and integration programmes. It is predicted that these challenges will only be exacerbated as a result of climate change, which predicts increased variability in weather extremes. This paper provides an overview government mining policy around MRAs and the environment and evaluates how these policies align with strategies to mitigate and adapt to climate change to create a more sustainable region. This paper identifies potential risks of exposing MRAs to changing climatic variables, informing the management of MRAs within the GCR. These findings will assist with clarifying appropriate mitigation and adaption strategies to ensure infrastructure and communities, infrastructure and the environment are not further affected.
Keywords: mine residue areas, mining, Gauteng City-Region, sustainability, climate change, settlement vulnerability.

1 Introduction

Like Australia, India and Canada, South Africa (SA) has become burdened with a legacy of unplanned mine closures, hazardous mine sites and ownerless and derelict mining lands (Smith [1]). This has largely been a result of insufficient and inadequately applied legislation that has allowed mines to cease activity without implementing appropriate mine closure plans.

SA's early gold mining economy was purely an extraction industry with very little consideration of the long term (Adler *et al.* [2]). Prior to 1991, mining companies used irresponsible mining methods with little consideration of their impact on the environment. Social and environmental costs were deflected by mines in order to keep profits high, diverting adverse socio-economic and environmental effects onto third parties (Adler *et al.* [2]). Unprofitable mines were left un-rehabilitated before liquidation, in some cases with mine owners simply abandoning their responsibilities and leaving the country (Swart [3]). The many ownerless and derelict mines in SA are a consequence of government not enforcing their regulatory role, allowing the mines to self-regulate (Adler *et al.* [2]). A current estimate of cleaning up SA's some 6000 ownerless and derelict mines, including mine dumps (DMR [4]), is R30 billion (WWF [5]).

This paper focuses on the Gauteng City-Region (GCR), where a cluster of cities, towns and urban nodes – including the primary cities of Johannesburg and Pretoria – together make up the economic heartland of SA. At the core of the city-region is Gauteng, which is the most densely populated province of SA supporting an estimated 12,272,263 individuals.

Gauteng's total land surface area is estimated to be 18,178.30km^2. Some 130 years of mining in this region has led to 374 mine residue areas (MRAs) with a total surface area of 321km^2 (GDARD [6]). This accounts for 1.8% of Gauteng's land surface area. Mine waste in the form of MRAs include tailings disposal facilities (either hydraulically or mechanically placed), waste rock dumps, open cast excavations, quarries, water storage facilities, return water dams, footprints left after the re-mining of tailings disposal facilities and a mixture of other building material, mine waste and industrial waste within the boundaries of current or former mines (GDARD [6]).

The region's MRAs stretch across the mid-section of Gauteng, dividing the urban core into two parts located to the north and south of the mining belt (fig. 1). Unlike other mining contexts in other parts of SA and abroad, where mining activities have been at the periphery of cities and towns, the urban areas of Gauteng have developed around the mines. This has put communities at a greater risk to the impacts of active mines and mine waste. The local municipalities of Merafong City, Westonaria, Randfontein, Johannesburg and Ekurhuleni are most affected by MRAs (fig. 1).

Most of the MRAs in Gauteng are associated with gold mining and are radioactive as a result of the high proportion of uranium contained within the mined ores (GDARD [6]). This is because uranium was not extracted as a by-product of gold mining prior to the 1950s (GDARD [6]). Because of both radioactive and non-radioactive elements, MRAs pollute and affect air quality, water quality, contribute to acid mine drainage and present geotechnical safety concerns.

Mine residue areas not only pose a series of environmental and social risks in Gauteng, but also create barriers to the movement of individuals. This creates challenges for post-apartheid spatial redevelopment and integration programmes.

In order to mitigate and adapt to climate change to create a more sustainable region for the future, it is important to qualify the historical and current mining contexts in the GCR. This includes understanding and addressing the mining landscape legacy inherited by the region and to reconcile present obstacles in applying SA's mining legislation. In order to investigate these dynamics, this paper aims: 1) To provide a brief overview of current mining policy around MRAs and the environment; 2) To identify the potential risks of exposing MRAs to changing climatic variables; 3) To assist with the development of appropriate mitigation and adaptation strategies to ensure communities, infrastructure and the environment are not further affected.

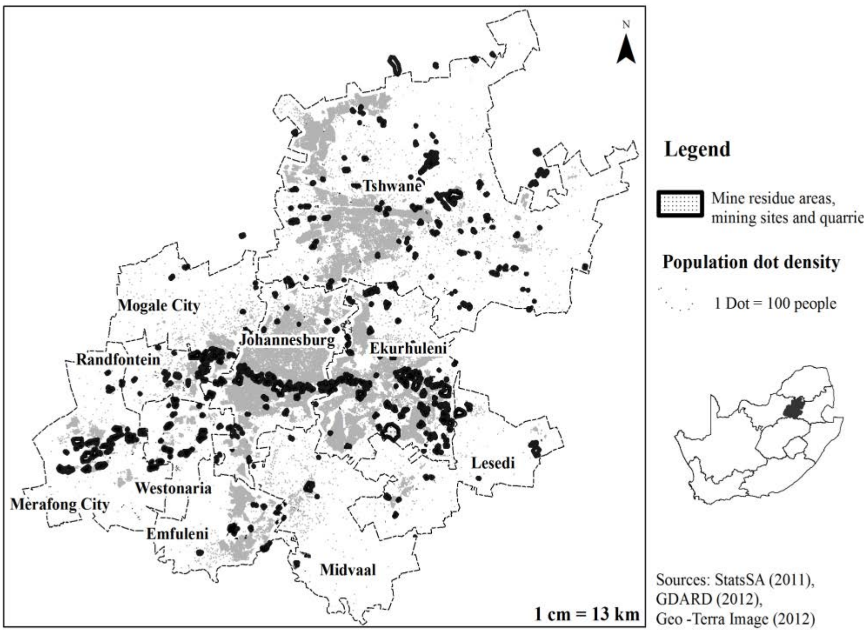

Figure 1: Mines and MRAs have developed along the gold bearing reef that runs along the mid-section of Gauteng.

2 Varied settlement vulnerability in the GCR

Historical strategies to control the distribution of the SA population along racial lines have created a highly distorted settlement geography in the Gauteng City-Region (Bremner [7]). The result is a spatially fragmented and dis-continuous city where natural or open land has been used to segregate the population according to land use zoning, income groups and race (Bremner [7]). Historically, MRAs were used as a buffer to divide race groups in Gauteng. In places like Soweto, individuals were purposely placed beyond the mining belt to separate the white northern parts of Johannesburg from the predominately black south. The spatial separations inherited from apartheid have not been systematically addressed in the democratic era (Bremner [7]), and mines and mine waste still dissect the province, acting as dividing lines for an unequal society divided in space.

Most common household income per small area layer (SAL) in GP, which has been derived by merging the enumerator area boundaries, can be used an indicator of financial vulnerability and the ability of households to financially mitigate and/or adapt to climate change. At present, areas of high and low annual household incomes typically fall above and below the gold reef in Johannesburg (fig. 2(a)). More specifically, maps (fig. 2(b)–(d)) indicate where mines and mine waste present challenges for spatial redevelopment and integration programmes. Mines and mine waste created along the reef preceded the development of road networks, and has created barriers to the flow of traffic (fig. 2(b)). Mines on the East Rand have created a fragmented settlement and road network across the areas that are in close proximity to the mines (fig. 2(b)). Mines, quarries and MRAs in the south of Gauteng are fragmented across different SALs and present challenges for spatial development programmes (fig. 2(c)). To the north of Gauteng, mines are located in peripheral areas where SALs are shown to have a lower common income per household versus more urban locations (fig. 2(d)).

It is for these reasons that the location of MRAs still serve as a constant reminder of SA's history of placing individuals on land that was not suitable for human occupation or development. Further, the current expansion of low income housing and the growth of informal settlements in the GCR still follow similar developmental patterns prescribed under the apartheid regime, situating individuals on dangerous ground or in areas that cannot support large influxes of people. New social housing projects continue to be developed on land adjacent to mine dumps, despite the effects on human and environmental health. This has exacerbated spatial inequalities where settlement vulnerability can be related to the poor location of settlements together with low annual incomes per household. Low annual incomes per household marks settlements more susceptible to environmental hazards and the risks associated with climate change (fig. 2(a)–(d)). This is a result of the reduced ability of households to financially mitigate and adapt to hazards over the long term, forcing them to rely on state or organisation funded interventions.

The patchwork of variable settlement vulnerability presents a key challenge for SA in light of predicted climate change in the region. Often these settlements are not only located around current or past mining activities; they are also located in low lying areas subject to flooding and on dolomitic land, which means these communities are 'doubly' or 'triply' burdened by risks and vulnerabilities.

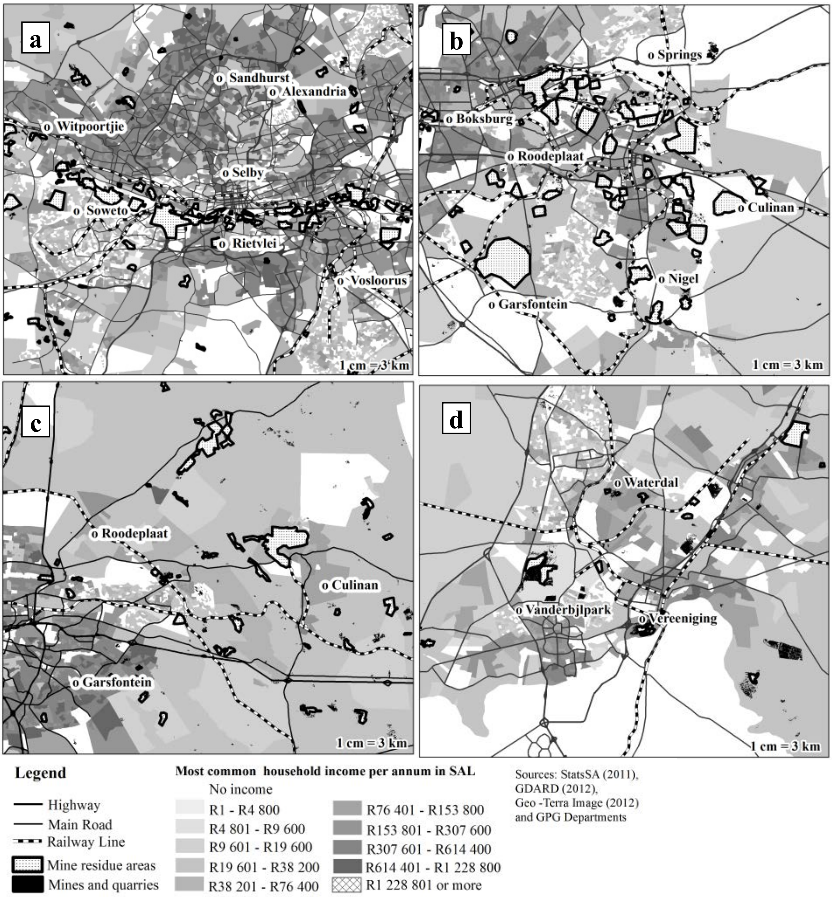

Figure 2: Mines, quarries and mining waste create obstacles for spatial redevelopment programmes and transport routes. (a) The gold reef dissects Johannesburg into north and south portions and pre-dates the development of roads. (b) Mines on the East Rand have created a fragmented settlement and road network. (c) Mines, quarries and MRAs present challenges for spatial development programmes. (d) Mines located in peripheral areas have a lower common income per household versus more urban locations.

3 Predicted changes

According to current Global Circulation Models (GCMs), it is predicted that variations in temperature and rainfall will become more extreme across the year with high intra- and inter-seasonal variability (DST [8]). Under this scenario, the existing 374 MRAs in the GCR presents a key challenge of increased risk to society and the environment. Predicted weather extremes can create heightened risks and increased settlement vulnerability as a result of its diverse impact on MRAs. On the one hand increased rainfall can contribute to the siltation and flooding of pits and dams (Loechel [9]), creating knock-on pollution impacts for downstream water users (DEA [10]). In the context of acid mine drainage (AMD), already a pressing challenge facing the region, increased rainfall will lead to increased pumping and treatment requirements as a result of greater water ingress into the mine voids. On the other hand a decrease in rainfall and increase in temperature can lead to droughts (EWT [11]), contributing to the increased transport of air-borne pollutants especially radioactive dust, a key concern in relation to MRAs.

4 Responsibility and governance of the mines

Given this historical context, and a future likely to be shaped by climate change, the governance of mines and mine residue areas in the GCR is extremely challenging, and becoming ever more so.

At present, all spheres of government are responsible for the administration of legislation and regulations around MRAs in the GCR. This includes over 13 national and 9 provincial departments and institutions (GDARD [6]). The local sphere of government is the one that is directly impacted by MRA issues and often is not equipped with the necessary skills, capacity and knowledge to deal with them.

SA's transition to democracy in 1994 presented an opportunity to transition its historic mining philosophy into one that is more sustainable. The adoption of SA's new Constitution and Mineral and Petroleum Resources Development Act, 2002, signified the agreement of natural resources as the people's collective property with government as the central custodian (Adler *et al.* [2]). The current SA mine legislative framework, under which mine closure and MRAs are situated, is currently bounded by eight separate common laws and acts (Table 1). The current SA legislation seeks to create a balanced legislative framework that ensures that human rights are upheld in respect of development and the hazards associated with active mining, mining waste and pollution.

Core concepts of sustainability are incorporated in the framework through the inclusion of the Environmental Management Act, 1998, National Water Act, 1998 and the Mineral and Petroleum Resources Development Act, 2002, that together seek to incorporate integrated environmental management considerations and economic, social and environmental costs associated with the whole life cycle of a mine (Table 1). While this framework attempts to encourage a more sustainable approach to mining, mine closure and mine waste, these concepts do not often run full circle in regulating and managing mining practices. This is due to the fragmented governance of mines, in particular because legislation was not rigorously and consistently enforced. Enforcement tends to be sporadic and episodic, frequently driven by public outcries over the worst symptoms of regulatory failure leading to environmental damage, or by the media campaigns of non-governmental organisations.

Table 1: Summary of South African Mining Legislation Framework (Swart [3]).

	Legislation	Summary
1.	Constitution of South Africa, 1996 and common law	– Mines to conduct operations and closure in consideration of the rights of others. – A person suffering as a result of mining activity can claim damages from a mine/or directors in terms of a company law. – Common law claims based on pollution emanating from a closed mine can be issued within 3 years of the incident.
2.	Environmental management Act, 1998 (act no. 107 of 1998)	– Provides principles of sustainable development and sets norms for integrated environmental management. – Government and organs of state need to consult and support each another. – Includes a 'polluter pays' principle where any person that causes, may cause and has caused environmental damage is responsible for its remediation.
3.	Minerals Act, 1991 (Act No. 50 of 1991)	– Provides statutory requirements to enforce environmental protection, management of environmental impacts and rehabilitation of the environment. – Requires that rehabilitation of the surface land concerned in any prospecting or active mining. To be carried out by the holder of the prospecting rights or mining authorisation and to be in accordance with an Environmental Management Programme (EMP). A mine closure certificate will not be issued if these objectives are not met.
4.	Mine Health and Safety Act, 1996 (Act No. 29 of 1996)	– Employers to ensure and maintain a safe and healthy environment for the entire mining lifecycle (commissioning, operation, decommissioning and closure). This must include adequate health and safety equipment, training and medical surveillance.
5.	National Water Act, 1998 (Act No.356 of 1998)	– Maintains the integrity of water resources through pollution prevention, water re-use, reclamation, water treatment and discharge. – Both the mining sector management strategy and the policy on groundwater quality management seek to employ controls and enforce remediation.
6.	Atmospheric Pollution Prevention act, 1965	– To prevent and control dust pollution through the prohibition of the disposal of assets by mines, prompting mines to follow a proper mine closure programme
7.	Nuclear Energy Act, 1996	– As mining waste contains radio-active elements as uranium, radiological requirements need to be met before mine closure is granted.
8.	Mineral and Petroleum Resources Development Act, 2002	– Provides a 'cradle to grave' approach to prospecting and active mining considering economic, social and environmental costs to achieve the sustainable development of mineral resources. – Requires that an environmental impact assessment be undertaken together with an EMP to identify areas of focus, mitigate and manage environmental impacts associated with mines. – Makes provisions for the management of mining residue waste and to adopt principles from the Integrated Pollution and Waste Management Policy and the precautionary approach as specified by the National Water Act. – Requires a mine closure certificate to be issued and the transfer of liabilities to a competent person.

Interventions around MRAs at a provincial level have been initiated by the Gauteng Premier and implemented through the Gauteng Department of Agriculture and Rural Development (GDARD). This intervention has focused on the reclamation of mine residue areas for development purposes, as MRAs were identified as a provincial priority for the reclamation of land. While phase 1 of this project – which aimed to quantify mine residues through a technical review – was achieved, the larger five-year programme has not been followed up neither at the level of national nor provincial government. Attempts by provincial government to create an AMD/MRA action committee have also fallen flat as a result of lack of interest by national government and no budget.

5 Disjuncture between mining legislation and practice

Systemic barriers have resulted in the episodic and sporadic enforcement of SA's current mining legislative framework. Systematic barriers have manifested partly as a result of staff capacity issues and budgetary constraints, with staff vacancy rates estimated to be at 30% (GDARD [6]).

For example, Department of Environmental Affairs (DEA) is largely responsible national government departments in coordinating the responsibilities of the DMR, National Nuclear Regulator (NNR) and Department of Water Affairs (DWA) around mining oversight and legislative enforcement GDARD [6]). Capacity issues in the DEA, prevent the effective enforcement of responsibility where onus is placed on other local or provincial departments or directorates for enforcement (GDARD [6]).

Tracing these systemic barriers from national to provincial government, the weak capacity and legal standing of provincial government also limits prospects for a co-ordinated response (Taviv [12]). In terms of the Municipal Systems Act, provincial government may lead processes to introduce draft standard local by-laws for all municipalities in a province to adopt. GDARD did attempt to implement a local by-law to prevent houses being built within a 500m buffer of MRAs, but poor legal representation, and objections stifled this attempt at managing settlement vulnerabilities and spatial development.

Current mine closure certificates, issued by DMR, do not incorporate all the aspects as laid out by the mining legislative framework, complying only with minimum criteria defined by the Department of Mineral Resources (DMR) and not those of DEA and DWA. This creates problems for local government, where land has not been sufficiently reclaimed and rehabilitated for further use (Taviv [12]). The liabilities of mining are thus passed on to other spheres of government that do not have the budgets or capacity to deal with the risks associated with mining and MRAs.

Local municipalities, at the face of issues related to MRAs, deal with the immediate effects of MRAs on communities and the environment. These departments or agencies typically have further limited capacity, small budgets and divided roles between internal departments.

In the case of the City of Johannesburg municipality (CoJ), one MRA in particular has presented a key challenge to the municipality and provides a case example of the difficulties of dealing with mine waste (Lekotso [13]).

The Princess dump, located to the west of central Johannesburg, has created social and environmental issues for the surrounding community who were forced to lodge a formal complaint through a legal group to have their voices heard and to engage with the relevant departments. In 2006, a court order was lodged against CoJ, a mining company and the DMR to rehabilitate the dump, but in 2013, the dump has still not been reclaimed. This is result of a complicated web of actor interests and agendas in applying and enforcing SA's mining legislative framework. While DMR is responsible for rehabilitating the mine dump, it has issued and renewed mining prospecting rights and prevented reclamation from taking place as this waste may create revenues in the future.

One common strand that weaves through various stakeholder interviews is that the DMR sees itself as the official custodian of the country's mineral wealth. There is therefore a self-regulating aspect to the management of mineral extraction activities in South Africa as DMR controls the issuing of prospecting and mining rights and also regulates the sector as a whole. The common viewpoint is that DMR cannot both promote and regulate the mining industry in SA. The division of roles in this regard is skewed, resulting in environment and human rights likely to take second place to mineral wealth development and extraction.

As mine waste is seen as a resource by the DMR, with potential reclamation projects generating profits for an already constrained industry, this presents a divided interest from the very beginnings of mining regulation and enforcement. This management conflict provides little incentive to either rehabilitate MRAs for the benefit of the communities surrounding them or to mitigate any local or regional environmental impacts.

6 Discussion

This paper has provided an overview of SA's current mining legislative framework around MRAs and the environment. It also investigated the potential risks of exposing MRAs to changing climatic variables, informing the management of MRAs within the GCR. These findings will assist with clarifying appropriate mitigation and adaption strategies to ensure infrastructure and communities are not further affected.

The perspective of this paper is how insufficient and unsustainable mine closure strategies of the past have created the mining landscape legacy inherited by the GCR. This, together with the poor enforcement of current mining legislation, presents a series of challenges for the planning and management of many settlements in the region.

Weather extremes predicted as a result of climate change will interact with MRAs over the long term and make these challenges even more complex. In this regard, it is important for mines to follow a 'cradle to the grave' approach as outlined by the Mineral and Petroleum Resources Development Act, 2002 (Table 1) (Swart [3]). This act aims to consider the whole life of a mine incorporating economic, social and environmental costs to achieve the sustainable development of mineral resources over time. This kind of approach is required to ensure that present mining sites do not become the derelict and waste sites of the future (Swart [3]).

While MRAs have not been included in SA's National Climate Change Green Response paper (DEA [10]), it is important to begin to consider the effects of climate change on mine waste and to acknowledge its likely effects on already vulnerable settlements. The harsh reality is that Gauteng already has faces a series of challenges and complexities associated with a legacy of mining that has not been resolved by the necessary stakeholders. The current mining legislation has been loosely applied to regulate the mining industry with mining waste still not being adequately addressed.

The actors that guide mine regulation are currently spread between the various spheres of government, non-governmental organisations, stakeholders and the public. These actors are guided by a framework of legislation in the form of acts and/or common laws that can allow for the interlacing of mining regulation with concepts of development and the rights of society and the environment. Although this framework incorporates concepts of sustainability and holistic mine management over the long term, in practice, it has allowed for the episodic and sporadic governance and regulation of the mines that is likely to remain for the foreseeable future.

Considering the transition that is required in the current mining philosophy of SA, the added pressures presented by climate change may only complicate the current disjuncture between the roles and responsibilities of government, amplifying current systemic pressures. Before climate change can begin to be addressed by SA mining legislation, the mining landscape legacy needs to be considered to create a more sustainable legacy for the future.

In order for the mining legacies and prospects of the GCR's mining landscapes to be addressed, the development of appropriate mitigation and adaption strategies around mine waste, mine closure and sustainable mining need to be levered across responsible stakeholders that have clearly defined roles, adequate budgets and trained staff. Enforcement at all levels of SA's current mining framework is necessary to create a fair and integrated regulatory system.

Advances may include alternative futures for the region that may evolve in the form of mining waste opportunities. Work on alternative mining futures is currently being executed by academics and researchers alike who have begun to showcase alternative solutions for the future through the media. While these technologies can provide the answers to reconciling past and present challenges associated with mine waste, these ideas are subject to government and stakeholder interest.

7 Conclusion

While the South African mining legislative framework incorporates concepts of sustainability, these are not necessarily put into practice by the various stakeholders and departments. The GCR has inherited a legacy of mining residues that impact communities and the environment in the present day and will continue to do so in light of predicted climate change. The GCR therefore faces a double conundrum in dealing with mine waste of the past and addressing current mining practise to create a more sustainable solution over the long term. If this double conundrum is not addressed, the legacy of mine residues will continue to influence its spatial form and will impact on the future management of its spatial redevelopment and integration programmes. In turn, the vulnerability of many low income communities will continue to deepen, with climate change risks further reducing their ability to mitigate and adapt to the many hazards associated with mine residues.

References

[1] Smith, B., Mining for closure: sustainable mine practices, rehabilitation and integrated mine closure planning. Sydney: UNSW Thesis, n.d.

[2] Adler, R., Claasen, M., Godfrey, L. & Turton, A., Water, mining and waste: an historical and economic perspective on conflict management in South Africa, *The Economics of Peace and Security Journal,* **2(2)**, pp. 31–41, 2007.

[3] Swart, E, The South African legislative framework for mine closure, *The Journal of the South African Institute of Mining and Metallurgy,* pp. 489–492, 2003.

[4] South African Department of Mineral Resources (DMR)., The national strategy for the management of derelict and ownerless mines in South Africa, Government printer: Pretoria, 2009.

[5] World Wildlife Fund (WWF), http://www.wwf.org.za/?6600/acid-mine-draining.

[6] Gauteng Department of Agricultural and Rural Development (GDARD), Study on Reclamation and Rehabilitation of mine residue areas for development purposes: Phase 1. Stratergy and implementation plan, Government Printer: Pretoria, 2012.

[7] Bremner, L., Crime and the emerging landscape of post-apartheid Johannesburg, in *Writing the city into being: Essays on Johannesburg 1998–2008*, Fourthwall Books: Johannesburg, pp. 207–321, 2010.

[8] South African Department of Science and Technology (DST)., South African risk and vulnerability atlas, Government Printer: Pretoria, 2010.

[9] Loechel, B., The Conversation, http://theconversation.com/mining-companies-are-underprepared-for-climate-change-13091.

[10] South African Department of Environmental Affairs (DEA)., National climate change response, http://www.climateresponse.co.za/home/gp/5.5.2.

[11] Endangered Wildlife Trust (EWT)., What is climate change and its relationship to mining and other development activities, http://www.miningtoolkit.ewt.org.za/mining_impacts_climate.html.
[12] Taviv, R., Personal communication, 7 August 2013, Deputy director: mining and energy.
[13] Letsoko, F., Personal communication, 16 August 2013, Assistant director: catchment managment at City of Johannesburg.

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The power of mining: the fall of gold and rise of Johannesburg

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The City of Johannesburg has developed through the entire life-cycle of the mining industry. In its early years, its development was tied to the varying, but generally upward, fortunes of the mining industry. During this time, gold mining in Johannesburg, and along the Witwatersrand, propelled the growth of South Africa's national economy into a phase of self-sustained development, and created an integrated labour market across southern Africa. It also played a key role in shaping the racial oligarchy that dominated South Africa until the fall of apartheid in the 1990s. However, gold was eventually to decline, first in the areas around Johannesburg, and then elsewhere. The growth of Johannesburg, however, continued and the urban economy became increasingly diversified and flexible. This growth seemed divorced from mining but was, in fact, deeply rooted in the history of mining. The mining industry played an intimate role in the development of the manufacturing sector and also in the emergence of financial services; which is currently the leading economic sector in Johannesburg. These economic changes are represented in continuous evolution of the spatial form of the city. Currently the physical legacy of mining is understood mainly in terms of its deleterious environmental consequences, including acid mine drainage, with the long and profound impact of mining on the patterning of urban growth largely forgotten.

Keywords: Johannesburg; mining; gold; labour; urbanisation; economy

> Will the gold-reef last; and the big city and the hiving population that have grown up around it – will these also endure? Or can it be that the Reef is approaching exhaustion, and that all its correlative interests are doomed to extinction? (Chilvers 1948, 222).

For almost the first half of the city's existence, there was a deep anxiety amongst its residents that Johannesburg would collapse when the mines closed. The mines eventually did shut down but the power of mining in Johannesburg is such that it ignited the development of an economy that outlived the mines and continued to grow and flourish.[1]

This contribution focuses on the development of Johannesburg through the full life cycle of the gold mines, and beyond. It shows how Johannesburg – in common with a few other cities in the world such as Melbourne and San Francisco – transcended the boom–bust scenario of a minerals-based economy and evolved into a diverse and competitive agglomeration. It supports the argument of Davis

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(1998), which challenged a conventional view that economies initially dependent on mining inevitably have substandard economic performance in later years.

The analysis focuses specifically on the Central Rand Goldfield, where large-scale, deep-level gold mining first began in South Africa, and where Johannesburg was proclaimed as a mining settlement in 1886. Central Rand is one of seven distinct gold fields in South Africa, and during its long history of productive activity has produced 15% of South Africa's total gold output. Its importance in terms of physical production has however declined progressively – from 80% of total gold output nationally in 1911 to 3% in 1980 and nearly zero currently[2] – but the economic weight of the urban agglomeration it spawned continues to grow.

The development of Central Rand, and then of outlying gold fields along the ridge of hills known as the Witwatersrand, did, of course, do far more than produce the City of Johannesburg. Yudelman (1984, 9) wrote that, 'The major influence behind the telescoped development of modern South Africa – the leap from a fledgling quasi-state to a surprisingly advanced modern industrial state within the space of eighty years – a process that took centuries in Europe – was the South African gold mining industry'. Innes (1984, 69) referred to the development of the gold mining industry as:

> formative, not only in terms of establishing the capitalist relations of production which were to be the basis of subsequent growth in the industry itself, but also in conditioning the form of evolution of wider social relations in the country, including such phenomena as the migrant labour system, the character and form of the state and the system of labour relations.

The analysis here is divided into two sections: 1886–c.1948 and c.1948–2012. There is a clear rationale for the starting date as this was when the main gold-bearing reef of the Witwatersrand was discovered. The rationale for the divide at 1948 is twofold: 1948 is a political watershed as it was the year that the National Party took power in South Africa and introduced its policy of apartheid, but it also roughly marks the commencement of a period in which manufacturing eclipsed mining as the core of the national and local (Johannesburg) economy.

The article brings together a significant existing literature on the mine labour (Wilson 1972, 2001; Crush 1986; Crush, Jeeves, and Yudelman 1991; Yudelman 1984) with work on: the political economy of mining (e.g. Innes 1984) and of Johannesburg (Beall, Crankshaw, and Parnell 2002); and the changing spatial configuration of Johannesburg (Beavon 2004; Tomlinson et al. 2003). It updates this with reference to recent data and analysis on the mining industry and the changing economy of Johannesburg.

1886–1948: The rise of gold and the rise of Johannesburg

The Witwatersrand

When the Witwatersrand gold fields were first opened up in 1886, there was a ready market for gold as the major European economies were tied to a gold standard, and the liquidity of their currencies depended on a ready supply of the metal. The mining of the gold was, however, extremely costly. For although the gold reefs on the Witwatersrand break the surface in small outcrops, they dip steeply into the earth,

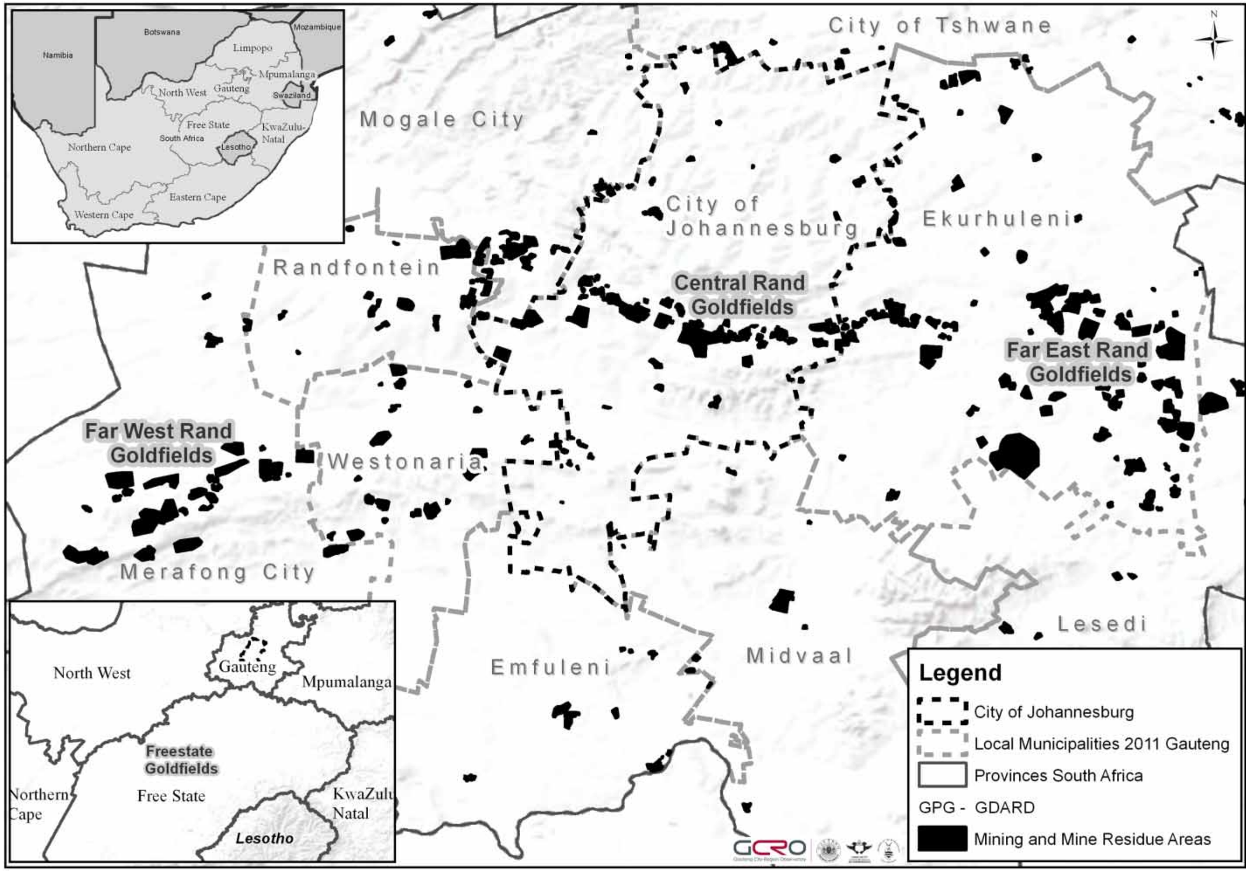

Figure 1. South Africa's gold fields.
Source: Gauteng City Region Observatory (GCRO).

requiring deep-level mining, with expensive technologies, for extraction (Beavon 2004; Innes 1984). It was because of this that a small-scale artisanal mining economy never developed, and that the new gold field was soon dominated by a handful of 'Randlords' who had made their fortunes on the Kimberley diamond fields, and who were backed by international investment capital. These Randlords founded the six dominant mining houses[3] in order to secure the conditions for the continued expansion of mining. A latecomer was the Anglo American Corporation of South Africa, founded in 1917 with capital from the New York bank J.P Morgan. Although there was never to be the same level of concentrated ownership in gold mining as there was with the diamond industry – which was controlled in a near monopoly by the De Beers Corporation – the mining houses established a form of oligarchic control. Ownership became increasingly concentrated as the Anglo American Corporation came to dominate the industry.

Within a decade of the discovery of the gold-bearing reef, the Witwatersrand was the largest gold-producing region in the world. This placed the region at the centre of a major political drama as Great Britain manoeuvred to wrest territorial control of the gold field from the Boer's *Zuid Afrikaansche Republiek* (ZAR) in the Transvaal. The struggle turned violent with full-scale warfare erupting between Great Britain and the two Boer republics in 1899. British forces occupied Johannesburg in May 1900, achieving its objective of economic *and* political dominance of the gold fields. However, in 1906 Great Britain granted autonomy to the Transvaal, which became part of the Union of South Africa in 1910, and the gold fields were thereafter increasingly shaped by South African, rather than British, capital and interests.

Formation of a mining labour force and the South African nation state

There was no guarantee that the gold mining industry on the Witwatersrand would survive. There was a delicate balance between cost and revenue, as the price of gold was fixed, and gold had to be mined at ever deepening levels. White workers arrived mainly from Great Britain and Australia and provided high-level skills, but their labour was expensive. A conventional colonial colour bar protected the interests of these workers by keeping black Africans out of higher-level jobs, but when profits were squeezed, mine owners tried to modify the colour bar and replace white workers with cheaper black African labour (Yudelman 1984).

There was a bitter struggle between white workers and mining bosses when the government agreed to assist the Chamber of Mines in addressing a severe labour shortage after the war by importing around 60,000 Chinese on indentured labour contracts. The Chinese were all repatriated by 1910, forcing the Chamber of Mines to search elsewhere for cheap labour.

From 1896, the Chamber of Mines coordinated the recruitment of black African labour through the Witwatersrand Native Labour Association (WNLA) but it failed to secure an adequate supply of labour from South Africa's 'native reserves' (later the so-called *homelands*). Two-thirds of black African workers in the period from 1910 to 1928 came from the Portuguese East Coast (now Mozambique), but a demand from the Portuguese government that this labour supply be capped compelled the WNLA to recruit further and further afield, in colonial-controlled territories such as Nyasaland (Malawi), Bechuanaland (Botswana), South West Africa (Namibia), Basutoland (Lesotho), Southern Rhodesia (Zimbabwe) and Northern Rhodesia (Zambia) (Innes 1984; Crush, Jeeves, and Yudelman 1991; Crush and James 1991).

Crush, Jeeves, and Yudelman (1991, 1) wrote that 'there is little doubt that if large numbers of low-wage, unskilled migrant miners had not been recruited from throughout the subcontinent, there would never have been a deep-level gold mining industry in South Africa'. The WNLA's labour recruitment tied much of southern Africa to Johannesburg's burgeoning economy, with the authors describing this as 'South Africa's labour empire' (Crush, Jeeves, and Yudelman 1991, 1). This system of labour recruitment was linked to a pattern of oscillating migration in which male workers were housed in single-sex compounds for limited periods, and returned to families in rural areas when their contracts expired. The state was complicit in supporting this system.

With the extensive use of cheap non-South African labour, mining companies were able to keep the lid on costs for a prolonged period (Wilson 2001). In 1921, however, there was a crisis as the price of gold dropped from 111 shillings per fine ounce to 97 shillings. The Chamber of Mines responded by modifying the colour bar and replacing expensive white labour with black African workers. This provoked a bloody rebellion – in which white workers notoriously marched under the banner 'Workers of the World Unite for a White South Africa' – that was ruthlessly suppressed. Two hundred and fifty people died and the white workers' struggle ended. The so-called Pact Government of the early 1920s pacified white workers by legislating the colour bar but otherwise did not act against mining interests. Throughout this formative period, the state played a critical role in supporting the reproduction of low labour costs to ensure the survival of gold mining, which was so central to the development of the national economy (Innes 1984).

Johannesburg's economic foundations

The spectacular growth of Johannesburg in its early years has been recalled in numerous, mainly romantic, accounts of a mining camp burgeoning into a modern metropolis. A few accounts (notably Chilvers 1948 and JSE 1948) provide a sense of how fragile and contingent this development really was. The initial dependence on gold subjected Johannesburg to the immense volatility of financial speculation.

In 1888/89, there was a great speculative boom in which the average value of mining companies increased five-fold, collapsing towards the end of 1889 when mining companies struck pyritic ore at 100 or so metres below the surface, and had no technical means to extract the gold. Johannesburg seemed doomed to a future as a ghost town. The town was saved in 1891 when a method to extract gold using cyanide was developed. This was followed by a surge in gold shares and another wave of property development, until 1895 when markets crashed because of tensions between the British and the Boers. Mines closed during the war but reopened with great optimism in 1902, only to slump again because of a severe shortage of labour (JSE 1948).

The turbulent roller coaster continued, with peaks of optimism and troughs of despair. In 1930, the future of gold mining and of Johannesburg appeared bleak, with South Africa's Chief Mining Engineer predicting the near collapse of gold mining by 1950 (Shorten 1970). In December 1932, however, South Africa reluctantly followed Great Britain and other major economies in abandoning the gold standard, with extraordinary results. Suddenly freed, the price of gold doubled overnight, and continued to rise over the next five years. There was an 'orgy of speculation in gold shares' (JSE 1948, 89), with massive private profit-taking. The boom incentivised prospecting and exploration, which led directly to the next major wave of mining development in the late 1940s (Chilvers 1948; JSE 1948).

After a peak in gold production in 1941, materials and labour were diverted to the war effort and African labour became increasingly militant (Chilvers 1948). The next speculative boom was in 1945, and again in 1948, when high yields from the newly discovered Free State gold field were confirmed (Chilvers 1948, 262).

In all of this, Johannesburg's role in the physical production of gold was declining. Central Rand's production peaked around 1911, when the gold field accounted for 80% of South Africa's output. During World War I, highly profitable mines were opened on the Far East Rand by the newly established Anglo American Corporation, and from 1923 this new gold field eclipsed Central Rand. During the 1930s, the Far West Rand was opened up, and when the Free State gold fields developed, the relative position of Central Rand declined further. Between 1938 and 1949, Central Rand accounted for 34% of national production (Scott 1951; Viljoen 2009).

Johannesburg nonetheless continued to grow in power, economic size and population because the mining companies, and also the stock exchange, were headquartered in central Johannesburg, channelling profits towards the city. This was reinforced by the rise of the Anglo American Corporation of South Africa, which, unlike the London-based Gold Fields of South Africa, was a South African company with headquarters in the centre of Johannesburg. In the 1940s, Anglo American became a multinational, expanding its interest northwards in Africa, with 51% control of the Zambian copper mines. It also gained ownership of the De Beers Corporation in the 1920s, and so held a monopoly over the diamond industry.

Johannesburg experienced a process of diversification beginning in the early twentieth century. The development of the mines created an immediate demand for industrial production such as iron and steel, explosives, construction materials and chemicals. The first major industrial development happened in 1890 when President Kruger granted a concession for the development of an explosives industry to the Nobel Trust. In 1913, a mining and property development company established Union Steel Corporation as South Africa's first steel producer. During World War I, South Africa faced a disruption to its supplies of imported manufactured goods, spurring the country to manufacture domestically. By the end of the war, South Africa had emergent industries in sectors including electricity, steel, engineering, chemicals, construction materials and clothing, and many of these industries were established in and around Johannesburg, where the mines and the growing population provided a ready market (Innes 1984).

There was a direct and continued involvement in the development of industry by the mining sector. Union Corporation, for example, established the South African Paper and Pulp Industries (SAPPI); Rand Mines spawned the Portland Cement Company; JCI owned South African Breweries (SAB); and Gold Fields operated factories producing clothing, metals, chemicals, construction materials and food. Importantly, the mining industry was also central to the development of an electricity producing and distribution industry. In 1906, the Chamber of Mines supported the establishment of the Victoria Falls and Transvaal Power Company to provide electricity to the mines until the Electricity Supply Commission (ESCOM) was founded in 1922.

Tariff protection introduced by the Pact Government from 1924 significantly aided manufacturing, and there was a further surge in the development of import replacement industry during World War II. At the end of the war, manufacturing was as important to the national economy as mining, with its contribution to GDP having risen from 10% in 1918 to 25% in 1945 (Innes 1984).

A tight link existed between mining and tertiary services. From the beginning mining needed large amounts of capital to finance production, and finance houses quickly emerged alongside the mining houses, with interlocking directorships. Banks and building societies were established in Johannesburg from the 1880s (such as the United Building Society, now part of ABSA Bank) or moved their headquarters to Johannesburg (for example, Nedbank and Standard Bank of SA). The formation of the Johannesburg Stock Exchange (JSE) in November 1887, which supported the equity requirements of the mining industry, was also a critically important development in strengthening Johannesburg's position as the centre of South Africa's emergent industrial and business economy.

Johannesburg's spatial expansion

Johannesburg's changing social structure is not dealt with in detail in this article, but one of the most striking social outcomes of mining that must be noted was the city's changing demographic profile. In 1911, there were only 36 females per 100 males, with 77 per 100 for the white population, and only five per 100 for the black African population. In 1946, towards the end of the first period of study, the overall figure was 75 females per 100 males, with 101 for whites and 56 for black Africans.[4] As sex ratios were narrowing, class differentiation was widening. Van Onselen's *New Babylon, New Nineveh* (1982) provides wonderful detail on the emergence of working class cultures in Johannesburg.

The spatial evolution of early Johannesburg was profoundly shaped by the physical presence of mining and by the hierarchies and intersections of a society that emerged around the mines. Johannesburg quickly emerged as the central node in a string of settlements in a nearly 50 km east–west belt along the gold-bearing reefs of the Witwatersrand. The mining belt was a defining physical feature, with settlement on both sides but mainly to the north as the land to the south was underlain by reefs and reserved mainly for future mining activity.

After the discovery of gold, mining claims were pegged out on privately owned farms along the reef, with mining camps spreading out north and south of the diggings. The formal settlement of Johannesburg was however proclaimed on a triangular piece of leftover state-owned land – *uitvalgrond* – immediately north of the mining belt. The settlement was not considered to be permanent and it was laid out crudely on a tight grid with small blocks (Beavon 2004).

Johannesburg had an improbable location and existed only because of a gold reef with uncertain prospects, but the mining camp soon burst into a bustling town with 'banks, shops, hotels and boarding houses, a stock exchange, and the inevitable saloons and brothels' (Beavon 2004, 6). Within 10 years, Johannesburg was the largest urban centre in Africa south of the equator, and its population of 102,000 exceeded that of Cape Town (Chipkin 1993). The trajectory of growth was not smooth, with the brusque fluctuations of the mining economy, and the effects of war and other disturbances, affecting the rate of population and physical growth. During the slump from 1889 to 1891, one-third of the population left the Witwatersrand, and there was another exodus during the South African War (Shorten 1970). By 1928, however, the government had sufficient confidence in the future of Johannesburg to formally proclaim it a city.

The mining boom of the 1930s brought rapid growth to Johannesburg and dramatic urban transformations. This was the time when the inner city went high-rise. Chilvers (1948, 235) notes that 'Buildings were continually being torn down and replaced by modern skyscrapers. Telephones, power, transport just couldn't keep pace with Johannesburg's development. And the pace was getting faster – and faster'. Alongside the control and repression of black settlement in the city, white space was experiencing a massive building boom as over 10,000 apartments were created on the north-eastern edge of the inner city. The rapid development of manufacturing in the 1940s was linked to the emergence of a string of industrial estates along the mining belt and around the edge of the inner city. The tertiary sector, including commerce and finance, consolidated in the inner city (Tomlinson et al. 2003).

The socially and racially segregated and unequal nature of Johannesburg's development has been the central theme in many accounts of the city's development (Guillaume 2001; Beall, Crankshaw, and Parnell 2002; Murray 2008). Beavon (2004) observes that Johannesburg's geography of segregation was apparent from as early as 1887 and that the patterns that shaped almost all future development were firmly in place by 1904.

By 1904, more than 100,000 black Africans, and large numbers of Chinese, were corralled in regimented single-sex compounds on mining property along the Witwatersrand. Initially the compounds were built of iron and wood, but later there were concrete, barrack-like structures with rooms housing 20 to 50 workers each (Crush and James 1991; Crush, Jeeves, and Yudelman 1991). Not all black Africans, however, lived in these compounds. As black Africans entered employment in other sectors, migrants found accommodation in municipal compounds and also in slums in and around the centre of town and in domestic accommodation in white residential areas. This led to the inter-racial proximity that the city council refused to accept, provoking a long history of attempts to segregate the race groups (Parnell and Mabin 1995). The origin of Soweto, for example, was as early as 1903 when the city council moved black Africans living in a slum in present-day Newtown to a remote settlement 16 km south-west of Johannesburg called Klipspruit, ostensibly in reaction to threats of bubonic plague.

From the time of the Native Urban Areas Act, 1923, which prevented black Africans from purchasing or renting land in white areas, the local authority gradually developed segregated housing estates to which black Africans were moved. The whole of the municipality of Johannesburg was proclaimed white by 1933[5] and by the late 1930s the local authority had used the provision of the Slums Act 1934 to clear mixed-race inner city neighbourhoods, and move black African residents to newly built townships such as Orlando. Much of the new township development was situated at some distance south of the mining belt in the area that became Soweto, thus establishing a fundamental divide in the structure of the city (Tomlinson et al. 2003; Beavon 2004). Indian and coloured (mixed race) communities maintained their foothold near the inner city, in places like Fietas, until the apartheid era, when they too were forced into peripheral townships.

By 1904, the wealthy white elite, including the Randlords, were occupying the high-lying ridges to the north of the mining belt away from the dust and noise of the mines, establishing a pattern of wealthy suburban development in a northwards direction. The white mine-workers who had arrived in Johannesburg from abroad lived in small but solidly constructed bungalows in suburbs strung out along the edges of the mining belt; the Jewish migrants from Eastern Europe and the Russian Empire lived in Yiddish-speaking enclaves in the east of the town; the Afrikaners who had arrived from the farms lived in generally poor neighbourhoods in the west of Johannesburg (Chipkin 1993; Beavon 2004). By the 1930s, the city council developed sub-economic housing estates for 'poor whites', often on land where racially mixed slums had been cleared (Parnell 1988). While extreme forms of segregation are generally associated with the system of apartheid, all of this was happening before 1948. The mining industry was a key driver in the increasing levels of urban segregation, and provided the template for the socio-spatial engineering of the National Party government in later years.

Although the dominant representation of Johannesburg has been of a divided and segmented city, recent literature, informed by post-colonialist theory and cultural studies, directs attention to the cross-over and syncrecity that was also a feature of Johannesburg's development (Nuttall and Mbembe 2008; Nuttall 2009; Bremner 2010). In the pre-apartheid era, there were cultural melting pots where new cultural formations emerged. The British, European and Russian immigrants forged a new English-speaking identity in Johannesburg while a creolised African working class identity arose from the inner city slums. There was also racial mixing that persisted into the 1940s despite the local authority's efforts to separate out the various groups.

1948–2012: The decline of gold and the rise of Johannesburg

Gold and labour force fluctuations

By the end of World War II, South Africa still accounted for 40% of the world's total gold output, with the mines around Johannesburg producing about one-third of the national output. The powerful trends away from mining were, however, already in motion.

In 1944, the Allied Nations signed the Bretton Woods Agreement that reinstated the gold standard and pegged the price of gold at US$35 per troy ounce. Once again South Africa was assured of a steady market for its gold, but with a fixed price and rising costs profit margins came under growing pressure. South Africa's gold production peaked in volume in 1970 when it accounted for 78% of global output, but most mines were economically marginal and the future was uncertain (Viljoen 2009).

In 1971, however, the United States unilaterally left the gold standard and the gold price soared to US$800 by 1980, bringing new prosperity to the South African gold mining industry. In spite of a decline in gold production the revenue earned from gold mining climbed dramatically from R830 million to R10 billion. The 1980s were more difficult. The gold price fluctuated between US$300 and US$500, but

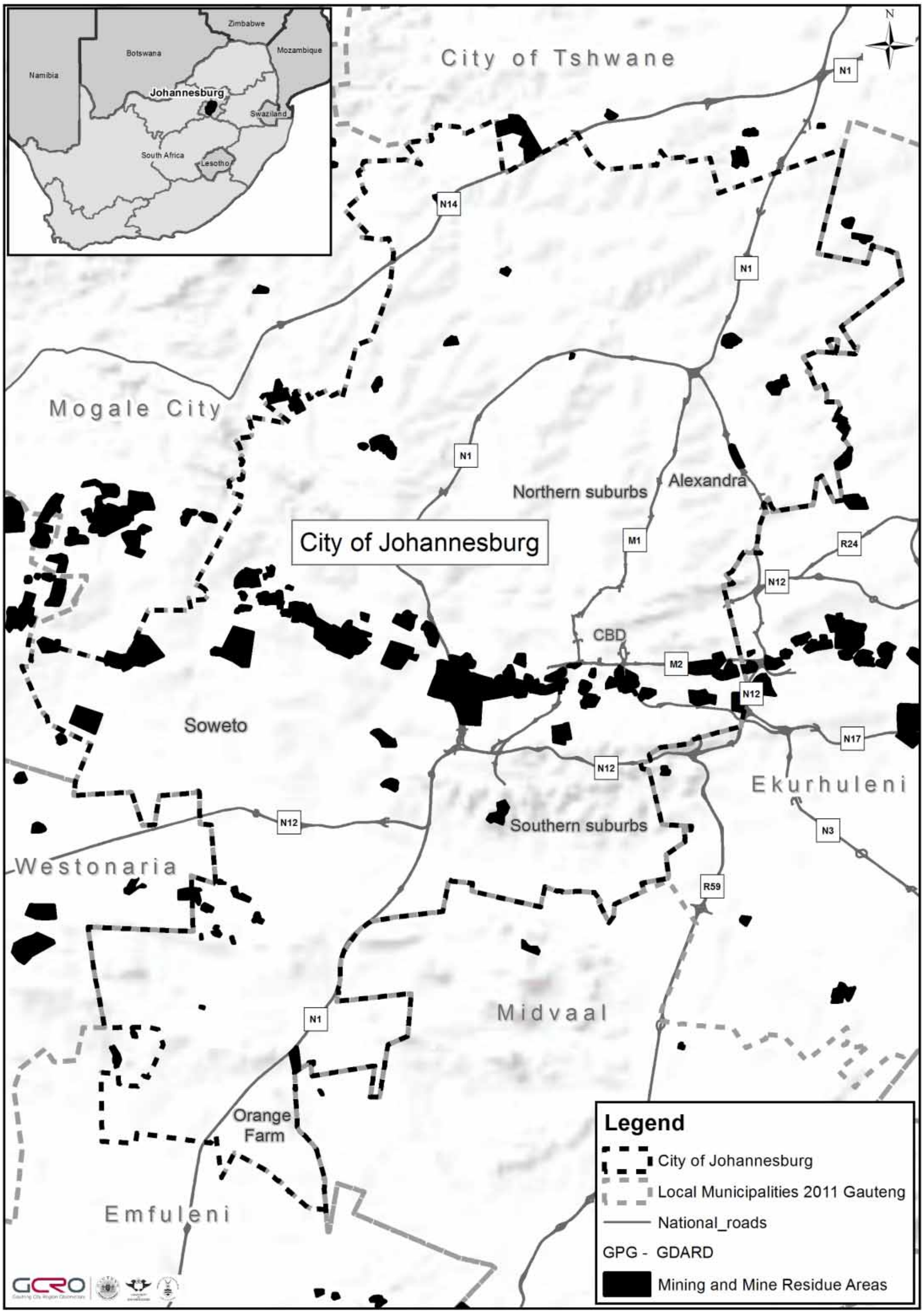

Figure 2. The physical footprint of mining in Johannesburg.
Source: Gauteng City Region Observatory (GCRO).

profits gradually declined, and there was almost no new investment in gold mines (Crush, Jeeves, and Yudelman 1991).

The effects on the labour force were far-reaching. The Chamber of Mines had responded to the cost pressures of the 1960s by expanding the use of foreign labour, with foreign workers accounting for nearly 80% of South Africa's total labour force in 1973 (Innes 1984). In the mid-1970s, however, there was a dramatic change as the colonial government in Mozambique collapsed, abruptly ending labour supply, and as the government of Malawi ordered 120,000 mineworkers to return home (Crush, Jeeves, and Yudelman 1991).

Increasingly, mines had to draw on local labour, and the number of South Africans employed on the mines rose from 87,000 in the mid-1970s to 333,000 in the mid-1980s. Deteriorating conditions in rural South African homelands and the stagnation of the manufacturing economy ensured that there was a strong supply of South African workers. For the first time in the history of gold mining in South Africa there was a surplus of labour (Wilson 2001).

Apartheid was in its final stages, as evidenced by a number of reforms, including: a rapid increase in the real wage of mine workers in the 1970s; recognition for the National Union of Mineworkers (NUM) in 1980; the abolition of the system of influx control into urban areas in 1986; and the lifting of the colour bar in 1988. With mechanisation of the mines there was more demand for skilled labour, and so there was growing talk of the need to 'stabilise' the workforce (Crush, Jeeves, and Yudelman 1991). The system of mining compounds and of oscillating migration did not end, however, with the lifting of influx control. Gold mining companies generally did not follow De Beers Corporation, which had abolished single-sex compounds on diamond mines and provided family accommodation. Instead there was a gradual loss of control over the compounds as families moved in with male workers or found accommodation in burgeoning informal settlements.

Johannesburg and the New South Africa

When South Africa made its transition to democracy in the early 1990s, it was still the world's dominant gold producer, accounting for 44.5% of global output, but difficult days were ahead. In 2010, South Africa produced only 191 tons of gold, 7% of global output, slipping to fifth in the world production rankings (Chamber of Mines 2011).

In the 1990s, mining employment in South Africa fell by 40%, and a further 179,000 jobs were lost between 2001 and 2011. In February 2012, mining production had hit a 50-year low, with the mining sector accounting for less than 5% of GDP. The sector had not only failed to benefit from the commodities boom of the 2000s but was contracting sharply. Gold was worst hit, with a 7% annual contraction in production since 2000, and an 11% decline in 2011 (*Business Times,* 9 June 2012). This deeply constrained the ability of the state to extract rent from the mining sector.

This slump in gold mining has had a severe impact on the economies of gold-producing areas, including towns in the Far West Rand and Free State, but has had no apparent effect on Johannesburg, where other sectors had long since replaced mining. In one sense, the situation in Johannesburg was worse than nationally as the Central Rand Goldfield declined more quickly than elsewhere. By the 1960s, the average profitability per ton of rock mined was only R1.92 for the Central Rand compared with R5.48 for the Far West Rand and R5.59 for the Free State (Cockhead 1970). All the large mines operating on Central Rand[6] shut down by the late 1970s, bringing production on the gold field to a near halt, although the high gold price did allow for the retreatment of old mine dumps (Viljoen 2009). Beall, Crankshaw, and Parnell (2002) calculated that gold mining's share of total employment for Johannesburg fell from 23% in 1946 to 1% in 1996. Very recently, new technologies have made ultra-deep mining feasible and restored the prospect of mining in the Central Rand, but to date efforts to implement the new technologies have not been successful (Seccombe 2012).

To understand the paradox of Johannesburg's continued economic growth despite the collapse of the Central Goldfield, it is necessary to look at the city's position as the economic hub of South Africa's national economy since 1948, which entails its continued role as the corporate rather than physical centre of mining and its continued urban economic diversification supported by the mining companies. The Johannesburg-based Anglo American Corporation, in particular, wielded immense economic power and political influence in South Africa, and was extending its reach internationally (Innes 1984).

In 1999, however, Johannesburg's pre-eminent position in the mining world experienced a setback when Anglo American merged with Minorco and transferred its headquarters and primary stock exchange listing to London. Anglo American did, however, retain a strong presence locally and Johannesburg remains the headquarters of at least seven companies in the Mining Top 100. Johannesburg thus remains a prominent node within a global corporate network of mining firms.

Johannesburg's economy diversified rapidly in the post-war era. In the 1950s and 1960s, manufacturing was the sector that most obviously led growth. Although this put pressure on wage rates in mining, the large mining companies played a dominant role in supporting manufacturing. Anglo American, for example, increased its manufacturing interests in the 1960s by 470% (Innes 1984).

The mines created original demand for industrial products, but a new process was underway in which mining companies expanded into multi-sector conglomerates, with industrial interests not necessarily linked to mining activity. From the 1970s, however, South Africa's manufacturing sector stagnated, and attempts at resuscitation by promoting export-led industrialisation largely failed.[7]

Specialised services, especially finance, took over from manufacturing as the lead sector in the South African economy. Here, too, mining companies played a leading role, becoming a central part of an expanding chain of financial power. Anglo American had significant equity stakes in major banks (Nedbank, Barclays and Standard) and in other financial institutions (such as Eagle Life Assurance) (Innes 1984).

Johannesburg's economic and spatial restructuring

Johannesburg remained at the centre of these economic transformations. Its own economy went through a profound process of change. Mining continued its seemingly inexorable decline. Manufacturing employment grew until around 1980 and then declined sharply thereafter, with its share of Johannesburg's total employment dropping from 24% to 13% in 1996 (Beall, Crankshaw, and Parnell

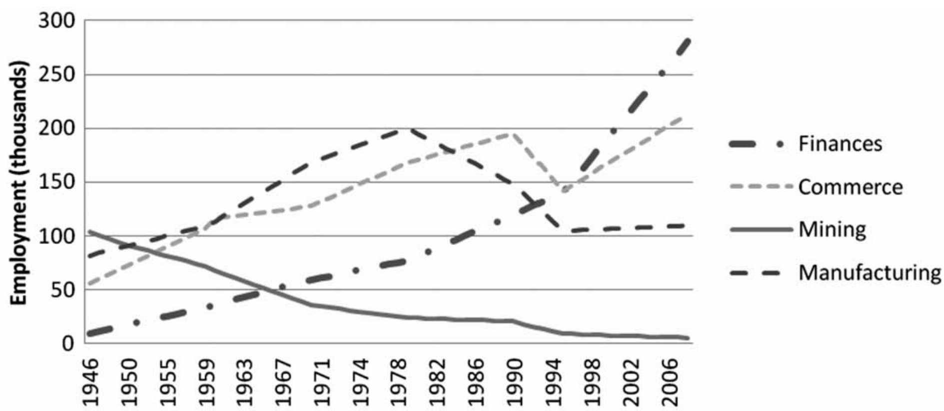

Figure 3. Change in employment by sector 1946–2009, Johannesburg.
Source: Beall, Crankshaw, and Parnell (2002), Quantec.
Data sources: Beall et al. (2002); Quantec

2002; Rogerson and Rogerson 1995). Community, personal and social services grew steadily until around the 1990s and then experienced modest employment decline. It was finance, insurance and real estate that continued growing and eventually outperformed all other sectors.

Initially, the rise of manufacturing more than compensated for the decline of mining and Johannesburg's economy performed well. In the 1980s, however, the decline of both manufacturing and mining took its toll, and Beall, Crankshaw, and Parnell (2002, 33) report 'a negative average annual rate of growth per capital gross geographic product per capita GGP of minus 0.6 percent'.[8]

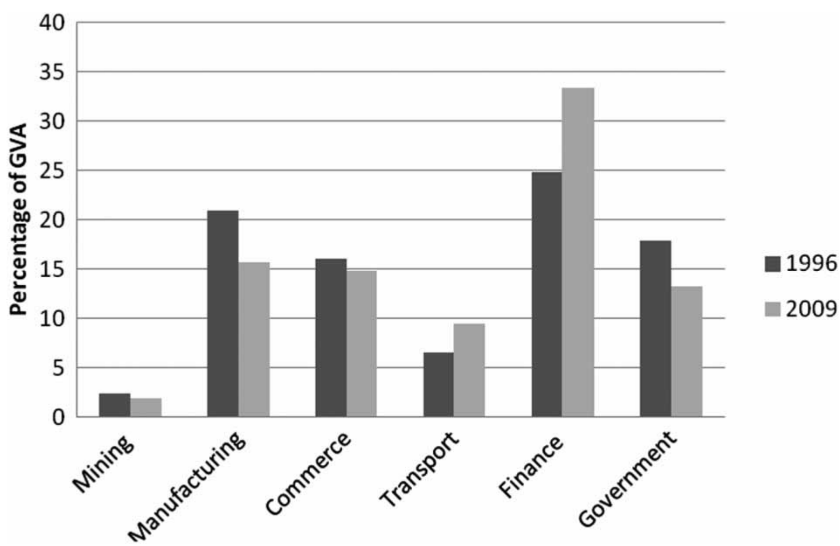

Figure 4. Change in contribution to GVA by sector 1996–2009, Johannesburg.
Source: Quantec.

In the period 1996 to 2009, however, Johannesburg's economy performed well. The local economy grew at an annual average of 4.5% measured in gross value added (GVA). This was higher than the national average of 3.3% and higher than that of any other metropolitan area in South Africa.[9] Johannesburg was consolidating its economic dominance of South Africa.

As Figure 4 shows, mining's direct contribution to GVA in the democratic era is almost negligible, and manufacturing has continued its relative decline, although there has been modest absolute growth. Finance has had the most impact on growth, with its contribution to GVA rising from 24.8% in 1996 to 33.4% in 2009. Johannesburg has emerged as a global service centre in banking, finances and related services (Hamilton 2006). Sassen (2009) ranks Johannesburg as the 22nd city in the world in the 'financial dimension', with a ranking of 8 for 'derivatives contracts' and 10 for 'commodities contracts'.

Present-day Johannesburg, with the economic structure and growth performance of a successful post-primary and post-industrial city, is far removed from its mining origins. However, Johannesburg remains deeply connected to its mining past, with its new flagship sector, finances, having evolved from the financial needs and power of mining.

Spatial transformation of the apartheid city

Although the broad pattern of Johannesburg's spatial pattern may have been established in the early decades, political and economic transformations have had far-reaching effects on spatial configuration. When the National Party took power in 1948 Johannesburg was already a highly segregated city as the city council had cleared most of the racial mixed neighbourhoods by the end of the 1930s and the workforce in the mines was extremely segmented. Apartheid was ruthless and extreme in separating out the remnants of integration, although it ultimately failed in its objective of absolute segregation.

The late 1940s to the early 1970s were the heyday of apartheid and a period of rapid economic growth underpinned by the expansion of manufacturing. This was accompanied by the suburban expansion of white residential areas in the north and south of the city. White suburbia initially developed in areas to the south of the city, ultimately becoming white working class neighbourhoods. The locational impetus for these settlements came less from mining and more from the presence of iron and steel works. It was in this period that the apartheid government developed large segregated townships with no industrial or commercial base for black Africans – most notably the agglomeration of townships that became known as Soweto – and eliminated racially mixed cultural melting pots such as Sophiatown and Western Native Township.[10]

The movement of Africans to the city continued apace and had reached 455,000 by 1948. The workforce for the mines remained in the compounds but there was an involvement of the mining industry in township development. In the 1950s, the founder and head of Anglo American, Sir Ernest Oppenheimer, provided a low-interest loan to Johannesburg City Council to construct 50,000 housing units in Soweto for families who were then living in shanty towns and emergency camps (Beavon 2004). This initiative, which accelerated the development of Soweto, may have represented an early attempt by the mining sector to create a more stable

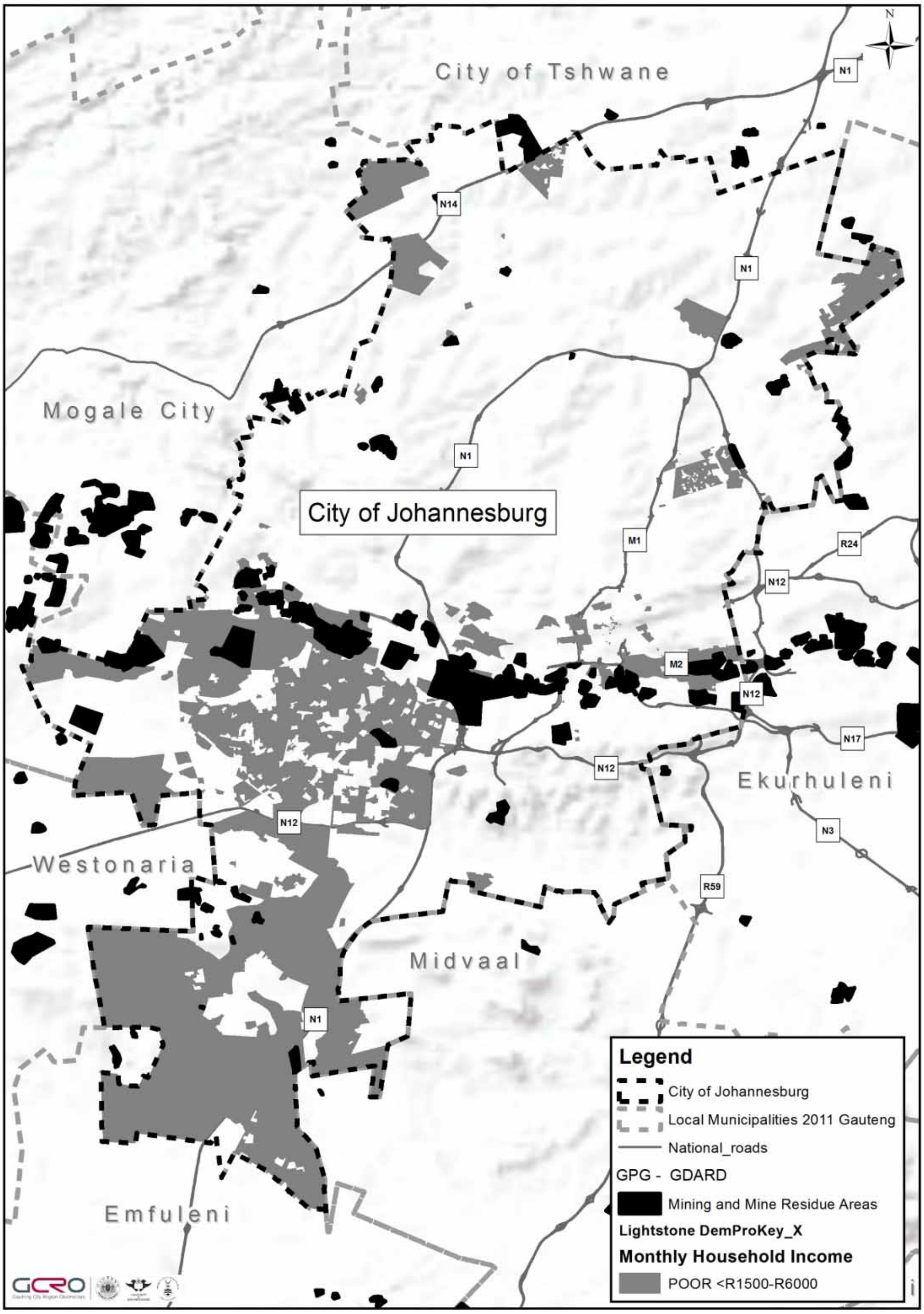

Figure 5. The mining belt in relation to areas of poverty in Johannesburg.
Source: Gauteng City Region Observatory (GCRO).

environment for labour, but it was not followed up in subsequent years. Mining compounds remained almost exclusively the residence of black African mineworkers until the arrival of democracy in the 1990s.

While the state was regulating and structuring the life of black residents, the rapid economic growth – which primarily benefited the white middle class – coupled with the expansion of freeways, supported suburban sprawl to the north of the city. There was a rapid expansion of industrial land around the inner city and along the mining belt as well as near townships with labour supply such as Alexandra. The tertiary sector was also growing, although not yet as dominant as manufacturing, concentrated in the inner city until the 1970s.

From about the time of the Soweto uprising in 1976, Johannesburg entered a new phase in its physical development. With the government having halted its large-scale township development and the system of influx control collapsing, informal settlements and backyard shacks reappeared in the city. After the abolition of influx control in 1986 the government tried to direct new settlement by black Africans to newly created townships such as Orange Farm and Diepsloot on the urban edge as African urbanisation accelerated.

The shift in economic structure from a manufacturing base to the services and financial sectors led to a more diffused spatial form that related to commercial and office decentralisation beginning in the late 1960s. Johannesburg became a sprawling multi-modal urban agglomeration, with private investment happening mainly in the prosperous north. Sandton emerged as the centre of the growing financial services sector, eventually eclipsing the inner city as the core of private sector enterprise in the city.

With the closure of the mines, new land was released for development, but the toxicity of the land and the large number of slimes dams and mine tailings was a major constraint. The largest landowner on the segment of the mining belt in Johannesburg, Rand Mines, established a property development company, which gradually reclaimed land for residential, industrial and business purposes.

Johannesburg in democratic South Africa

The democratic era, from 1994, brought a series of complex transformations to Johannesburg, which represented both change and continuity. As formal business left for the expanding nodes in the northern parts of the city, the private sector invested heavily on the northern frontier, creating new 'edge cities'. Meanwhile, there were dramatic land use and demographic shifts in the inner city. Informal traders and new immigrant communities from across Africa established a large presence. Against the background of pent-up housing demand in black townships and the rise in both internal and sub-Saharan urbanisation to the city, there was an influx of people occupying abandoned inner city buildings and infrastructure, resulting in overcrowded and distressed living spaces. The first decade of the twenty-first century saw many of these buildings converted to low- to middle-income housing opportunities. The inner city encapsulated the competing forces and complexities of gentrification, decline, housing opportunity and exclusion. At the same time, an emerging black middle class left the townships and moved into previously white suburbs, while state-subsidised housing, largely on the edge of the city, created new ghettoes of poverty.

The physical legacy of mining was reasserted during the post-apartheid period. The continued presence of the compounds was a bitter reminder of the past, with government committed to demolishing them or refurbishing them as family accommodation. Mining companies also agreed to this in the Mining Charter 2003. Implementation of the programme was slow and halting as it competed with the multiple demands for state housing subsidies. While some progress has been made with the 'hostel eradication programme', a number of large hostels remain along the old mining belt.

The rehabilitation and redevelopment of the mining belt accelerated demand for industrial, commercial and residential land, renewing growth of the city since the 1990s. The city administration has proposed an east–west corridor of development to knit together the wealthier north and poorer south, but the development has been driven mainly by the strategies of the mining companies. There is a lingering dispute over the right of a municipality to impose planning controls on mining land, but a recent judgment of the High Court in the Western Cape upheld the right of municipalities to regulate land development on all land within their jurisdiction (Kidd 2011). This, together with a plan to consolidate all mine tailings along the mining belt at a single site, may lead to more coherent land development away from the extremely disjointed patterns at present.

A deep concern currently is the danger of acid mine drainage arising from previous gold mining activity. As water percolates into old mines, slimes dams and dumps it is exposed to pyrites and other sulphides and becomes acidic. As water pumps no longer operate, this acidic drainage gradually rises and eventually spills onto the surface, threatening vegetation, water courses, human health and even the foundations of buildings. There have been belated efforts by government and mining companies to address this threat but the levels of acid mine drainage are still rising and have reached the surface in places (Naicker, Cukrwosja, and McCarthy 2003; Kidd 2011).

Conclusion

In common with a handful of other cities which have survived the boom–bust cycle of a mineral economy, Johannesburg owes its origins to mining. What is also important, however, is the *contingency* of Johannesburg's development. The mining industry in Johannesburg, shaped by considerations ranging from geotechnical to geopolitical, took a political form that had immense consequences for the future development of the city, but also for the shaping of social, political and economic formations and relations across southern Africa and beyond.

The minerals revolution that followed the gold discoveries fuelled far-reaching processes of urbanisation; shaped the nature of labour relations in southern Africa for more than a century; tied the development of communities from the rural parts of South Africa and neighbouring countries to the requirements of mining on the Witwatersrand; and provided the template for socio-spatial engineering of the apartheid government. Johannesburg was originally built to serve the mining industry and this is reflected in its spatial structure.

Mining has faded but Johannesburg has continued growing. Today Johannesburg can hardly be regarded as a mining city. However, the industries and sectors that now dominate Johannesburg's economy are themselves a product of a mining history.

Johannesburg's current status as an emergent global service centre in finance owes much to the historical links between mining and banking.

The extent to which the ills and the virtues of the large and complex urban agglomeration, of which Johannesburg is the core, is owed to mining is poorly understood and rarely acknowledged. In recent years, however, the ghost of the mining past has reappeared with the environmental threats posed by acid mine drainage, and also with some renewed prospects for mining within the Central Rand Goldfield. The future is uncertain but gold mining is unlikely to emerge again as a major economic activity. Johannesburg's economic prospects rest mainly on its ability to consolidate its role as a financial and service centre at a time of global and national economic vulnerability.

Acknowledgements

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Notes

1. Beavon (1997, 153) first wrote that 'gold . . . ignited the development of Johannesburg'.
2. Figures provided in Viljoen (2009).
3. Consolidated Gold Fields of South Africa, Rand Mines, General Mining, Union Corporation, and Johannesburg Consolidated Investments (JCI) collaborated through the powerful Witwatersrand Chamber of Mines.
4. See the National Population Census reports of 1911 and 1946 available in the national government and legal deposit libraries in South Africa.
5. In response to resistance from black freehold landowners and because the municipality could not provide alternative accommodation for all the Africans that it would need to house, the adjoining areas of Sophiatown, Newclare and Martindale were exempted from the declaration (Beavon 2004).
6. From west to east the mines were: Durban Roodepoort Deep, Rand Leases Mines, Consolidated Main Reef, Crown Mines, Robinson Deep, City Deep, Simmer and Jack.
7. The cause of this decline in performance has been extensively debated, with observers pointing to racial policies which prevented the growth of a black middle class and so restricted the size of the domestic markets, declining productivity and protectionism which prevented a competitive export market from developing (Bell 1995; Kaplan 2010).
8. Comparability of statistics is a problem. Figures for GGP were only provided between 1968 and 1991. Since 1996, private firms (Quantec and Global Insight) provide modelled estimated of economic output for municipalities for South Africa but these boundaries do not coincide with the previous statistical boundaries.
9. Based on figures provided by Quantec.
10. Segregated townships were also built for the Indian (Lenasia) and coloured (Eldorado Park and Ennerdale) groups.

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References

Beall, J., O. Crankshaw, and S. Parnell. 2002. *Uniting a divided city: Governance and social exclusion in Johannesburg*. London: Earthscan Publications.

Beavon, K. 1997. Johannesburg: A city and urban area in transformation. In *The urban challenge in Africa: Growth and management of its large cities*, ed. C. Rakodi, 150–91. Tokyo: United Nations University.

Beavon, K. 2004. *Johannesburg: The making and shaping of the city.* Pretoria: University of South Africa Press.

Bell, T. 1995. Improving manufacturing performance in South Africa: A contrary view. *Transformation* 28: 1–34.

Bremner, L. 2010. *Writing the city into being: Essays on Johannesburg, 1998–2008*. Johannesburg: Fourthwall Books.

Chamber of Mines of South Africa. 2011. *Annual Report, 2010/11*. Johannesburg.

Chilvers, H. 1948. *Out of the crucible*. Johannesburg: Juta and Co.

Chipkin, C.M. 1993. *Johannesburg style: Architecture and society 1880s–1960s.* Cape Town: David Philip.

Cockhead, P.J. 1970. The East Rand: A geographical analysis of the transition of the economic base of the region from gold mining to manufacturing, and its effects upon future economic development. MA thesis, University of the Witwatersrand.

Crush, J. 1986. The extrusion of foreign labour from the South African gold mining industry. *Geoforum* 17, no. 2: 161–72.

Crush, J., and W. James. 1991. Depopulating the compounds: Migrant labour and mine housing in South Africa. *World Development* 9, no. 4: 301–16.

Crush, J., A. Jeeves, and D. Yudelman. 1991. *South Africa's labor empire: A history of black migrancy to the mines.* Cape Town: David Philip.

Davis, D. 1998. The minerals sector, sectoral analysis, and economic development. *Resources Policy* 24, no. 4: 217–28.

Guillaume, P. 2001. *Johannesburg – Geographies de l'exclusion*. Paris and Johannesburg: Karthala/IFAS.

Hamilton, M. 2006. Global cities of the South: Mexico and Johannesburg in an era of globalization. MA thesis, University of Stellenbosch.

Innes, D. 1977. The mining industry in the context of South Africa's economic development, 1910–1940. Seminar Paper, Institute of Commonwealth Studies, London.

Innes, D. 1984. *Anglo American and the rise of modern South Africa*. Johannesburg: Ravan Press.
JSE (Johannesburg Stock Exchange). 1948. *The story of the Johannesburg stock exchange: 1887–1947*. Johannesburg: Committee of the Johannesburg Stock Exchange.
Kaplan, D. 2010. Manufacturing in South Africa over the last decade: A review of industrial performance and policy. *Development Southern Africa* 21, no. 4: 623–44.
Kidd, M. 2011. Developments in South African environmental law during 2010: Focus on two decisions relating to mining, IUCN Academy of Environmental Law, e Journal Issue 2011, 1. http://www.politicsweb.co.za/politicsweb/view/politicsweb/en/page71656?oid=196410&sn=Detail.
Murray, M. 2008. *Taming the disorderly city: The spatial landscape of Johannesburg after apartheid*. Cape Town: UCT Press.
Naicker, K., Cukrowoska, C., and T.S. McCarthy. 2003. Acid mine drainage from gold mining activity in Johannesburg, South Africa and environs. *Environmental Pollution* 122: 29–40.
Nuttall, S. 2009. *Entanglement: Literary and cultural reflections on post-apartheid*. Johannesburg: Wits University Press.
Nuttall, S., and A. Mbembe, eds. 2008. *Johannesburg: The elusive metropolis*. Johannesburg: Wits University Press.
Parnell, S. 1988. Public housing as a device for white residential segregation in Johannesburg, 1934–1953. *Urban Geography* 9: 584–602.
Parnell, S., and A. Mabin. 1995. Rethinking urban South Africa. *Journal of Southern Africa Studies* 21, no. 1: 39–61.
Rogerson, C., and J. Rogerson. 1995. The decline of manufacturing in inner city Johannesburg, 1980–1994. *Urban Forum* 6, no. 1: 17–42.
Sassen, S. 2009. Cities in today's global age. *SAIS Review* 1: 3–32.
Scott, P. 1951. The Witwatersrand goldfield. *Geographical Review* 41, no. 4: 561–89.
Seccombe, A. 2012. Central Rand goes back to basics. *Business Day*, 16 April.
Shorten, J. 1970. *The Johannesburg saga*. Johannesburg: John Shorten Proprietry Limited.
Tomlinson, R., A. Beauregard, L. Bremner, and X. Mangcu, eds. 2003. *Emerging Johannesburg: Perspectives on the post apartheid city*. New York and London: Routledge.
Van Onselen, C. 1982. *New Babylon, new Nineveh: Everyday life on the Witwatersrand 1886–1914*. Johannesburg and Cape Town: Jonathan Ball Publishers.
Viljoen, M. 2009. The life, death and revival of the Central Rand Goldfield. *World Gold Conference* 2009: 131–8.
Wilson, F. 1972. *Labour in the South African gold mines, 1911–1969*. Cambridge: Cambridge University Press.
Wilson, F. 2001. Minerals and migrants: How the mining industry has shaped South Africa. *Daedalus*, 130, no. 1: 99–121.
Yudelman, D. 1984. *The emergence of modern South Africa: State, capital and the emergence of organized labour on the South African goldfields, 1902–1939*. Cape Town: David Philip Publisher.

14 The wrong side of the mining belt? Spatial transformations and identities in Johannesburg's southern suburbs

PHILIP HARRISON AND TANYA ZACK

Absences and insights

The southern suburbs are the *terra incognita* of urban scholarship in Johannesburg. Hart (1968) dealt expressly with this part of Johannesburg and a few other contributions have provided insights into specific aspects of the history and development of the southern suburbs (e.g. Mooney 1998; Parnell 1988). The seemingly mundane spaces of the historically white working-class south have remained largely outside the purview of the academic elite in Johannesburg, who have directed their attention to either the spaces of the black working class or to the glitzy spaces of the north.

The south is the in-between space, seemingly neither poor enough nor rich enough to warrant serious attention. However, the southern suburbs offer urban researchers a wealth of insight into processes of socio-spatial development in the city. They provide an intriguing window into the social lives and identities of a diversity of groups, but also into the social and cultural construction of space. The shaping of space in the south cannot be separated from the emergence and consolidation of a white working class in the early decades of Johannesburg's mining and industrial history; the state response to an influx of largely destitute rural Afrikaners; the arrival of southern European immigrants in significant numbers from the 1940s; the rapid expansion of the white middle class in the 1950s and 1960s; the rapid expansion of a black middle class from the 1990s; and the arrival of large numbers of African migrants, including those from Mozambique, Zimbabwe, the Congo, Nigeria and Somalia.

The southern suburbs elucidate many other spatial processes shaping Johannesburg with a clarity missing elsewhere in the city. Here the spatial fragmentation of the city is barely concealed. The area as a whole retains a level of separateness that has outlasted the south's distinctive role as a space of the white working class. The suburbs are a motley, poorly connected collection of neighbourhoods, developed separately at different times, with little apparent thought for internal integration or citywide connections. A book celebrating the Turf Club racecourse offers a commentary on its location in the lacklustre southern suburbs:

> It is not the most beautiful situation; one might even suppose it to have been chosen by mistake. Close by, on the north and west, sit mine dumps … to the south and east lie squat, working class suburbs, their density broken here and there by public transport depots, low-rise commercial and industrial buildings and other uglinesses. (Collings 1987: 10)

There are few other spaces in the city where the legacy of mining is so clearly present in the urban landscape. The mining belt creates a physical and perceptual barrier between the southern suburbs and the central-north of the city, and its undermined status for many years froze this belt against development. However, as the old mining land is progressively redeveloped, so the built environment surrounding and intruding into the southern suburbs evolves. This sets the area apart as one of the few places in the city where industrial and residential landscapes are deeply entangled. The development trajectory of the southern suburbs also reflects the spatial effects of state investment in transportation infrastructure. The arrival of freeways in the 1970s and 1980s had a dramatic expansionary impact, opening up a large swathe of land to suburban development. In this chapter we elaborate on these insights with a narrative that broadly follows a chronological ordering. Before doing this, however, we provide a brief scan of the southern suburbs.

A scan of the southern suburbs

The southern suburbs stretch in an irregular belt between Soweto in the west and Alberton (in the Ekurhuleni Metropolitan Municipality) in the east (Figure 14.1). Historically, it was bordered by mining land in the north and the Klipriviersberg in the south but the southern suburbs have now extended into the mining belt, and over and beyond the Klipriviersberg. There is also a sharp differentiation within the area, with common reference to the 'old South' – an area of historically white, compact, working-class suburbs and some associated industrial development – and the 'new South', an area of middle- and upper-middle-class suburban development that emerged from the late 1960s.

Almost every journey to and from the southern suburbs traverses the scarred landscapes associated with mining land, while some of the suburbs are literally wrapped around old mines: West Turffontein, for example, completely surrounds a slime dam while Ormonde is one of the suburbs developed on the old Crown Mines site. Most of the mines closed in the 1970s and gradually (and fitfully) the derelict mining land has been rehabilitated. Today slime dams and mine dumps, and land sterilised by undermining, still interrupt

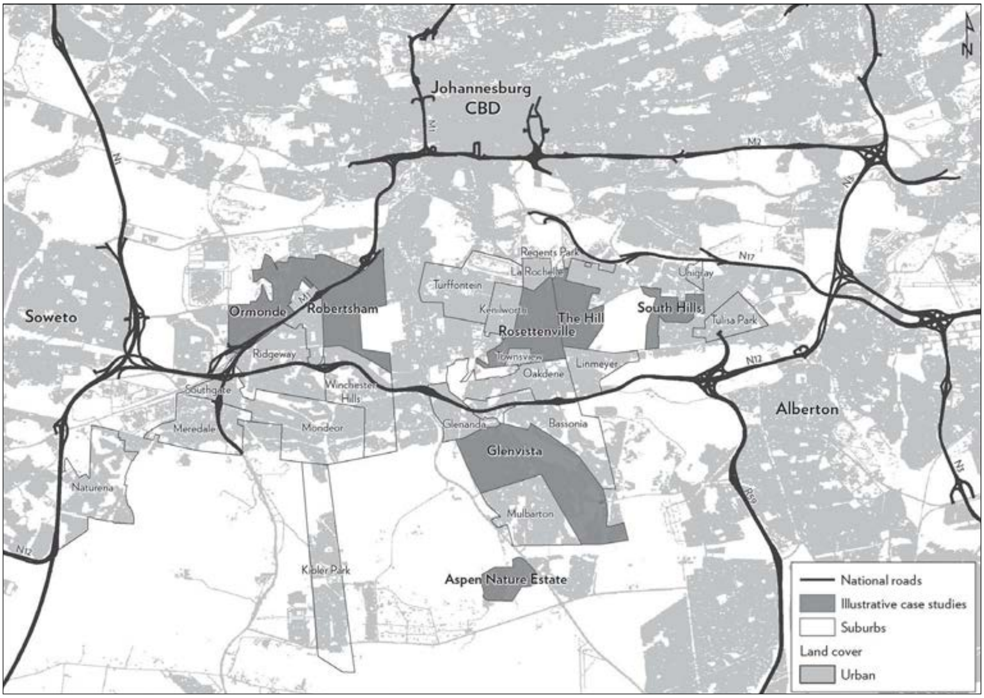

FIGURE 14.1: Johannesburg's southern suburbs, 2009 (indicating suburbs referred to in this chapter)
Data sources: AfriGIS (2011); GTI (2009). Cartography by Jennifer Paul

suburbia, but there is an assortment of other land uses including residential development, industry, warehousing and wholesale outlets, and recreational and cultural facilities.

The 'old South' is a historically white working-class area that has housed skilled and semi-skilled workers and been a gateway for working-class immigrants from southern Europe. The core of this area constitutes the suburbs of Rosettenville, Kenilworth, Turffontein, La Rochelle and Regents Park. While each is distinctive, these older suburbs comprise small semi-detached and bungalow-style houses with intermittent row housing and medium-rise walk-ups. They are flanked to the east by the slightly higher-valued residential areas of Linmeyer and The Hill as well as the sub-economic housing estate of South Hills developed for 'poor whites', and suburbs such as Unigray and Tulisa Park built for white railway and factory workers. To the west lies the low-middle-class Robertsham, which forms the northern edge of a first belt of emerging middle-class southern suburbs that begin to traverse the hills of the Klipriviersberg, formerly the southern boundary to this part of Johannesburg. Mondeor, Ridgeway, Meredale and Kibler Park are characterised by detached housing set in gardens and a number of shopping malls. At their southern edges they overlook the residential developments that sweep across the hills of the 'new South'.

The 'new South' is an expanding area for the middle class and upper middle class, and is characterised by private homes set in large gardens, face-brick townhouse developments and also a number of shopping malls. The suburbs include Winchester Hills, Glenanda,

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The power of mining: the fall of gold and rise of Johannesburg

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The City of Johannesburg has developed through the entire life-cycle of the mining industry. In its early years, its development was tied to the varying, but generally upward, fortunes of the mining industry. During this time, gold mining in Johannesburg, and along the Witwatersrand, propelled the growth of South Africa's national economy into a phase of self-sustained development, and created an integrated labour market across southern Africa. It also played a key role in shaping the racial oligarchy that dominated South Africa until the fall of apartheid in the 1990s. However, gold was eventually to decline, first in the areas around Johannesburg, and then elsewhere. The growth of Johannesburg, however, continued and the urban economy became increasingly diversified and flexible. This growth seemed divorced from mining but was, in fact, deeply rooted in the history of mining. The mining industry played an intimate role in the development of the manufacturing sector and also in the emergence of financial services; which is currently the leading economic sector in Johannesburg. These economic changes are represented in continuous evolution of the spatial form of the city. Currently the physical legacy of mining is understood mainly in terms of its deleterious environmental consequences, including acid mine drainage, with the long and profound impact of mining on the patterning of urban growth largely forgotten.

Keywords: Johannesburg; mining; gold; labour; urbanisation; economy

> Will the gold-reef last; and the big city and the hiving population that have grown up around it – will these also endure? Or can it be that the Reef is approaching exhaustion, and that all its correlative interests are doomed to extinction? (Chilvers 1948, 222).

For almost the first half of the city's existence, there was a deep anxiety amongst its residents that Johannesburg would collapse when the mines closed. The mines eventually did shut down but the power of mining in Johannesburg is such that it ignited the development of an economy that outlived the mines and continued to grow and flourish.[1]

This contribution focuses on the development of Johannesburg through the full life cycle of the gold mines, and beyond. It shows how Johannesburg – in common with a few other cities in the world such as Melbourne and San Francisco – transcended the boom–bust scenario of a minerals-based economy and evolved into a diverse and competitive agglomeration. It supports the argument of Davis

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(1998), which challenged a conventional view that economies initially dependent on mining inevitably have substandard economic performance in later years.

The analysis focuses specifically on the Central Rand Goldfield, where large-scale, deep-level gold mining first began in South Africa, and where Johannesburg was proclaimed as a mining settlement in 1886. Central Rand is one of seven distinct gold fields in South Africa, and during its long history of productive activity has produced 15% of South Africa's total gold output. Its importance in terms of physical production has however declined progressively – from 80% of total gold output nationally in 1911 to 3% in 1980 and nearly zero currently[2] – but the economic weight of the urban agglomeration it spawned continues to grow.

The development of Central Rand, and then of outlying gold fields along the ridge of hills known as the Witwatersrand, did, of course, do far more than produce the City of Johannesburg. Yudelman (1984, 9) wrote that, 'The major influence behind the telescoped development of modern South Africa – the leap from a fledgling quasi-state to a surprisingly advanced modern industrial state within the space of eighty years – a process that took centuries in Europe – was the South African gold mining industry'. Innes (1984, 69) referred to the development of the gold mining industry as:

> formative, not only in terms of establishing the capitalist relations of production which were to be the basis of subsequent growth in the industry itself, but also in conditioning the form of evolution of wider social relations in the country, including such phenomena as the migrant labour system, the character and form of the state and the system of labour relations.

The analysis here is divided into two sections: 1886–c.1948 and c.1948–2012. There is a clear rationale for the starting date as this was when the main gold-bearing reef of the Witwatersrand was discovered. The rationale for the divide at 1948 is twofold: 1948 is a political watershed as it was the year that the National Party took power in South Africa and introduced its policy of apartheid, but it also roughly marks the commencement of a period in which manufacturing eclipsed mining as the core of the national and local (Johannesburg) economy.

The article brings together a significant existing literature on the mine labour (Wilson 1972, 2001; Crush 1986; Crush, Jeeves, and Yudelman 1991; Yudelman 1984) with work on: the political economy of mining (e.g. Innes 1984) and of Johannesburg (Beall, Crankshaw, and Parnell 2002); and the changing spatial configuration of Johannesburg (Beavon 2004; Tomlinson et al. 2003). It updates this with reference to recent data and analysis on the mining industry and the changing economy of Johannesburg.

1886–1948: The rise of gold and the rise of Johannesburg

The Witwatersrand

When the Witwatersrand gold fields were first opened up in 1886, there was a ready market for gold as the major European economies were tied to a gold standard, and the liquidity of their currencies depended on a ready supply of the metal. The mining of the gold was, however, extremely costly. For although the gold reefs on the Witwatersrand break the surface in small outcrops, they dip steeply into the earth,

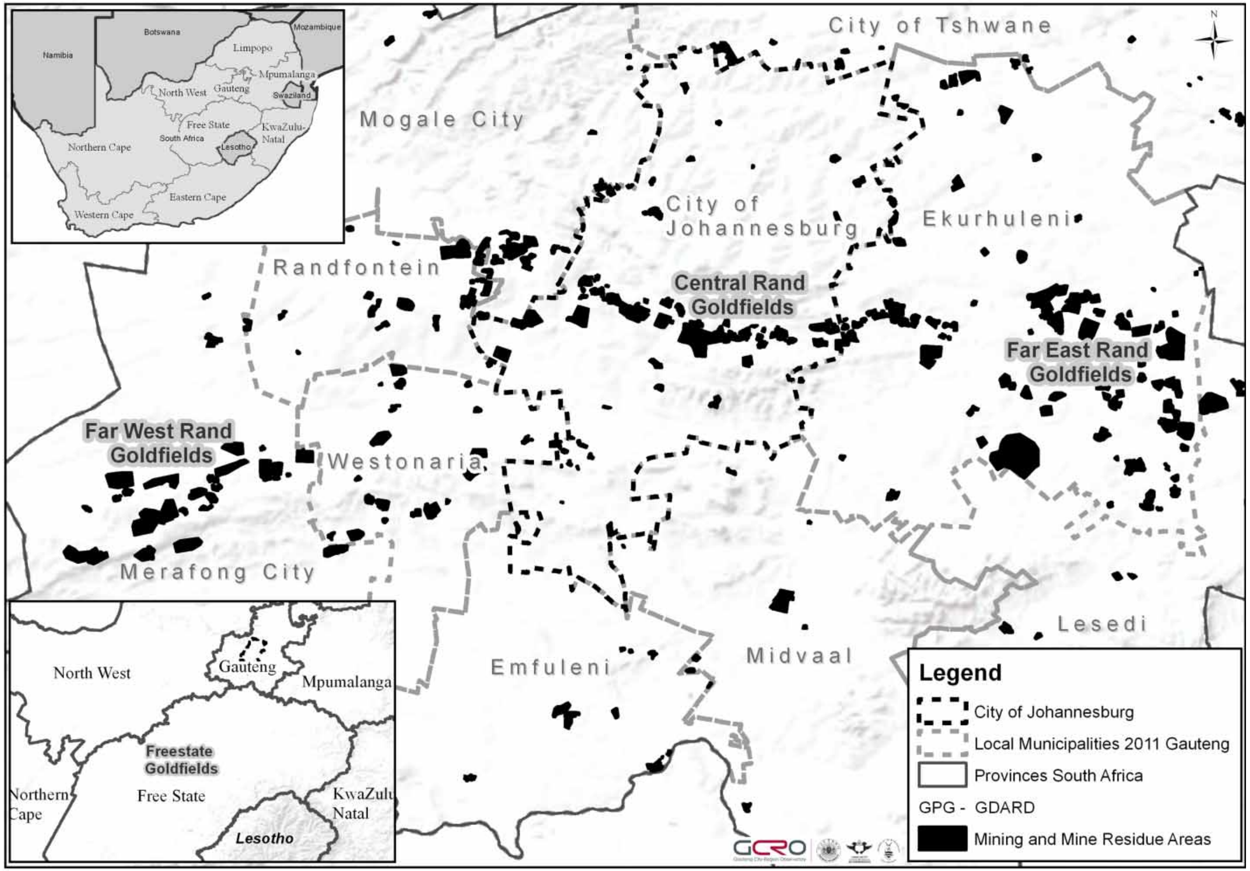

Figure 1. South Africa's gold fields.
Source: Gauteng City Region Observatory (GCRO).

requiring deep-level mining, with expensive technologies, for extraction (Beavon 2004; Innes 1984). It was because of this that a small-scale artisanal mining economy never developed, and that the new gold field was soon dominated by a handful of 'Randlords' who had made their fortunes on the Kimberley diamond fields, and who were backed by international investment capital. These Randlords founded the six dominant mining houses[3] in order to secure the conditions for the continued expansion of mining. A latecomer was the Anglo American Corporation of South Africa, founded in 1917 with capital from the New York bank J.P Morgan. Although there was never to be the same level of concentrated ownership in gold mining as there was with the diamond industry – which was controlled in a near monopoly by the De Beers Corporation – the mining houses established a form of oligarchic control. Ownership became increasingly concentrated as the Anglo American Corporation came to dominate the industry.

Within a decade of the discovery of the gold-bearing reef, the Witwatersrand was the largest gold-producing region in the world. This placed the region at the centre of a major political drama as Great Britain manoeuvred to wrest territorial control of the gold field from the Boer's *Zuid Afrikaansche Republiek* (ZAR) in the Transvaal. The struggle turned violent with full-scale warfare erupting between Great Britain and the two Boer republics in 1899. British forces occupied Johannesburg in May 1900, achieving its objective of economic *and* political dominance of the gold fields. However, in 1906 Great Britain granted autonomy to the Transvaal, which became part of the Union of South Africa in 1910, and the gold fields were thereafter increasingly shaped by South African, rather than British, capital and interests.

Formation of a mining labour force and the South African nation state

There was no guarantee that the gold mining industry on the Witwatersrand would survive. There was a delicate balance between cost and revenue, as the price of gold was fixed, and gold had to be mined at ever deepening levels. White workers arrived mainly from Great Britain and Australia and provided high-level skills, but their labour was expensive. A conventional colonial colour bar protected the interests of these workers by keeping black Africans out of higher-level jobs, but when profits were squeezed, mine owners tried to modify the colour bar and replace white workers with cheaper black African labour (Yudelman 1984).

There was a bitter struggle between white workers and mining bosses when the government agreed to assist the Chamber of Mines in addressing a severe labour shortage after the war by importing around 60,000 Chinese on indentured labour contracts. The Chinese were all repatriated by 1910, forcing the Chamber of Mines to search elsewhere for cheap labour.

From 1896, the Chamber of Mines coordinated the recruitment of black African labour through the Witwatersrand Native Labour Association (WNLA) but it failed to secure an adequate supply of labour from South Africa's 'native reserves' (later the so-called *homelands*). Two-thirds of black African workers in the period from 1910 to 1928 came from the Portuguese East Coast (now Mozambique), but a demand from the Portuguese government that this labour supply be capped compelled the WNLA to recruit further and further afield, in colonial-controlled territories such as Nyasaland (Malawi), Bechuanaland (Botswana), South West Africa (Namibia), Basutoland (Lesotho), Southern Rhodesia (Zimbabwe) and Northern Rhodesia (Zambia) (Innes 1984; Crush, Jeeves, and Yudelman 1991; Crush and James 1991).

Crush, Jeeves, and Yudelman (1991, 1) wrote that 'there is little doubt that if large numbers of low-wage, unskilled migrant miners had not been recruited from throughout the subcontinent, there would never have been a deep-level gold mining industry in South Africa'. The WNLA's labour recruitment tied much of southern Africa to Johannesburg's burgeoning economy, with the authors describing this as 'South Africa's labour empire' (Crush, Jeeves, and Yudelman 1991, 1). This system of labour recruitment was linked to a pattern of oscillating migration in which male workers were housed in single-sex compounds for limited periods, and returned to families in rural areas when their contracts expired. The state was complicit in supporting this system.

With the extensive use of cheap non-South African labour, mining companies were able to keep the lid on costs for a prolonged period (Wilson 2001). In 1921, however, there was a crisis as the price of gold dropped from 111 shillings per fine ounce to 97 shillings. The Chamber of Mines responded by modifying the colour bar and replacing expensive white labour with black African workers. This provoked a bloody rebellion – in which white workers notoriously marched under the banner 'Workers of the World Unite for a White South Africa' – that was ruthlessly suppressed. Two hundred and fifty people died and the white workers' struggle ended. The so-called Pact Government of the early 1920s pacified white workers by legislating the colour bar but otherwise did not act against mining interests. Throughout this formative period, the state played a critical role in supporting the reproduction of low labour costs to ensure the survival of gold mining, which was so central to the development of the national economy (Innes 1984).

Johannesburg's economic foundations

The spectacular growth of Johannesburg in its early years has been recalled in numerous, mainly romantic, accounts of a mining camp burgeoning into a modern metropolis. A few accounts (notably Chilvers 1948 and JSE 1948) provide a sense of how fragile and contingent this development really was. The initial dependence on gold subjected Johannesburg to the immense volatility of financial speculation.

In 1888/89, there was a great speculative boom in which the average value of mining companies increased five-fold, collapsing towards the end of 1889 when mining companies struck pyritic ore at 100 or so metres below the surface, and had no technical means to extract the gold. Johannesburg seemed doomed to a future as a ghost town. The town was saved in 1891 when a method to extract gold using cyanide was developed. This was followed by a surge in gold shares and another wave of property development, until 1895 when markets crashed because of tensions between the British and the Boers. Mines closed during the war but reopened with great optimism in 1902, only to slump again because of a severe shortage of labour (JSE 1948).

The turbulent roller coaster continued, with peaks of optimism and troughs of despair. In 1930, the future of gold mining and of Johannesburg appeared bleak, with South Africa's Chief Mining Engineer predicting the near collapse of gold mining by 1950 (Shorten 1970). In December 1932, however, South Africa reluctantly followed Great Britain and other major economies in abandoning the gold standard, with extraordinary results. Suddenly freed, the price of gold doubled overnight, and continued to rise over the next five years. There was an 'orgy of speculation in gold shares' (JSE 1948, 89), with massive private profit-taking. The boom incentivised prospecting and exploration, which led directly to the next major wave of mining development in the late 1940s (Chilvers 1948; JSE 1948).

After a peak in gold production in 1941, materials and labour were diverted to the war effort and African labour became increasingly militant (Chilvers 1948). The next speculative boom was in 1945, and again in 1948, when high yields from the newly discovered Free State gold field were confirmed (Chilvers 1948, 262).

In all of this, Johannesburg's role in the physical production of gold was declining. Central Rand's production peaked around 1911, when the gold field accounted for 80% of South Africa's output. During World War I, highly profitable mines were opened on the Far East Rand by the newly established Anglo American Corporation, and from 1923 this new gold field eclipsed Central Rand. During the 1930s, the Far West Rand was opened up, and when the Free State gold fields developed, the relative position of Central Rand declined further. Between 1938 and 1949, Central Rand accounted for 34% of national production (Scott 1951; Viljoen 2009).

Johannesburg nonetheless continued to grow in power, economic size and population because the mining companies, and also the stock exchange, were headquartered in central Johannesburg, channelling profits towards the city. This was reinforced by the rise of the Anglo American Corporation of South Africa, which, unlike the London-based Gold Fields of South Africa, was a South African company with headquarters in the centre of Johannesburg. In the 1940s, Anglo American became a multinational, expanding its interest northwards in Africa, with 51% control of the Zambian copper mines. It also gained ownership of the De Beers Corporation in the 1920s, and so held a monopoly over the diamond industry.

Johannesburg experienced a process of diversification beginning in the early twentieth century. The development of the mines created an immediate demand for industrial production such as iron and steel, explosives, construction materials and chemicals. The first major industrial development happened in 1890 when President Kruger granted a concession for the development of an explosives industry to the Nobel Trust. In 1913, a mining and property development company established Union Steel Corporation as South Africa's first steel producer. During World War I, South Africa faced a disruption to its supplies of imported manufactured goods, spurring the country to manufacture domestically. By the end of the war, South Africa had emergent industries in sectors including electricity, steel, engineering, chemicals, construction materials and clothing, and many of these industries were established in and around Johannesburg, where the mines and the growing population provided a ready market (Innes 1984).

There was a direct and continued involvement in the development of industry by the mining sector. Union Corporation, for example, established the South African Paper and Pulp Industries (SAPPI); Rand Mines spawned the Portland Cement Company; JCI owned South African Breweries (SAB); and Gold Fields operated factories producing clothing, metals, chemicals, construction materials and food. Importantly, the mining industry was also central to the development of an electricity producing and distribution industry. In 1906, the Chamber of Mines supported the establishment of the Victoria Falls and Transvaal Power Company to provide electricity to the mines until the Electricity Supply Commission (ESCOM) was founded in 1922.

Tariff protection introduced by the Pact Government from 1924 significantly aided manufacturing, and there was a further surge in the development of import replacement industry during World War II. At the end of the war, manufacturing was as important to the national economy as mining, with its contribution to GDP having risen from 10% in 1918 to 25% in 1945 (Innes 1984).

A tight link existed between mining and tertiary services. From the beginning mining needed large amounts of capital to finance production, and finance houses quickly emerged alongside the mining houses, with interlocking directorships. Banks and building societies were established in Johannesburg from the 1880s (such as the United Building Society, now part of ABSA Bank) or moved their headquarters to Johannesburg (for example, Nedbank and Standard Bank of SA). The formation of the Johannesburg Stock Exchange (JSE) in November 1887, which supported the equity requirements of the mining industry, was also a critically important development in strengthening Johannesburg's position as the centre of South Africa's emergent industrial and business economy.

Johannesburg's spatial expansion

Johannesburg's changing social structure is not dealt with in detail in this article, but one of the most striking social outcomes of mining that must be noted was the city's changing demographic profile. In 1911, there were only 36 females per 100 males, with 77 per 100 for the white population, and only five per 100 for the black African population. In 1946, towards the end of the first period of study, the overall figure was 75 females per 100 males, with 101 for whites and 56 for black Africans.[4] As sex ratios were narrowing, class differentiation was widening. Van Onselen's *New Babylon, New Nineveh* (1982) provides wonderful detail on the emergence of working class cultures in Johannesburg.

The spatial evolution of early Johannesburg was profoundly shaped by the physical presence of mining and by the hierarchies and intersections of a society that emerged around the mines. Johannesburg quickly emerged as the central node in a string of settlements in a nearly 50 km east–west belt along the gold-bearing reefs of the Witwatersrand. The mining belt was a defining physical feature, with settlement on both sides but mainly to the north as the land to the south was underlain by reefs and reserved mainly for future mining activity.

After the discovery of gold, mining claims were pegged out on privately owned farms along the reef, with mining camps spreading out north and south of the diggings. The formal settlement of Johannesburg was however proclaimed on a triangular piece of leftover state-owned land – *uitvalgrond* – immediately north of the mining belt. The settlement was not considered to be permanent and it was laid out crudely on a tight grid with small blocks (Beavon 2004).

Johannesburg had an improbable location and existed only because of a gold reef with uncertain prospects, but the mining camp soon burst into a bustling town with 'banks, shops, hotels and boarding houses, a stock exchange, and the inevitable saloons and brothels' (Beavon 2004, 6). Within 10 years, Johannesburg was the largest urban centre in Africa south of the equator, and its population of 102,000 exceeded that of Cape Town (Chipkin 1993). The trajectory of growth was not smooth, with the brusque fluctuations of the mining economy, and the effects of war and other disturbances, affecting the rate of population and physical growth. During the slump from 1889 to 1891, one-third of the population left the Witwatersrand, and there was another exodus during the South African War (Shorten 1970). By 1928, however, the government had sufficient confidence in the future of Johannesburg to formally proclaim it a city.

The mining boom of the 1930s brought rapid growth to Johannesburg and dramatic urban transformations. This was the time when the inner city went high-rise. Chilvers (1948, 235) notes that ‘Buildings were continually being torn down and replaced by modern skyscrapers. Telephones, power, transport just couldn’t keep pace with Johannesburg’s development. And the pace was getting faster – and faster’. Alongside the control and repression of black settlement in the city, white space was experiencing a massive building boom as over 10,000 apartments were created on the north-eastern edge of the inner city. The rapid development of manufacturing in the 1940s was linked to the emergence of a string of industrial estates along the mining belt and around the edge of the inner city. The tertiary sector, including commerce and finance, consolidated in the inner city (Tomlinson et al. 2003).

The socially and racially segregated and unequal nature of Johannesburg’s development has been the central theme in many accounts of the city’s development (Guillaume 2001; Beall, Crankshaw, and Parnell 2002; Murray 2008). Beavon (2004) observes that Johannesburg’s geography of segregation was apparent from as early as 1887 and that the patterns that shaped almost all future development were firmly in place by 1904.

By 1904, more than 100,000 black Africans, and large numbers of Chinese, were corralled in regimented single-sex compounds on mining property along the Witwatersrand. Initially the compounds were built of iron and wood, but later there were concrete, barrack-like structures with rooms housing 20 to 50 workers each (Crush and James 1991; Crush, Jeeves, and Yudelman 1991). Not all black Africans, however, lived in these compounds. As black Africans entered employment in other sectors, migrants found accommodation in municipal compounds and also in slums in and around the centre of town and in domestic accommodation in white residential areas. This led to the inter-racial proximity that the city council refused to accept, provoking a long history of attempts to segregate the race groups (Parnell and Mabin 1995). The origin of Soweto, for example, was as early as 1903 when the city council moved black Africans living in a slum in present-day Newtown to a remote settlement 16 km south-west of Johannesburg called Klipspruit, ostensibly in reaction to threats of bubonic plague.

From the time of the Native Urban Areas Act, 1923, which prevented black Africans from purchasing or renting land in white areas, the local authority gradually developed segregated housing estates to which black Africans were moved. The whole of the municipality of Johannesburg was proclaimed white by 1933[5] and by the late 1930s the local authority had used the provision of the Slums Act 1934 to clear mixed-race inner city neighbourhoods, and move black African residents to newly built townships such as Orlando. Much of the new township development was situated at some distance south of the mining belt in the area that became Soweto, thus establishing a fundamental divide in the structure of the city (Tomlinson et al. 2003; Beavon 2004). Indian and coloured (mixed race) communities maintained their foothold near the inner city, in places like Fietas, until the apartheid era, when they too were forced into peripheral townships.

By 1904, the wealthy white elite, including the Randlords, were occupying the high-lying ridges to the north of the mining belt away from the dust and noise of the mines, establishing a pattern of wealthy suburban development in a northwards direction. The white mine-workers who had arrived in Johannesburg from abroad lived in small but solidly constructed bungalows in suburbs strung out along the edges of the mining belt; the Jewish migrants from Eastern Europe and the Russian Empire lived in Yiddish-speaking enclaves in the east of the town; the Afrikaners who had arrived from the farms lived in generally poor neighbourhoods in the west of Johannesburg (Chipkin 1993; Beavon 2004). By the 1930s, the city council developed sub-economic housing estates for 'poor whites', often on land where racially mixed slums had been cleared (Parnell 1988). While extreme forms of segregation are generally associated with the system of apartheid, all of this was happening before 1948. The mining industry was a key driver in the increasing levels of urban segregation, and provided the template for the socio-spatial engineering of the National Party government in later years.

Although the dominant representation of Johannesburg has been of a divided and segmented city, recent literature, informed by post-colonialist theory and cultural studies, directs attention to the cross-over and syncrecity that was also a feature of Johannesburg's development (Nuttall and Mbembe 2008; Nuttall 2009; Bremner 2010). In the pre-apartheid era, there were cultural melting pots where new cultural formations emerged. The British, European and Russian immigrants forged a new English-speaking identity in Johannesburg while a creolised African working class identity arose from the inner city slums. There was also racial mixing that persisted into the 1940s despite the local authority's efforts to separate out the various groups.

1948–2012: The decline of gold and the rise of Johannesburg

Gold and labour force fluctuations

By the end of World War II, South Africa still accounted for 40% of the world's total gold output, with the mines around Johannesburg producing about one-third of the national output. The powerful trends away from mining were, however, already in motion.

In 1944, the Allied Nations signed the Bretton Woods Agreement that reinstated the gold standard and pegged the price of gold at US$35 per troy ounce. Once again South Africa was assured of a steady market for its gold, but with a fixed price and rising costs profit margins came under growing pressure. South Africa's gold production peaked in volume in 1970 when it accounted for 78% of global output, but most mines were economically marginal and the future was uncertain (Viljoen 2009).

In 1971, however, the United States unilaterally left the gold standard and the gold price soared to US$800 by 1980, bringing new prosperity to the South African gold mining industry. In spite of a decline in gold production the revenue earned from gold mining climbed dramatically from R830 million to R10 billion. The 1980s were more difficult. The gold price fluctuated between US$300 and US$500, but

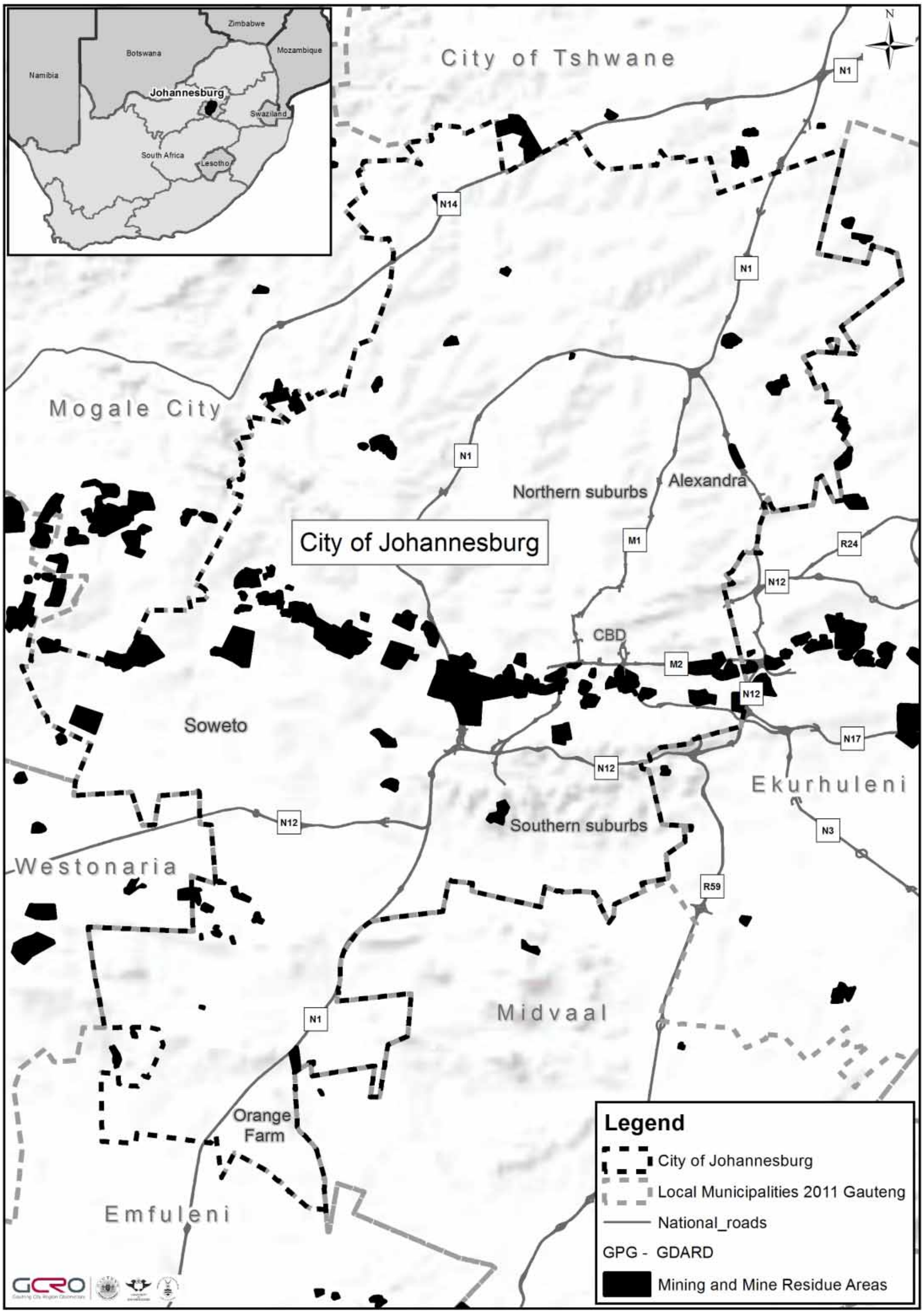

Figure 2. The physical footprint of mining in Johannesburg.
Source: Gauteng City Region Observatory (GCRO).

profits gradually declined, and there was almost no new investment in gold mines (Crush, Jeeves, and Yudelman 1991).

The effects on the labour force were far-reaching. The Chamber of Mines had responded to the cost pressures of the 1960s by expanding the use of foreign labour, with foreign workers accounting for nearly 80% of South Africa's total labour force in 1973 (Innes 1984). In the mid-1970s, however, there was a dramatic change as the colonial government in Mozambique collapsed, abruptly ending labour supply, and as the government of Malawi ordered 120,000 mineworkers to return home (Crush, Jeeves, and Yudelman 1991).

Increasingly, mines had to draw on local labour, and the number of South Africans employed on the mines rose from 87,000 in the mid-1970s to 333,000 in the mid-1980s. Deteriorating conditions in rural South African homelands and the stagnation of the manufacturing economy ensured that there was a strong supply of South African workers. For the first time in the history of gold mining in South Africa there was a surplus of labour (Wilson 2001).

Apartheid was in its final stages, as evidenced by a number of reforms, including: a rapid increase in the real wage of mine workers in the 1970s; recognition for the National Union of Mineworkers (NUM) in 1980; the abolition of the system of influx control into urban areas in 1986; and the lifting of the colour bar in 1988. With mechanisation of the mines there was more demand for skilled labour, and so there was growing talk of the need to 'stabilise' the workforce (Crush, Jeeves, and Yudelman 1991). The system of mining compounds and of oscillating migration did not end, however, with the lifting of influx control. Gold mining companies generally did not follow De Beers Corporation, which had abolished single-sex compounds on diamond mines and provided family accommodation. Instead there was a gradual loss of control over the compounds as families moved in with male workers or found accommodation in burgeoning informal settlements.

Johannesburg and the New South Africa

When South Africa made its transition to democracy in the early 1990s, it was still the world's dominant gold producer, accounting for 44.5% of global output, but difficult days were ahead. In 2010, South Africa produced only 191 tons of gold, 7% of global output, slipping to fifth in the world production rankings (Chamber of Mines 2011).

In the 1990s, mining employment in South Africa fell by 40%, and a further 179,000 jobs were lost between 2001 and 2011. In February 2012, mining production had hit a 50-year low, with the mining sector accounting for less than 5% of GDP. The sector had not only failed to benefit from the commodities boom of the 2000s but was contracting sharply. Gold was worst hit, with a 7% annual contraction in production since 2000, and an 11% decline in 2011 (*Business Times,* 9 June 2012). This deeply constrained the ability of the state to extract rent from the mining sector.

This slump in gold mining has had a severe impact on the economies of gold-producing areas, including towns in the Far West Rand and Free State, but has had no apparent effect on Johannesburg, where other sectors had long since replaced mining. In one sense, the situation in Johannesburg was worse than nationally as the Central Rand Goldfield declined more quickly than elsewhere. By the 1960s, the average profitability per ton of rock mined was only R1.92 for the Central Rand compared with R5.48 for the Far West Rand and R5.59 for the Free State (Cockhead 1970). All the large mines operating on Central Rand[6] shut down by the late 1970s, bringing production on the gold field to a near halt, although the high gold price did allow for the retreatment of old mine dumps (Viljoen 2009). Beall, Crankshaw, and Parnell (2002) calculated that gold mining's share of total employment for Johannesburg fell from 23% in 1946 to 1% in 1996. Very recently, new technologies have made ultra-deep mining feasible and restored the prospect of mining in the Central Rand, but to date efforts to implement the new technologies have not been successful (Seccombe 2012).

To understand the paradox of Johannesburg's continued economic growth despite the collapse of the Central Goldfield, it is necessary to look at the city's position as the economic hub of South Africa's national economy since 1948, which entails its continued role as the corporate rather than physical centre of mining and its continued urban economic diversification supported by the mining companies. The Johannesburg-based Anglo American Corporation, in particular, wielded immense economic power and political influence in South Africa, and was extending its reach internationally (Innes 1984).

In 1999, however, Johannesburg's pre-eminent position in the mining world experienced a setback when Anglo American merged with Minorco and transferred its headquarters and primary stock exchange listing to London. Anglo American did, however, retain a strong presence locally and Johannesburg remains the headquarters of at least seven companies in the Mining Top 100. Johannesburg thus remains a prominent node within a global corporate network of mining firms.

Johannesburg's economy diversified rapidly in the post-war era. In the 1950s and 1960s, manufacturing was the sector that most obviously led growth. Although this put pressure on wage rates in mining, the large mining companies played a dominant role in supporting manufacturing. Anglo American, for example, increased its manufacturing interests in the 1960s by 470% (Innes 1984).

The mines created original demand for industrial products, but a new process was underway in which mining companies expanded into multi-sector conglomerates, with industrial interests not necessarily linked to mining activity. From the 1970s, however, South Africa's manufacturing sector stagnated, and attempts at resuscitation by promoting export-led industrialisation largely failed.[7]

Specialised services, especially finance, took over from manufacturing as the lead sector in the South African economy. Here, too, mining companies played a leading role, becoming a central part of an expanding chain of financial power. Anglo American had significant equity stakes in major banks (Nedbank, Barclays and Standard) and in other financial institutions (such as Eagle Life Assurance) (Innes 1984).

Johannesburg's economic and spatial restructuring

Johannesburg remained at the centre of these economic transformations. Its own economy went through a profound process of change. Mining continued its seemingly inexorable decline. Manufacturing employment grew until around 1980 and then declined sharply thereafter, with its share of Johannesburg's total employment dropping from 24% to 13% in 1996 (Beall, Crankshaw, and Parnell

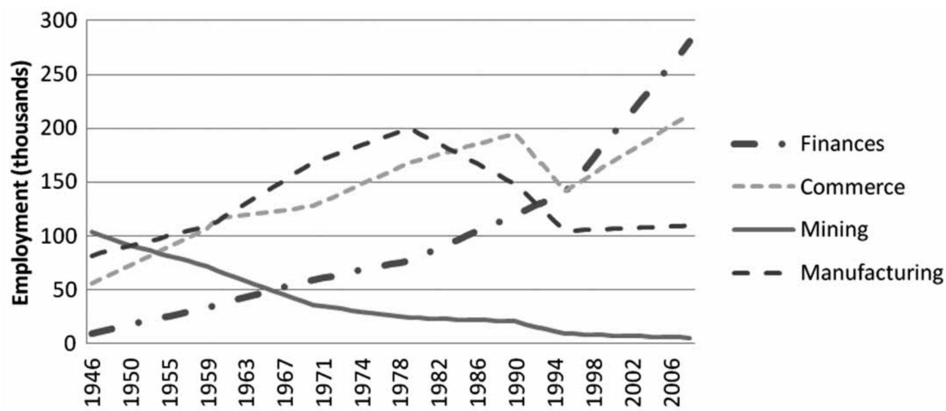

Figure 3. Change in employment by sector 1946–2009, Johannesburg.
Source: Beall, Crankshaw, and Parnell (2002), Quantec.
Data sources: Beall et al. (2002); Quantec

2002; Rogerson and Rogerson 1995). Community, personal and social services grew steadily until around the 1990s and then experienced modest employment decline. It was finance, insurance and real estate that continued growing and eventually outperformed all other sectors.

Initially, the rise of manufacturing more than compensated for the decline of mining and Johannesburg's economy performed well. In the 1980s, however, the decline of both manufacturing and mining took its toll, and Beall, Crankshaw, and Parnell (2002, 33) report 'a negative average annual rate of growth per capital gross geographic product per capita GGP of minus 0.6 percent'.[8]

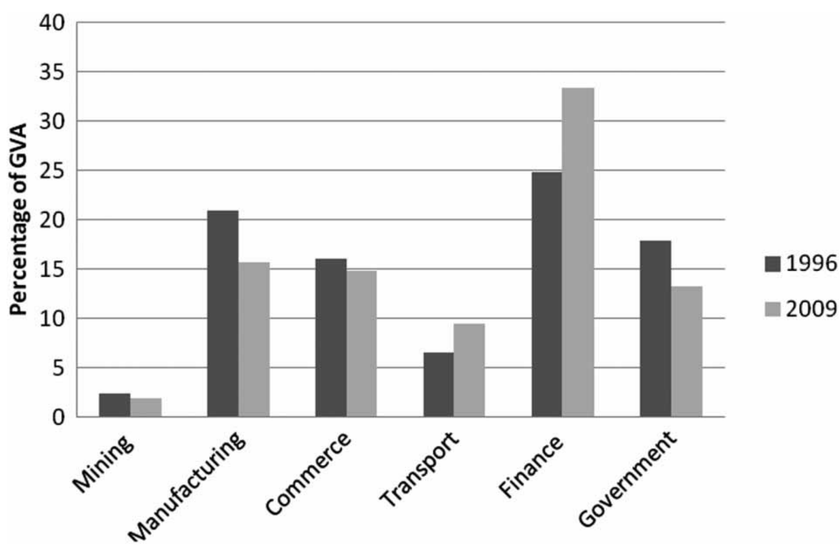

Figure 4. Change in contribution to GVA by sector 1996–2009, Johannesburg.
Source: Quantec.

In the period 1996 to 2009, however, Johannesburg's economy performed well. The local economy grew at an annual average of 4.5% measured in gross value added (GVA). This was higher than the national average of 3.3% and higher than that of any other metropolitan area in South Africa.[9] Johannesburg was consolidating its economic dominance of South Africa.

As Figure 4 shows, mining's direct contribution to GVA in the democratic era is almost negligible, and manufacturing has continued its relative decline, although there has been modest absolute growth. Finance has had the most impact on growth, with its contribution to GVA rising from 24.8% in 1996 to 33.4% in 2009. Johannesburg has emerged as a global service centre in banking, finances and related services (Hamilton 2006). Sassen (2009) ranks Johannesburg as the 22nd city in the world in the 'financial dimension', with a ranking of 8 for 'derivatives contracts' and 10 for 'commodities contracts'.

Present-day Johannesburg, with the economic structure and growth performance of a successful post-primary and post-industrial city, is far removed from its mining origins. However, Johannesburg remains deeply connected to its mining past, with its new flagship sector, finances, having evolved from the financial needs and power of mining.

Spatial transformation of the apartheid city

Although the broad pattern of Johannesburg's spatial pattern may have been established in the early decades, political and economic transformations have had far-reaching effects on spatial configuration. When the National Party took power in 1948 Johannesburg was already a highly segregated city as the city council had cleared most of the racial mixed neighbourhoods by the end of the 1930s and the workforce in the mines was extremely segmented. Apartheid was ruthless and extreme in separating out the remnants of integration, although it ultimately failed in its objective of absolute segregation.

The late 1940s to the early 1970s were the heyday of apartheid and a period of rapid economic growth underpinned by the expansion of manufacturing. This was accompanied by the suburban expansion of white residential areas in the north and south of the city. White suburbia initially developed in areas to the south of the city, ultimately becoming white working class neighbourhoods. The locational impetus for these settlements came less from mining and more from the presence of iron and steel works. It was in this period that the apartheid government developed large segregated townships with no industrial or commercial base for black Africans – most notably the agglomeration of townships that became known as Soweto – and eliminated racially mixed cultural melting pots such as Sophiatown and Western Native Township.[10]

The movement of Africans to the city continued apace and had reached 455,000 by 1948. The workforce for the mines remained in the compounds but there was an involvement of the mining industry in township development. In the 1950s, the founder and head of Anglo American, Sir Ernest Oppenheimer, provided a low-interest loan to Johannesburg City Council to construct 50,000 housing units in Soweto for families who were then living in shanty towns and emergency camps (Beavon 2004). This initiative, which accelerated the development of Soweto, may have represented an early attempt by the mining sector to create a more stable

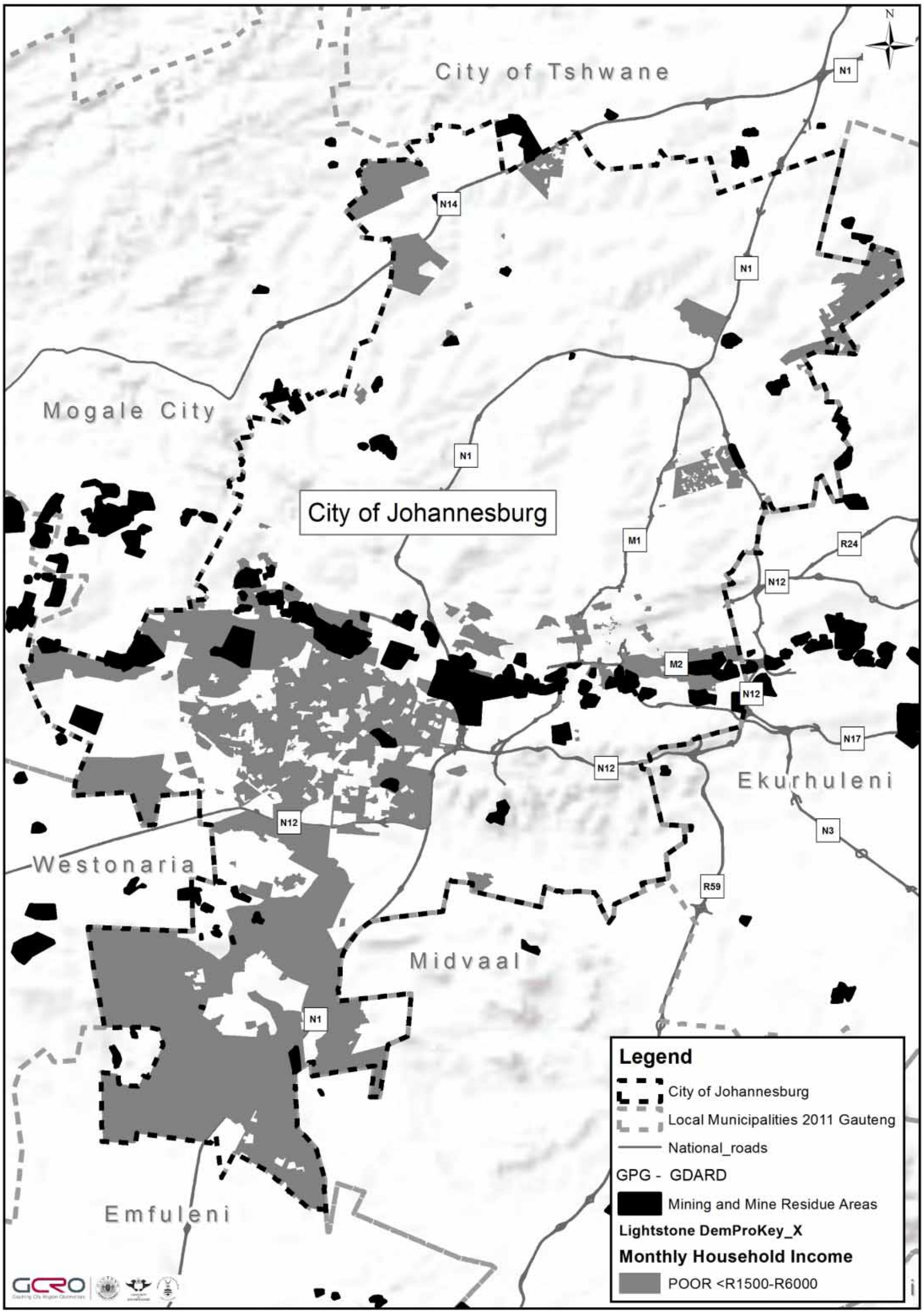

Figure 5. The mining belt in relation to areas of poverty in Johannesburg.
Source: Gauteng City Region Observatory (GCRO).

environment for labour, but it was not followed up in subsequent years. Mining compounds remained almost exclusively the residence of black African mineworkers until the arrival of democracy in the 1990s.

While the state was regulating and structuring the life of black residents, the rapid economic growth – which primarily benefited the white middle class – coupled with the expansion of freeways, supported suburban sprawl to the north of the city. There was a rapid expansion of industrial land around the inner city and along the mining belt as well as near townships with labour supply such as Alexandra. The tertiary sector was also growing, although not yet as dominant as manufacturing, concentrated in the inner city until the 1970s.

From about the time of the Soweto uprising in 1976, Johannesburg entered a new phase in its physical development. With the government having halted its large-scale township development and the system of influx control collapsing, informal settlements and backyard shacks reappeared in the city. After the abolition of influx control in 1986 the government tried to direct new settlement by black Africans to newly created townships such as Orange Farm and Diepsloot on the urban edge as African urbanisation accelerated.

The shift in economic structure from a manufacturing base to the services and financial sectors led to a more diffused spatial form that related to commercial and office decentralisation beginning in the late 1960s. Johannesburg became a sprawling multi-modal urban agglomeration, with private investment happening mainly in the prosperous north. Sandton emerged as the centre of the growing financial services sector, eventually eclipsing the inner city as the core of private sector enterprise in the city.

With the closure of the mines, new land was released for development, but the toxicity of the land and the large number of slimes dams and mine tailings was a major constraint. The largest landowner on the segment of the mining belt in Johannesburg, Rand Mines, established a property development company, which gradually reclaimed land for residential, industrial and business purposes.

Johannesburg in democratic South Africa

The democratic era, from 1994, brought a series of complex transformations to Johannesburg, which represented both change and continuity. As formal business left for the expanding nodes in the northern parts of the city, the private sector invested heavily on the northern frontier, creating new ‘edge cities’. Meanwhile, there were dramatic land use and demographic shifts in the inner city. Informal traders and new immigrant communities from across Africa established a large presence. Against the background of pent-up housing demand in black townships and the rise in both internal and sub-Saharan urbanisation to the city, there was an influx of people occupying abandoned inner city buildings and infrastructure, resulting in overcrowded and distressed living spaces. The first decade of the twenty-first century saw many of these buildings converted to low- to middle-income housing opportunities. The inner city encapsulated the competing forces and complexities of gentrification, decline, housing opportunity and exclusion. At the same time, an emerging black middle class left the townships and moved into previously white suburbs, while state-subsidised housing, largely on the edge of the city, created new ghettoes of poverty.

The physical legacy of mining was reasserted during the post-apartheid period. The continued presence of the compounds was a bitter reminder of the past, with government committed to demolishing them or refurbishing them as family accommodation. Mining companies also agreed to this in the Mining Charter 2003. Implementation of the programme was slow and halting as it competed with the multiple demands for state housing subsidies. While some progress has been made with the 'hostel eradication programme', a number of large hostels remain along the old mining belt.

The rehabilitation and redevelopment of the mining belt accelerated demand for industrial, commercial and residential land, renewing growth of the city since the 1990s. The city administration has proposed an east–west corridor of development to knit together the wealthier north and poorer south, but the development has been driven mainly by the strategies of the mining companies. There is a lingering dispute over the right of a municipality to impose planning controls on mining land, but a recent judgment of the High Court in the Western Cape upheld the right of municipalities to regulate land development on all land within their jurisdiction (Kidd 2011). This, together with a plan to consolidate all mine tailings along the mining belt at a single site, may lead to more coherent land development away from the extremely disjointed patterns at present.

A deep concern currently is the danger of acid mine drainage arising from previous gold mining activity. As water percolates into old mines, slimes dams and dumps it is exposed to pyrites and other sulphides and becomes acidic. As water pumps no longer operate, this acidic drainage gradually rises and eventually spills onto the surface, threatening vegetation, water courses, human health and even the foundations of buildings. There have been belated efforts by government and mining companies to address this threat but the levels of acid mine drainage are still rising and have reached the surface in places (Naicker, Cukrwosja, and McCarthy 2003; Kidd 2011).

Conclusion

In common with a handful of other cities which have survived the boom–bust cycle of a mineral economy, Johannesburg owes its origins to mining. What is also important, however, is the *contingency* of Johannesburg's development. The mining industry in Johannesburg, shaped by considerations ranging from geotechnical to geopolitical, took a political form that had immense consequences for the future development of the city, but also for the shaping of social, political and economic formations and relations across southern Africa and beyond.

The minerals revolution that followed the gold discoveries fuelled far-reaching processes of urbanisation; shaped the nature of labour relations in southern Africa for more than a century; tied the development of communities from the rural parts of South Africa and neighbouring countries to the requirements of mining on the Witwatersrand; and provided the template for socio-spatial engineering of the apartheid government. Johannesburg was originally built to serve the mining industry and this is reflected in its spatial structure.

Mining has faded but Johannesburg has continued growing. Today Johannesburg can hardly be regarded as a mining city. However, the industries and sectors that now dominate Johannesburg's economy are themselves a product of a mining history.

Johannesburg's current status as an emergent global service centre in finance owes much to the historical links between mining and banking.

The extent to which the ills and the virtues of the large and complex urban agglomeration, of which Johannesburg is the core, is owed to mining is poorly understood and rarely acknowledged. In recent years, however, the ghost of the mining past has reappeared with the environmental threats posed by acid mine drainage, and also with some renewed prospects for mining within the Central Rand Goldfield. The future is uncertain but gold mining is unlikely to emerge again as a major economic activity. Johannesburg's economic prospects rest mainly on its ability to consolidate its role as a financial and service centre at a time of global and national economic vulnerability.

Acknowledgements

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Notes

1. Beavon (1997, 153) first wrote that 'gold . . . ignited the development of Johannesburg'.
2. Figures provided in Viljoen (2009).
3. Consolidated Gold Fields of South Africa, Rand Mines, General Mining, Union Corporation, and Johannesburg Consolidated Investments (JCI) collaborated through the powerful Witwatersrand Chamber of Mines.
4. See the National Population Census reports of 1911 and 1946 available in the national government and legal deposit libraries in South Africa.
5. In response to resistance from black freehold landowners and because the municipality could not provide alternative accommodation for all the Africans that it would need to house, the adjoining areas of Sophiatown, Newclare and Martindale were exempted from the declaration (Beavon 2004).
6. From west to east the mines were: Durban Roodepoort Deep, Rand Leases Mines, Consolidated Main Reef, Crown Mines, Robinson Deep, City Deep, Simmer and Jack.
7. The cause of this decline in performance has been extensively debated, with observers pointing to racial policies which prevented the growth of a black middle class and so restricted the size of the domestic markets, declining productivity and protectionism which prevented a competitive export market from developing (Bell 1995; Kaplan 2010).
8. Comparability of statistics is a problem. Figures for GGP were only provided between 1968 and 1991. Since 1996, private firms (Quantec and Global Insight) provide modelled estimated of economic output for municipalities for South Africa but these boundaries do not coincide with the previous statistical boundaries.
9. Based on figures provided by Quantec.
10. Segregated townships were also built for the Indian (Lenasia) and coloured (Eldorado Park and Ennerdale) groups.

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References

Beall, J., O. Crankshaw, and S. Parnell. 2002. *Uniting a divided city: Governance and social exclusion in Johannesburg*. London: Earthscan Publications.

Beavon, K. 1997. Johannesburg: A city and urban area in transformation. In *The urban challenge in Africa: Growth and management of its large cities*, ed. C. Rakodi, 150–91. Tokyo: United Nations University.

Beavon, K. 2004. *Johannesburg: The making and shaping of the city.* Pretoria: University of South Africa Press.

Bell, T. 1995. Improving manufacturing performance in South Africa: A contrary view. *Transformation* 28: 1–34.

Bremner, L. 2010. *Writing the city into being: Essays on Johannesburg, 1998–2008*. Johannesburg: Fourthwall Books.

Chamber of Mines of South Africa. 2011. *Annual Report, 2010/11*. Johannesburg.

Chilvers, H. 1948. *Out of the crucible*. Johannesburg: Juta and Co.

Chipkin, C.M. 1993. *Johannesburg style: Architecture and society 1880s–1960s.* Cape Town: David Philip.

Cockhead, P.J. 1970. The East Rand: A geographical analysis of the transition of the economic base of the region from gold mining to manufacturing, and its effects upon future economic development. MA thesis, University of the Witwatersrand.

Crush, J. 1986. The extrusion of foreign labour from the South African gold mining industry. *Geoforum* 17, no. 2: 161–72.

Crush, J., and W. James. 1991. Depopulating the compounds: Migrant labour and mine housing in South Africa. *World Development* 9, no. 4: 301–16.

Crush, J., A. Jeeves, and D. Yudelman. 1991. *South Africa's labor empire: A history of black migrancy to the mines.* Cape Town: David Philip.

Davis, D. 1998. The minerals sector, sectoral analysis, and economic development. *Resources Policy* 24, no. 4: 217–28.

Guillaume, P. 2001. *Johannesburg – Geographies de l'exclusion*. Paris and Johannesburg: Karthala/IFAS.

Hamilton, M. 2006. Global cities of the South: Mexico and Johannesburg in an era of globalization. MA thesis, University of Stellenbosch.

Innes, D. 1977. The mining industry in the context of South Africa's economic development, 1910–1940. Seminar Paper, Institute of Commonwealth Studies, London.

Innes, D. 1984. *Anglo American and the rise of modern South Africa*. Johannesburg: Ravan Press.
JSE (Johannesburg Stock Exchange). 1948. *The story of the Johannesburg stock exchange: 1887–1947*. Johannesburg: Committee of the Johannesburg Stock Exchange.
Kaplan, D. 2010. Manufacturing in South Africa over the last decade: A review of industrial performance and policy. *Development Southern Africa* 21, no. 4: 623–44.
Kidd, M. 2011. Developments in South African environmental law during 2010: Focus on two decisions relating to mining, IUCN Academy of Environmental Law, e Journal Issue 2011, 1. http://www.politicsweb.co.za/politicsweb/view/politicsweb/en/page71656?oid=196410&sn=Detail.
Murray, M. 2008. *Taming the disorderly city: The spatial landscape of Johannesburg after apartheid*. Cape Town: UCT Press.
Naicker, K., Cukrowoska, C., and T.S. McCarthy. 2003. Acid mine drainage from gold mining activity in Johannesburg, South Africa and environs. *Environmental Pollution* 122: 29–40.
Nuttall, S. 2009. *Entanglement: Literary and cultural reflections on post-apartheid*. Johannesburg: Wits University Press.
Nuttall, S., and A. Mbembe, eds. 2008. *Johannesburg: The elusive metropolis*. Johannesburg: Wits University Press.
Parnell, S. 1988. Public housing as a device for white residential segregation in Johannesburg, 1934–1953. *Urban Geography* 9: 584–602.
Parnell, S., and A. Mabin. 1995. Rethinking urban South Africa. *Journal of Southern Africa Studies* 21, no. 1: 39–61.
Rogerson, C., and J. Rogerson. 1995. The decline of manufacturing in inner city Johannesburg, 1980–1994. *Urban Forum* 6, no. 1: 17–42.
Sassen, S. 2009. Cities in today's global age. *SAIS Review* 1: 3–32.
Scott, P. 1951. The Witwatersrand goldfield. *Geographical Review* 41, no. 4: 561–89.
Seccombe, A. 2012. Central Rand goes back to basics. *Business Day*, 16 April.
Shorten, J. 1970. *The Johannesburg saga*. Johannesburg: John Shorten Proprietry Limited.
Tomlinson, R., A. Beauregard, L. Bremner, and X. Mangcu, eds. 2003. *Emerging Johannesburg: Perspectives on the post apartheid city*. New York and London: Routledge.
Van Onselen, C. 1982. *New Babylon, new Nineveh: Everyday life on the Witwatersrand 1886–1914*. Johannesburg and Cape Town: Jonathan Ball Publishers.
Viljoen, M. 2009. The life, death and revival of the Central Rand Goldfield. *World Gold Conference* 2009: 131–8.
Wilson, F. 1972. *Labour in the South African gold mines, 1911–1969*. Cambridge: Cambridge University Press.
Wilson, F. 2001. Minerals and migrants: How the mining industry has shaped South Africa. *Daedalus*, 130, no. 1: 99–121.
Yudelman, D. 1984. *The emergence of modern South Africa: State, capital and the emergence of organized labour on the South African goldfields, 1902–1939*. Cape Town: David Philip Publisher.

Glenvista, Mulbarton and Bassonia. These suburbs were built against the Klipriviersberg range, and are among the most attractive residential neighbourhoods of Johannesburg. They have, since the 1990s, been supplemented with the affluent gated communities of Aspen Hills and Aspen Lakes – security villages of often ostentatious homes surrounded by swathes of open land, all monitored by guards and cameras. Although a 20-year splurge of residential development occurred from the late 1960s, the south still lags behind the north in terms of the scale of development.

Identity-in-place: the makings of a white working class, 1886 to 1945

Working-class 'respectability'

The development of the southern suburbs was closely tied to the formation and evolution of Johannesburg's white working class. The southern suburbs offered a less desirable location than the northern parts of Johannesburg as they had a harsh micro climate with south-facing slopes and winds blowing the dust from the mine dumps into residential areas. Developers quickly marked out the area for the working class by subdividing the land into relatively small stands – generally around 500 m^2 compared with a norm of between 1 000 m^2 and 4 000 m^2 in the northern suburbs (Hart 1968). The area was initially designated for skilled artisans (electricians, plumbers, builders, carpenters, boilermakers and so forth) who serviced the mines and other emerging industries of Johannesburg. It was an area of 'working-class respectability', reflected in the sturdy workers' cottages laid out in strict gridiron pattern.

A key physical and institutional presence in the south was the Turffontein Racecourse. This introduced a strong gambling culture into the south which has persisted to this day, but it also brought Johannesburg's elite – on occasion, at least – into the working-class suburbs. The Johannesburg Turf Club initiated much of the residential development in the 'old South', including the suburb of Turffontein as it developed or sold off portions of its land holdings (Collings 1987).

In the early years there was a rush of township establishment in a broad crescent to the south of the mining belt.[1] After about 1910, however, development tailed off as opportunities for residential development expanded in the north of the city. From 1910 to 1940 relatively few new residential areas were laid out and these catered for a slightly higher-income group.[2]

By 1931 only about 14.9 per cent of Johannesburg's white population lived in the south, a figure that increased only gradually to around 16 per cent in the 1960s (Hart 1968).

The tramline between the Johannesburg CBD and the southern suburbs sustained suburban expansion as it provided the critical link across the mining belt in an era when private car ownership was still relatively low in working-class suburbs. The electric tram was introduced to the south in 1906 and gradually extended until the early 1930s (Spit 1976).

The southern suburbs were not the only spaces of the white working class in Johannesburg, but they did exhibit peculiar characteristics linked to their ethnic mix. The white working class at the time was segmented between an Afrikaner grouping that had arrived from rural areas of South Africa and included a significant proportion of 'poor whites'; Yiddish-speaking Jews from the western parts of the Russian Empire who came to the goldfields with few resources but with the advantage of a long intellectual and educational tradition; and a relatively skilled English-speaking grouping from the mining regions of the United Kingdom, including Cornwall, Wales and north England.

Afrikaners settled mainly in the west of Johannesburg and Jewish immigrants in a band extending north-east from Doornfontein and Hillbrow. English speakers settled in centrally located suburbs along the Witwatersrand Ridge, including Brixton, Jeppe and Malvern. The southern suburbs were more ethnically and linguistically mixed although they were initially English-dominated. In the 1930s, small groups of Jewish families were clustered around the Rosettenville-La Rochelle and Ophirton synagogues (Rubin 2005).[3] The Afrikaner presence in the southern suburbs was also relatively small to begin with but it was to expand significantly: in 1938, 20.4 per cent of the municipal voters in the southern suburbs were Afrikaans speaking but this increased to 44.2 per cent by 1961 (Stals 1986).

English-speaking immigrants brought a tradition of trade unionism that meshed with a history of Afrikaner struggle. In 1922 – when white workers marched under the banner 'Workers of the World, Fight and Unite for a White South Africa' – English and Afrikaner workers drilled together on the streets of Turffontein, La Rochelle, Regents Park and Booysens, and organised attacks on police stations and neighbouring mines (Krikler 2005). In 1924, the (mainly English-speaking) Labour Party, which was strong in the southern suburbs, collaborated with the (mainly Afrikaans-speaking) National Party to form the Pact Government, which introduced measures to protect white labour. The possibility existed of a broad front of white labour that would have been well represented in the ethnically diverse south. However, from the 1930s, instead of a continued process of white working-class formation, there was the 'growth of a distinct Afrikaner working class consciousness and a sense of cultural distance from English-speaking workers' (Visser 2005: 141).

'Poor whites'

In the 1930s the number of Afrikaners on the Witwatersrand expanded rapidly as drought and other dire circumstances in rural areas forced thousands of Afrikaners to move to the cities in what historians have referred to as 'the last Great Trek' (Van Jaarsveld 1982). The newly arrived Afrikaners mobilised along ethnic lines and established their own churches, trade unions and social and cultural organisations. Many of these Afrikaners were destitute and fell within a category known as 'poor whites'. Economically, poor whites were protected by the policies of job reservation introduced by the Pact Government but they competed with Africans for accommodation in inner-city slums and often resided in racially mixed precincts. Parnell (1988) argues that it was this racial mixing that most offended the municipal authority and which prompted it to intervene in the 'poor-white problem'. Thus, during the 1930s the Johannesburg City Council tried to separate racial groups into different housing estates – moving Africans to Orlando, coloureds to Coronationville, and whites to sub-economic housing estates in areas such as Bertrams and Jan Hofmeyr near the inner city. In this way, what may have formed the seeds of an integrated society were forcibly splintered by the state.

In the 1930s, planning commenced for around 2 000 sub-economic houses for whites, to be built on open land east of the southern suburbs. The proposed development provoked strong opposition from the established working class in the area but the municipality persevered and eventually around 530 houses were built (Parnell 1988). The housing estate was laid out using Garden City principles 'in a half-baked way' (Parnell 1993: 83) and when it was proclaimed in 1942 the estate was patronisingly called 'Welfare Park'. In the 1960s the name of the estate was changed to South Hills, but the stigma remained. A *Wikipedia* entry, for example, reports that the colloquial name for South Hills is 'Storks', referring to the number of unplanned pregnancies in the suburb.[4]

In South Hills, as in the sub-economic suburbs near the inner city, whites became tenants of a state that was alarmed at the social pathologies of poor-white communities: 'In these new suburbs, poor whites were offered a "proper environment" where they were taught how to be hard-working and respectable good whites' (Teppo 2004: 221). From 1948, there was further development of mainly Afrikaner working-class housing towards the east of the southern suburbs, linked mainly to post-war industrial development.

Post-war developments, 1945 to 1970

The post-war era was accompanied by sustained economic growth, which raised many working-class whites into the middle classes, and also by an influx of European immigrants, including from southern Europe. These processes were to significantly influence the spatial form and social composition of the southern suburbs.

The 'American Dream'

Mondeor and Robertsham, both proclaimed in 1948, were the largest of the middle- and new lower-middle-class suburbs built to meet the housing demand of servicemen returning from the war, and in the 1940s and 1950s, middle-class expansion was modest. By the 1960s, however, a sustained period of rapid economic growth in South Africa eventually translated into a middle-class lifestyle among white South Africans that was comparable to that of post-war USA. This was reflected in the mini housing boom in Mondeor, described vividly by an interviewee who grew up in the suburb:

> This late, miniature version of the 'American Dream' was expressed in a lifestyle where just about every family had two cars, wives worked in offices in downtown Johannesburg and could be seen waiting for the morning bus in their stiletto heels, tight skirts and beehive hairstyles. Swimming pools were constructed on many of these newer properties, and Penguin Pools, who seemed to have the monopoly on pool construction, were a byword amongst house-proud suburbanites.[5]

Immigrant gateway

From the mid 1940s the southern suburbs emerged as a gateway for immigrant communities arriving from southern Europe (and neighbouring Mediterranean states). Smuts's immigration programme of 1946 was an attempt to fill the skills gap in the post-war era. It brought Greek, Lebanese, Italian, Portuguese, Irish, Polish and other immigrants to the working-class suburbs of Johannesburg.

The initial immigration scheme was short-lived, as Smuts was defeated in 1948 by Afrikaner nationalists who discouraged the immigration of dark-skinned, mainly Catholic southern Europeans, preferring Germans and Dutch. In the 1960s, however, when rapid economic growth led to a growing skills deficit, the National Party government relaxed its immigration policies, allowing for a further (and expanded) influx of immigrants from southern Europe (Glaser 2010; Peberdy 2009). Browett and Hart (1977) identify the southern suburbs as a major point of concentration for these immigrants, with Portuguese migrants clustering in La Rochelle, Regents Park, Rosettenville, Kenilworth and Turffontein.

Glaser (2010) explains that the earliest wave of Portuguese arrivals came from the impoverished island of Madeira. This group had been trickling into South Africa from the end of the nineteenth century, and continued to do so until the 1970s. They found a home in unfashionable suburbs where houses were cheap and often shared by an extended family. The second wave involved Portuguese from the mainland who generally had higher levels of education and skill but who also found an entry into Johannesburg in the southern (and eastern) suburbs. The second wave reached its peak in 1966 when over 8 700 immigrants were recorded as arriving from mainland Portugal. The Portuguese occupied an ambivalent position within white South Africa. As Glaser put it, 'they were white, yes, but on the margins: exotic, darker-skinned, Catholic, poorer than most whites, less educated, keeping to themselves, unpredictable in their loyalties' (2010: 77).

Greek and Lebanese communities also occupied an ambivalent position in South Africa's white society, which was predominantly Protestant and of northern European origin.[6] Some of the communities made special efforts to prove their identification with their host society. One interviewee noted that in their efforts to integrate into South Africa as enfranchised whites, Lebanese immigrants abandoned their language and did not speak it to their children.[7]

Youth culture

The identity of the 'old South' was shaped in the context of its diversity of white working-class communities. The youth culture of the south was especially important in shaping this identity.

The Ducktail gangs of working-class neighbourhoods in Johannesburg in the 1950s shared many of the characteristics of an international youth culture at the time (akin, for example, to the Teddy Boys in the United Kingdom). They were 'rebellious, hedonistic, apolitical and displayed little respect for the law, education or work' (Mooney 1998: 753).

Ducktails were a partial consequence of the post-war immigration programme. As Mooney explained, 'this influx and the social dislocation and insecurity that families experienced in moving to a new country, led to the youths forming themselves into ethnically based groups in search of security, familiarity and a sense of belonging' (2006: 182). The gangs were highly territorial and often ethnically exclusive, with Lebanese and Greek gangs gaining special notoriety. In the southern suburbs there were the Rosettenville Gang and the notoriously violent South Hills Gang, which would clash frequently with gangs from the eastern suburbs. Local gangs claimed territory over certain hotels.[8]

However, despite these divisions, Ducktail culture was hybridised and 'Ducktail argot was an interesting synthesis of English, Afrikaans and "South African English", loosely based on old Cockney rhyming slang ("Rub & Tub") combined with the incorporation of a few Americanisms from the film industry' (Mooney 2006: 120). The blending of the linguistic traits of different groups into a local patois was especially pronounced in the southern suburbs, where it was famously captured in 1961 by Jeremy Taylor's hit single 'Ag Pleez Daddy' (also known as 'The Ballad of the Southern Suburbs').

A southern identity

The core of the 'old South' remained resolutely working class. While around 2 per cent of Johannesburg's white population earned more than R10 000 per annum in 1970, the proportional figure for the suburbs of Rosettenville, La Rochelle, Kenilworth, Regents Park and South Hills was less than 0.1 per cent.[9]

Despite the continued working-class identity, there was a switch in political allegiance. From its earliest days the 'old South' had been doggedly supportive of the Labour Party, but in the 1950s the mood shifted. This was evidenced when the Labour Party MP for Rosettenville, Alex Hepple, offended his constituency with his radical politics and was rejected in 1958 in favour of a United Party MP. From then on, there was no obvious political home for the waning white working class.

Our interviewees revealed considerable nostalgia for the 1960s as the heyday of white working-class culture. In that decade, before the arrival of television and the economic and political uncertainties of the 1970s, social life happened in the high streets, hotels, cinemas and sports clubs of the old suburbs. Our respondents reminisced about dancing and partying in the Portuguese Hall, the Italian Club and in local hotels; carousing at the drive-in cinemas; drinking in the Lebanese-run backyard shebeens; sharing late-night milkshakes and toasted sandwiches in the roadhouses (that remained open after hotels had closed their doors at midnight); and socialising at the public swimming pools. Sport was an important element of the local culture with boxing, soccer, rugby, tennis, horse racing and pigeon racing featuring prominently in stories we were told of the 1960s. The south was also remembered as a tough place with gang violence and ethnic rivalries.[10]

The southern suburbs identity that had coalesced by the 1960s was a deliberate counterpoint to perceived behaviours and identities in the north. Residents of the south saw the north as pretentious and effete in contrast to the gritty honesty and practicality of the south. This identity has persisted in the 'old South' although it has been diluted by recent immigration. In a 2004 study on white identity in Johannesburg, it was said of the proletarian south that 'there was no norm of an intellectual culture here. There were elements of a hearty and mean local chauvinism' (Stewart 2004: 134–135).

Spatial transformations

Development through the 1950s and early 1960s was incremantal. However, from the late 1960s powerful processes were to fundamentally transform the face of the south. In the post-war era, private car ownership expanded dramatically, including within working-class suburbs. The electric tramway's key link to the south was closed in 1957, with all tramway operations terminated by 1961 (Spit 1976). The tramways were followed by electric trolley and then diesel buses, but public transportation was in sharp decline. By the 1960s white South Africa was a car-oriented society with levels of car ownership exceeded only in North America, and investment in public transportation was almost entirely abandoned.

The period of sustained economic growth through the 1950s and 1960s largely benefited the politically powerful white population. It lifted a large proportion of the white working class into the middle class and created a pent-up demand for middle-class suburban expansion. This coincided with the freeway developments around Johannesburg and also with the release of land by mining companies for residential development.

There were other changes. In 1961 Southdale, adjoining Robertsham, was established as Johannesburg's first out-of-town shopping centre. It was a modest development but it heralded the beginning of a major shift in retail typology across the city. Furthermore, there was also a significant improvement in the number and quality of services in the southern suburbs, with the white working class proving highly successful in making demands on the state. There were, for example, new recreational facilities, the opening of the South Rand Hospital, and the development of a number of new (mainly Afrikaans-language) schools.

While the southern suburbs were the spaces of the white working class (with some middle-class incursions in the post-war era), there was, importantly, also an island of the African elite. St Peters Secondary School, both a school and a seminary, was opened in 1907 in Rosettenville for African males (the same year that St Agnes School, where 'native girls could be trained as useful servants', was opened in Rosettenville [Joubert 1998: 11]).[11]

The 'new South': suburban expansion in the orbital motorway, the 1970s and 1980s

The next great rush of suburban growth was associated with the planning and construction of Johannesburg's 'orbital motorway', which dramatically changed the relative advantage of locations in the south for new development. The construction of Johannesburg's ring road began in the late 1960s and proceeded in phases until the N12, or southern bypass, was finally completed in 1986. It was the anticipation of the N12 that led to the emergence of the so-called 'new South'.

There were 25 township establishments in the 1970s. These were middle-class suburbs that profoundly changed the class composition of the south. By the end of the 1980s, it was no longer possible to characterise (white) Johannesburg in terms of the wealthy north and working-class south, as the south had expansive middle-class areas (the 'new South') as well as the traditional working-class suburbs (the 'old South'). The expansion was facilitated by the Johannesburg City Council, which was incrementally and deliberately expanding its boundaries to incorporate peri-urban areas.

The new suburbs had individual properties around four times larger than in the 'old South'. With little regard for environmental considerations, developers built over the hills of the Klipriviersberg, taking advantage of the spectacular views offered along the ecologically sensitive ridges.

During the 1970s, suburban development in the south actually outpaced that of the north of Johannesburg (Beavon 2004). This growth, however, slowed markedly from the mid 1980s, coincident with the stagnation of the South African economy and infrastructural constraints on expansion to the south. Such constraints included a lack of sewer outfall capacity and stronger environmental controls, such as the proclamation of the 680-hectare Klipriviersberg Nature Reserve in 1984.

Strategies of the mining companies

Alongside the development of freeways, the strategic decision of mining companies to release land for property development was a significant force in the expansion of the south. In the early 1960s, eight large gold mines operated in the Central Rand Goldfield immediately adjoining the southern suburbs, but all had closed by the late 1970s owing to the growing cost and difficulty of deep-level mining (Viljoen 2009).

Much of the mining land was dangerously undermined and environmentally damaged but significant tracts of land held development opportunity. The biggest land owner by far was Rand Mines Limited with a huge tract of land across the mining belt, comprising at least 13 per cent of the land area of Johannesburg Municipality at the time (Prinsloo 1993).

In 1968, Rand Mines Property (RMP) was established and listed on the Johannesburg Stock Exchange. An architectural and planning office was set up at RMP under the directorship of well-known architect Ivor Prinsloo, and a Master Plan for the area was produced by a consortium led by Roelof Uytenbogaardt from the University of Cape Town. The plan proposed restructuring development by grouping land uses, organising east-west movement, and reclaiming derelict land for residential, industrial, business and recreation purposes in a systematic way (RMP 1969, 1971). Many of the proposals were advanced for their time, including the idea of an express bus route that prefigured the present-day Bus Rapid Transit system.

The choice portion of RMP land was the old Crown Mines site. Multiple proposals for its use were outlined, with Ormonde New Town development as a central feature

(Prinsloo 1993). The planning for Ormonde was cutting edge, grounded in ideals of urban ecology and drawing on an *avant-garde* modernism.[12] The plan was, however, devised within the context of the Group Areas Act, and Ormonde was intended for around 40 000 middle- to upper-middle-income whites, separated from Soweto by a buffer of industry and warehousing (RMP 1969, 1971).[13]

Ormonde was proclaimed in 1973 but it never attracted the white middle class as expected. The development was interrupted by the 1976 Soweto uprising which created growing anxiety around white residential settlement near black townships.[14] But Ormonde expanded incrementally over time and more rapidly when apartheid barriers began to break down and, in a departure from the original vision, lower-middle-class residential demand was catered for.

Beyond Ormonde, the staccato development of the mining belt continued with RMP (later known as iProp) developing 1 065 hectares of land between 1968 and 1980 for uses including a fresh produce market, a flower market, the Gold Reef City casino, industrial townships and office developments. Among the largest developments were the government-sponsored Nasrec Expo Centre (1984) and Nasrec Soccer Stadium (1989) on the Crown Mines site on land purchased from the mining company. In 2010, the refurbished stadium was a centrepiece in the FIFA Soccer World Cup.

A Portuguese influx

The spatial development of the 'old South' during the 1970s and 1980s was gradual, but it was socially significant. There was a shift in character as the Portuguese community became increasingly dominant in some areas, especially around Rosettenville, Regents Park and La Rochelle.

In the mid 1970s the Portuguese administrations in Angola and Mozambique collapsed, and large numbers of colonial Portuguese fled to South Africa where many found a home in the southern suburbs of Johannesburg. Eventually as many as 400 000 Portuguese were living in South Africa with perhaps as many as 70 000 in the southern suburbs. The Portuguese-medium newspaper *O Século de Joanesburgo*, with its offices in Ormonde, claimed a circulation of 40 000 and a readership of over 200 000 (Glaser 2010).

Glaser reveals that these newcomers established their own Mozambican and Angolan associations when they arrived in South Africa, but that they were drawn into the established Portuguese communities by the ties of language and church. Portuguese cultural life in the southern suburbs proliferated.[15]

The (colonial) Portuguese influx reinforced the conservative, family-oriented traditions of the 'old South'. With many of the Portuguese being tradesmen, the increasingly shabby suburbs in the south were given a makeover, and Portuguese cultural markers like blue porcelain tiles, grapevines and religious statues became local features. Rosettenville and La Rochelle became known for their Portuguese eateries. The Portuguese-style Nando's fast-food restaurant, established in Rosettenville in 1987, expanded into a global chain and is now represented in 34 countries.

Democracy and space in the southern suburbs, the 1990s onwards

Differentiated change

There have been far-reaching socio-spatial transformations in the southern suburbs associated with the arrival and consolidation of democracy in South Africa, and that are indicated in the figures provided by Census 2011.[16] An initial overview of the data revealed a high degree of differentiation within the southern suburbs and even within the broad categories 'old South' and 'new South'. Post-apartheid spatial transformations have been far from uniform.

The data suggest that the southern suburbs may now, broadly speaking, be divided into at least seven demographic zones, each with distinctive characteristics but with the inevitable blurring of boundaries between (see Figure 14.1):

1. The historic core of the 'old South' (Rosettenville, Turffontein, Kenilworth, Regents Park and La Rochelle);
2. The sector of the 'old South' historically characterised by public housing for 'poor whites' (e.g. South Hills, Unigray, Tulisa Park);
3. Suburbs in the 'old South' which were historically of higher income than the core (e.g. The Hill, Townsview, Oakdene);
4. Suburbs to the east of the 'old South' which were historically developed for the emergent white middle class during and immediately after World War Two (e.g. Robertsham, Mondeor, Ridgeway, Alan Manor, Southdale);
5. A zone of interface with Soweto, with a mix of older developments associated with the old and new South, and new post-1994 expansion (e.g. Ormonde, Meredale, Southgate, Naturena, Kibler Park);
6. The suburbs of the 'new South' developed from the 1970s for the white middle class (e.g. Winchester Hills, Glenanda, Glenvista, Mulbarton and Bassonia);
7. Expansion to the 'new South' through the development of gated nature estates (e.g. Aspen Hills).

Within these zones there is a differential mix of demographic processes, including the in-migration of low-income Africans, both South African and foreign nationals; the in-migration of an emergent and established black middle class; the in-migration of middle-class Indians of South African origin, with a trickle also of new migrants from Asia; white flight from suburbs undergoing rapid demographic transition; and white movement into new enclaves. The southern suburbs have become a cauldron of the changing post-apartheid space and society.

It is impossible to adequately represent the extent and complexity of this transformation, but we illustrate below what has been happening through a brief account of a 'representative' suburb within each zone. Tables 14.1 and 14.2 provide a comparative view of the suburbs, and a more detailed demographic analysis is referred to in the discussions of the suburbs that follow.

Demographic indicators	Rosettenville	South Hills	The Hill	Robertsham	Ormonde	Glenvista	Aspen Hills
1996 population	8 381	3 903	3 170	5 393	1 394	5 471	n/a
2011 population	17 318	8 716	4 092	6 727	9 820	10 176	1 556
% change in population, 1996–2011	+107	+123	+29	+16	+604	+86	n/a
Population density, 2011 persons/km^2	7 569	7 525	2 498	1 959	1 970	1 898	939
% white, 1996	64.8	75.5	75.6	60.9	54.0	77.6	n/a
% white, 2011	12.0	33.3	55.3	23.1	2.3	60.3	42.0
% African, 1996	25.1	15.0	20.2	15.7	20.7	17.8	n/a
% African, 2011	77.1	51.3	30.2	18.0	64.4	23.2	32.2
% Indian/Asian, 1996	2.6	1.9	1.3	16.7	16.0	2.9	n/a
% Indian/Asian, 2011	1.8	2.7	4.8	49.8	20.8	10.5	6.5
% foreign national, 2011	31.2	13.5	19.8	8.5	10.8	12.7	n/a

TABLE 14.1: Comparative demographic indicators for selected suburbs, Johannesburg, 1996 and 2011
Source: StatsSA (1998; 2012)

Economic indicators	Rosettenville	South Hills	The Hill	Robertsham	Ormonde	Glenvista	Aspen Hills
% of households owning homes	19.8	37.8	57.8	64.9	71.6	71.5	80.5
% very poor or indigent households (<R38 400 p.a.)	48.7	42.8	33.2	29.6	16.9	23.3	31.6
% low-income households (R38 400–R307 200 p.a.)	44.8	48.9	42.7	43.4	45.8	29.3	10.4
% middle-income and affluent households (>R307 200 p.a.)	6.4	8.3	23.9	27.0	37.3	47.4	58.0

TABLE 14.2: Comparative indicators of class structure for selected suburbs Johannesburg, 2011
Source: StatsSA (1998; 2012)

Rapid and contested transitions at the core of the 'old South' (Rosettenville)

Rosettenville and its immediately adjoining suburbs were, as noted, the home of a white working class that was predominantly English but with a growing Afrikaner and Portuguese presence in later years. From the 1990s (and especially after 2000) this area has experienced dramatic demographic and social transitions. Large numbers of Africans from South Africa and other African countries have moved in, occupying stand-alone houses, backyard rooms and apartments. According to the 1996 Census report, there were 2 100 Africans in Rosettenville, representing 25 per cent of the suburb's population. By 2011, there were 13 449 Africans, or 78 per cent of the population.

As Africans moved in, the white population left, with the white proportion of the total declining sharply from 65 per cent to 12 per cent, and numbers dropping from 5 437 to 2 079 over the same period of time. Racial change was linked to a shift from owner-occupied dominance to a predominantly rental market. By 2011, fewer than 20 per cent of the population owned their homes.

The increase in foreign nationals resident in the area has also been dramatic. The 2011 Census reveals that 31 per cent (or 50 per cent of Africans) were born outside South Africa. The actual figures may, however, be considerably higher as many transnational migrants live 'under the radar' and don't announce their presence to Census officials. Census figures by country of origin per suburb are not available, but the figures do indicate that the foreign migrants come predominantly from the SADC[17] countries, although there is a significant minority from the 'rest of Africa'.

Indications are that Rosettenville and surrounds have a particularly strong Mozambican presence. La Rochelle, a previously white Portuguese enclave, remains one of Johannesburg's few suburbs where a language classified as 'other' dominated. Here, Portuguese-speaking African Mozambicans have moved in, often renting from white Portuguese home owners.[18] A ward councillor in the area told us that 'the Mozambicans are in La Rochelle, the Congolese in Roseacre, the Nigerians in Rosettenville, South African blacks in Turffontein and the Zimbabweans all over'.[19] This may oversimplify a more variegated pattern, but it does suggest a degree of local ethnic clustering. A 2006 survey by the Forced Migration Programme at the University of the Witwatersrand confirmed the clustering of Mozambicans in the 'old South', not only in La Rochelle but across an area known generally to immigrants as 'Rosettenville', but which includes suburbs such as Turffontein and Kenilworth (Landau 2010).[20]

The ethnic patterning emerging in the area is also happening at a micro scale. Ostanel (2011) wrote of how Mozambican migrants occupy ethnically defined spaces such as eating houses, bars and internet cafes. One of our interviewees reinforced this observation of ethnic clustering and solidarity, telling us that:

> Here we live in a segregated way; we live in groups. When you go to a certain club or a certain restaurant, you will find only Angolans and Mozambicans. In another club you will find Nigerians. In yet another club, 90 per cent of those who go there are Ghanaian. We all have our own particular spots and we know our spot. Everyone knows where to go and where not to go.[21]

A respondent from Cote d'Ivoire says, 'We go to church together, we cut our hair together, we go shopping. We eat in African restaurants; we meet in internet cafes.'[22] The proliferation of hair salons relates to the social function of this activity: the salons cater mainly to customers who have their hair attended to at least twice a week. Here immigrants share news from 'home' and from the local neighbourhood, and discuss tactics necessary to survive in a sometimes hostile environment. Internet cafes perform a similar function: they allow for transnational financial transfers and are places to job hunt and to find out about accommodation possibilities.

But respondents also indicated that ethnic clustering is a safety strategy. For instance, 'Immigrants prefer to frequent bars rather than shebeens, because it is threatening to drink in South African-dominated shebeens, less threatening to drink in more public places.'[23]

Two narratives of contemporary processes of change compete in this part of the 'old South'. The first is of physical decay and rising crime, and the second is of increasing social vibrancy and diversity. Local ward councillors and some long-standing residents point to the migrant influx as a tipping point, and express despair at properties being taken over by criminal syndicates, the emergence of prostitution and drug dealing, and a surge in illegal land uses. One white interviewee bemoaned the invasion of foreigners and the overcrowding, saying that 'the old South is now the new Hillbrow'.[24] A local estate agent advised us that the influx of migrants into the 'old South' has been especially dramatic since 2005.[25] A degree of physical deterioration has clearly occurred in the 'old South' since the early 2000s, as the newcomers are a largely transient, tenant grouping compared with the stable owner-occupier communities of the past. Landlords frequently take advantage of migrants, crowding them into dwellings, extracting unreasonably high rents and failing to maintain properties (Landau 2009).

The competing narrative of a new social (and even economic) vibrancy has to do with new forms of entrepreneurialism and new activities evident in the 'old South'. A businessman who manages retail space pointed to the high levels of entrepreneurialism among new African migrants, arguing that there is still a thriving market for retail in the 'old South' – 'it's just that there are different customers now'.[26] He explained that the demand is now for smaller and shared shop spaces. The new vibrancy is also indicated in the proliferation of informal economic activities such as shebeens, internet cafes, spaza shops, eating houses and hairdressing salons. Our survey of visible informal activity in the core of the 'old South' is mapped in Figure 14.2.

The proliferation of churches is a particular feature of the immigrant presence with Landau referring to religion as one of the key strategies 'for negotiating inclusion and belonging while transcending ethnic, national and transnational paradigms' (2009: 197).[27] Many of the new churches have their origins in Nigeria and the Democratic Republic of the Congo (DRC), and are linked to evangelical and Pentecostal movements across Africa, but Brazil's Universal Church of the Kingdom of God also has a strong presence, offering daily Portuguese-language services for Mozambican and Angolan immigrants.

The role of Rosettenville and adjoining suburbs as an immigrant gateway is similar to that of inner-city Johannesburg, and in some respects this area is a southerly extension of the inner city, leapfrogging the mining belt. However, population pressures and densities are still many times lower than that of the inner city, and also less than in suburbs such as Yeoville, which began the demographic transition about a decade earlier than Rosettenville. Immigrants we interviewed indicated that they are attracted to the 'old South' because it is safer and quieter than inner-city localities.[28]

FIGURE 14.2: Location of informal activities identified in a survey of Rosettenville, La Rochelle, Kenilworth and Turffontein, 2012

Cartography by Geoffrey Bickford

'Poor whites' in a new world (South Hills)

While the white working class in Rosettenville disassembled, the 'poor whites' in South Hills remained. In 1996, there were 2 947 whites in South Hills and by 2011 there were still 2 908, a mere 1 per cent decline. However, the proportion of whites dropped from 75.5 per cent to 33.3 per cent as the population overall more than doubled – driven by the growth of an African and coloured population. We may speculate that, unlike the white communities of Rosettenville, the whites of South Hills lacked the resources to move on.

The case of South Hills is rare in Johannesburg as in almost all instances post-apartheid demographic transition in historically white working-class suburbs has led to a near complete replacement of white residents by black residents. What emerged in South Hills is an unusually integrated suburb with 51.3 per cent Africans, 33.3 per cent whites, 12.2 per cent coloureds and a smattering of other groups.

The class and income profiles of Rosettenville and South Hills are now very similar – both are areas with a mix of indigent and low-income households, with virtually no middle-class residence. There are, however, some differences: in South Hills, Afrikaans remains the dominant language spoken by the white and coloured communities; home ownership is more prevalent, reflecting government efforts to transfer rental stock to ownership; and there are fewer foreign nationals.

Ironically, it is in South Hills, which has long been associated with right-wing politics in the marginalised white community, that there are at least glimpses of an emergent society of racial crossover. The integration process has been fractious and complex but persistent, as explained by Vandeyar and Jansen (2008) in their story of how the previously all-white Afrikaans-language Hoërskool JG Strijdom in South Hills underwent a transition to social and demographic diversity, even changing its name to Diversity High School in 2005.

Relative stability along the ridge (The Hill)

While Rosettenville and some neighbouring suburbs may be attracting attention in the media for crime, grime and decay, there are suburbs in the 'old South' where change is slow. These are suburbs which are working class but which have, historically, had a slightly more elevated income profile than places like Rosettenville or Turffontein. They are a little further away from the grit of the mining belt and are strung out along the ridge with expansive views to the south and northwards to the city skyline.

In The Hill, for example, whites remain in a majority, despite an increase in the African and coloured populations. Overall population increase and densification has been slow – less than 30 per cent over 15 years – and the majority of households are still home owners. Councillors and property agents report stable property markets.[29]

Muslim space in the west (Robertsham)

A mainly Muslim Indian population has concentrated in Robertsham and Ridgeway where there are now six mosques, and, to some extent, also in Mondeor and other neighbouring suburbs. This area now forms part of a broad arc of Indian residence in the city, from Lenasia in the south-west of Johannesburg to Fordsburg and Mayfair on the western side of the inner city. Already in 1996, 16.7 per cent of Robertsham's population was Indian, indicating processes similar to those in Mayfair where Indians gradually infiltrated despite the Group Areas Act, often using whites as nominees. In 2011, 50 per cent of Robertsham's population was classified as Indian/Asian, representing an absolute increase from 902 to 3 353 Indians. At the same time, the proportion of whites declined from 61 per cent to 23 per cent with an absolute decline from 3 277 to 1 551. There was only a small increase in the African population.

While the demographics of Robertsham have shifted, the suburb has retained its lower middle-class/stable working-class profile. The expansion of the Indian population has stimulated the property market, with the participants of a focus group we held with former residents of the 'old South' crediting Indian households for a wave of gentrification in and around Robertsham, as homes have been extended and upgraded.

The tendency of the (mainly Muslim) Indian population to concentrate their residences in specific areas is linked to the importance of being near religious facilities (the process of expanding Muslim space in Johannesburg is explained in Chapter 23). And while Indian residential space has extended into the western parts of the 'old South', this community has retained strong links with the historically Indian township of Lenasia, with many children from households in the southern suburbs still attending schools in Lenasia.[30]

The African middle class and the interface with Soweto (Ormonde)

The expansion of the African middle class has been one of the key drivers of spatial change in post-apartheid Johannesburg (Crankshaw 2008). The emergent and established African middle class has moved into previously white suburbs, although some segments of the middle class have remained in historically African townships, and especially in Soweto.[31] In making locational choices, the African middle class is responding to the opportunity to move into high-amenity residential suburbs previously reserved for whites, but also to the desire to remain physically connected to social networks and cultural experiences in the townships. The southern suburbs closest to Soweto provide the opportunity to do both.

The interface zone in the southern suburbs is separated from Soweto by the mining belt and freeways but is growing towards Soweto through infill and new expansion. In 1996, Ormonde, for example, was a small, failed, residential suburb with a population of 1 394. It was already reasonably mixed racially but had a white majority. Between 1996 and 2011 Ormonde's population expanded by over 600 per cent to 9 820, with all the new growth from African, Indian and coloured households. The white proportion dropped from 55 per cent to a negligible 2 per cent, with Africans increasing from 21 per cent to 64 per cent, and Indians from 16 per cent to 21 per cent. The new residential developments were private, and catered to the emergent black middle class. In 2011, 72 per cent of Ormonde's households owned their own house.

Population increase has been equally significant in the other suburbs along the interface, although there are some differences between the suburbs. Meredale, for example, is attracting higher numbers of coloured households because of its relative proximity to the coloured township of Eldorado Park. And not all the spillover from Soweto is middle class. An extension to Naturena has a distinctly working-class Soweto character, with an energetic street life and informal activities including spaza shops, street traders and doctors' consulting rooms on residential properties.

The interface may either be regarded as part of a gradual extension of Soweto into the southern suburbs or as a new socio-spatial formation which has hybridised Soweto with the southern suburbs. This spatial configuration has begun to erode the deeply entrenched perceptual divide between Soweto and the southern suburbs. An illustration of this redefinition of spatial identity can be found in the Southern Johannesburg Business and

Tourism Association's concept of a Business, Tourism and Recreation Loop linking the southern suburbs and Soweto.

Politically, this area of interface is the only part of the southern suburbs which is not a stronghold of the opposition Democratic Alliance, a party mainly supported by white, coloured and Indian voters. The African National Congress controls the two wards in the southern suburbs closest to Soweto.

White dominance in the 'new South' (Glenvista)

The 'new South' remains majority white. Not only has the white population retained its dominance but it has grown in absolute terms. In the case of Glenvista, the number of whites increased from 4 246 in 1996 to 6 137 in 2011.

There is a link between the 'old South' (of white working-class days) and the 'new South', as many of the families who made good in the 'old South' moved into the 'new South', taking with them ethnically oriented associations and establishments. Examples include the well-known Calisto's Portuguese Restaurant which was relocated from Turffontein to Gillview, and also the Lebanese Maronite Church which established in the suburb of Liefde-en-Vrede in 2001, recongregating the Lebanese community which had dispersed across the city.[32] The suburbs in the 'new South' still have the highest proportion of Europe-born residents in any part of Johannesburg, although migrants from Europe are overall now a tiny proportion of total transnational immigrants.

Although the 'new South' may be forging a social character that is at least partly different from other middle-class areas in Johannesburg, it is also mimicking the north in its patterns of development. For example, the retail offerings and spatial forms of the shopping malls are very similar to those in the north, as are the gated qualities and aesthetic sensibilities of the new generation of residential estates with their fake Tuscan and Bali-style architecture.

A retreat into eco-estates (Aspen Hills Nature Estate)

Some of the newest expansion in the 'new South' – within Johannesburg and immediately across the border in Ekurhuleni and Midvaal – has taken the form of 'eco-estates' with mansion-style living in estates with quiet roads and footpaths, nature reserves hosting antelope and other wild animals, and no private boundary walls. The Aspen Hills Nature Estate, 8 km from the Johannesburg CBD in the 'new South', is marketed as country-style living:

> Imagine awakening every morning to the sweet sound of birdsong, breathing in the fresh country air and being enveloped with a sense of peace and security that nothing can spoil … Be part of the select few who escape the imprisoned lifestyle of suburban living.[33]

Extreme measures are taken to secure the safety of residents in this estate, including more than a hundred cameras that provide thermal imaging and follow visitors to their destinations within the estate.[34] A prominent resident of the southern suburbs, owner of the Calisto's restaurant, has moved to an eco-estate where, he says, his children can roam the streets freely as he did in the 'old South' of his youth.[35] This notion of the 'old South' as a safe place was echoed by an estate agent who noted that the form created by semi-detached housing, compact properties and small apartments was a precursor to the perceived safety created by 'cluster living'.[36]

As may be expected, the Aspen Hills Nature Estate has the highest proportion of middle-class residents and home owners of all selected suburbs. However, there is not an absolute majority of white residents and there is also a large proportion of 'indigent or very poor' households. The reason for this is that the affluent residents of Aspen Hills are served by a significant number of African domestic and other workers.

Business nodes

The 'new South' mimics the northern suburbs in terms of its polycentric pattern of decentralised commercial development. There is a network of neighbourhood shopping nodes in the south, but also two mega regional shopping malls that rival centres in the north in terms of size. The first is the Southgate Shopping Mall, established in 1990 between Mondeor and Soweto at a major freeway junction, with 69 750 m^2 of commercial space.[37] Initially, Southgate was intended to serve a mainly white middle-class market that had expanded in the region since the 1960s but it soon reoriented towards the spending power of the rising black middle class, and became a key retail node for residents in Soweto. The next major development was The Glen, launched in 1998 in Oakdene near the Camaro Junction on the N12. Its main market is the middle- and upper-middle-class suburbs of the 'new South'.

Despite these nodes and a number of linear strips of business activity, the southern suburbs still barely feature in terms of formal business development citywide. In the period 2006–2010 there were only 196 rezonings in the southern suburbs, which was around 4 per cent of the total for Johannesburg as a whole, and not one of the 21 office nodes in Johannesburg analysed annually by the South African Property Owners Association is in the southern suburbs.[38] There is, however, a significant emergent business node in Ormonde which includes a business park with the headquarters of De Beers Corporation, a large casino and the Apartheid Museum.

Conclusion

In this chapter we sought to remedy the 'forgottenness' of the south but also to use the southern suburbs to illustrate the ongoing evolution of space in Johannesburg, connected as it is with social and political transformations. An important work on Johannesburg, titled *City of Extremes* (Murray 2011), invokes an image of Johannesburg as a continuation and even an exaggeration of apartheid divisions. It is a popular academic argument about the city. Our assessment of the south suggests that the realities within the city's neighbourhoods are more complex. There is a substantial class divide in the south (between the 'old South' and the 'new South'), but within each of these new categories there is complexity and blurring. Suburbs are racially and ethnically diverse; identities are being revised and new forms of mixing are occurring in spaces such as churches, where cultural and ethnic divisions are overridden by social and religious cohesion.

In the intricate mix of spatial stability and spatial turbulence in the southern suburbs, the outlines of new urban futures are present in their utopian and dystopian forms. The 'old South' may be pointing us towards a future of decay and new forms of socio-spatial segregation or to a new 'Afropolitanism' in which diversity and new entrepreneurial and social energies restore urbanity to the city. The 'new South' may be pointing to the retreat of the middle class into fortress-like enclaves, on individual properties and in collective estates, or to new forms of interracial solidarity in response to common 'middle-class concerns'.

The old identities of the southern suburbs, established during a period of predominantly white working-class residence, have been significantly eroded, although they linger in some circles. While older residents may still have a fierce loyalty to the 'old South', the new arrivals have transnational identities and live transiently between places. There may, however, be the beginnings of a revised identity for the south which has to do with social diversity. Significantly, despite the large immigrant presence, the 'old South' did not experience xenophobic attacks during the violence of May 2008, with a local ward councillor suggesting that this is because there is more experience of living with diversity in the 'old South' than elsewhere.[39]

This Afropolitanism is, however, fractious at best, given the high levels of social segregation between communities that live in close proximity, and the ethnic and racial prejudice which prevails. Our task is to 'envisage alternative futures whose very propagation might help them to be realised' (Giddens 1990: 154).

Acknowledgements

This chapter has been written with the research assistance of a number of people. Melinda Silverman contributed desktop research, interview material and valuable insights. Ori Ben Zeev and Isabella Kentridge undertook archival research, with Isabella also conducting several of the interviews. Geoffrey Bickford assisted with mapping while Peter Ahmad of the City of Johannesburg provided valuable data. John Harrison, a previous resident of the southern suburbs, assisted with editing and provided insight into the history of the area.[40] This work is based upon research supported by the South African Research Chairs Initiative of the Department of Science and Technology and the National Research Foundation.

Notes

1 Including Ophirton (1886), Booysens (1887), Rosettenville (1889), Turffontein (1889), La Rochelle (1895), Regents Park (1904) and Kenilworth (1907).
2 The Hill (1919), Townsview (1922) and Haddon (1927).
3 Only two of Johannesburg's 40 synagogues were in the southern suburbs.
4 See http://en.wikipedia.org/wiki/South_Hills,_Gauteng.
5 Email from Richard Holden, 8 December 2010.
6 Initially, the Lebanese were regarded as non-white (Asiatic) but an Appeal Court ruling in 1913 reversed this classification.
7 Interview with Father Maurice, Our Lady of Lebanon Maronite Church, Mulbarton, interviewed by Isabella Kentridge, 14 February 2011.

8 Former Residents Focus Group (a group of eight former residents of the 'old South' who recall the 1960s and 1970s), interviewed by Tanya Zack and Isabella Kentridge, March 2011, Johannesburg.
9 Population Census Reports for Johannesburg, 1970, 1996, 2001, 2011.
10 Former Residents Focus Group, interviewed March 2011, Johannesburg.
11 The school closed in 1956 owing to pressure from the apartheid state and reopened as the whites-only St Martin's Boys' School.
12 The planner for Ormonde was Roelof Uytenbogaardt who had studied under the University of Pennsylvania's Louis Kahn.
13 Interview with Roger Boden, a planner who worked for Rand Mine Properties, interviewed by Geoffrey Bickford, 15 August 2011, Johannesburg.
14 The modest development at the time was, however, notable for including the earliest example of cluster housing in Johannesburg.
15 Portuguese sports clubs proliferated, with roller hockey being especially popular; particular bars, restaurants and events halls also attracted a largely Portuguese crowd, while the annual Lusito Festival in the southern suburbs grew into a significant event on the Johannesburg calendar. The children of Portuguese immigrants attended Portuguese classes in the afternoons at Rosettenville Central Primary School. (Interview with Isabel Dos Santos, resident of La Rochelle, interviewed by Isabella Kentridge and Tanya Zack, 15 February 2011, Johannesburg).
16 In our analysis we supplemented these data with quantitative information provided through an assessment of township establishment, rezoning, and building-plan applications, as well as qualitative information provided by ward councillors, local estate agents, local residents and the local media.
17 Southern African Development Community.
18 A detailed study of La Rochelle, showing the relationship between Mozambicans and white Portuguese, is being conducted by Khangelani Moyo, who is working as a researcher with one of the authors of this chapter, and will be published shortly. A focus group we conducted also confirmed this relationship, with one respondent explaining that Portuguese-speaking Africans are attracted to the area because they can access work without having to speak English, as required elsewhere in the city (Anonymous 1, Migrants Focus Group 2: six migrants from Mozambique and Angola, interviewed by Tanya Zack, April 2011, Johannesburg).
19 Interview with Councillor Turk, Johannesburg, interviewed by Philip Harrison, Melinda Silverman and Tanya Zack, November 2010.
20 The survey involved a sample of 847 respondents across seven neighbourhoods in central Johannesburg. Of the 202 Mozambicans in the sample, 53.5 per cent lived in 'Rosettenville'.
21 Anonymous 2, participant in Migrants Focus Group 1: four migrants from Cote d'Ivoire and DRC, interviewed by Melinda Silverman and Tanya Zack, April 2011, Johannesburg.
22 Anonymous 3, participant in Migrants Focus Group 2, April 2011, Johannesburg.
23 Anonymous 3, April 2011.
24 Interview with Jorge Calisto, long-standing resident and restaurateur in the South, interviewed by Isabella Kentridge and Tanya Zack, 21 February 2011, Johannesburg.
25 Interview with Louis Birkenstock, estate agent, Johannesburg, interviewed by Isabella Kentridge and Tanya Zack, 2 March 2011.
26 Interview with Jorge Calisto, 21 February 2011.
27 This was confirmed by religious leaders we interviewed who explained the role of their

churches in providing newly arrived migrants with assistance in finding accommodation and jobs, and in providing feeding schemes and support to single parents (interviews with pastors of Evergreen Chapel and the Universal Church of the Kingdom of God, February 2011).

28 Migrants Focus Group 1, April 2011, Johannesburg.

29 Interview with Deseree Hauser, Lencar Properties, interviewed by Isabella Kentridge, 21 February 2011, Johannesburg; interview with Louis Birkenstock, 2 March 2011; interview with Councillor Turk, interviewed by Philip Harrison, Melinda Silverman and Tanya Zack, November 2010, Johannesburg.

30 Interview with Deseree Hauser, 21 February 2011, Johannesburg.

31 The Unilever Institute of Strategic Marketing reports that the proportion of black middle-class families living in the suburbs increased from 23 per cent in 1993 to 47 per cent in 2007.

32 Interview with Father Maurice, 14 February 2011, Mulbarton.

33 See http://www.aspennature.co.za/.

34 Interview with anonymous estate agent, Aspen Hills, interviewed by Philip Harrison and Tanya Zack, May 2011, Johannesburg.

35 Interview with Jorge Calisto, 21 February 2011, Johannesburg.

36 Interview with Deseree Hauser, 21 February 2011, Johannesburg.

37 These figures compare with Cresta Shopping Centre in the northern suburbs at 94 000 m^2 and Maponya Mall in Soweto at 58 500 m^2.

38 The most significant node for office development in the south is Theta, adjacent to Ormonde, which has De Beers Corporation as its blue chip tenant.

39 Interview with Councillor Dennis Jane, interviewed by Isabella Kentridge and Tanya Zack, 15 February 2011, Johannesburg.

40 Interview with John Harrison, former resident of Rosettenville, interviewed by Philip Harrison, February 2012, Johannesburg.

References

AfriGIS (2011) Suburbs data, May release. Dataset obtained from AfriGIS, http://www.afrigis.co.za/

Beavon, K (2004) *Johannesburg: The Making and Shaping of the City*. Pretoria: UNISA Press.

Browett, JG and Hart, T (1977) 'The distribution of white minority groups in Johannesburg.' *South African Geographer* 5(5): 404–421.

Collings, J (1987) *Gold under Their Hooves: A History of the Johannesburg Turf Club 1887–1987*. Johannesburg: Chris van Rensburg Publications.

Crankshaw, O (2008) 'Race, space and the post-Fordist spatial order of Johannesburg.' *Urban Studies* 45(8): 1692–1711.

Giddens, A (1990) *The Consequences of Modernity*. Cambridge: Polity Press.

Glaser, C (2010) 'Portuguese immigrant history in twentieth century South Africa: A preliminary overview.' *African Historical Review* 42(2): 61–83.

GTI (GeoTerraImage) (2009) Urban 2.5-metre land-cover data. Dataset obtained from GTI, http:// www.geoterraimage.com

Hart, G (1968) 'An introduction to the anatomy of Johannesburg's southern suburbs.' *South African Geographical Journal* 50: 65–72.

Joubert, L (1998) *The Story of St Martin's School: A School with a Difference*. Johannesburg: St Martin's School.

Krikler, J (2005) *The Rand Revolt: The 1922 Insurrection and Racial Killing in South Africa*. Johannesburg and Cape Town: Jonathan Ball Publishers.

Landau, L (2009) 'Living within and beyond Johannesburg: Exclusion, religion and emerging forms of being.' *African Studies* 68(2): 197–214.

Landau, L (2010) '*Passage, Profit, Protection and the Challenge of Participation: Building and Belonging in African Cities*.' Working Paper No. 2010/49, World Institute for Development Economics Research, United Nations University.

Mooney, K (1998) '"Ducktails, flick-knives and pugnacity": Subcultural and hegemonic masculinities in South Africa, 1948–1960.' *Journal of Southern African Studies* 24(4): 753–774.

Mooney, K (2006) 'Die Eendstert Euwel' and Societal Responses to White Youth Subcultural Identities on the Witwatersrand, 1930–1964. PhD thesis, Faculty of Humanities, University of the Witwatersrand, Johannesburg.

Murray, M (2011) *City of Extremes: The Spatial Politics of Johannesburg*. Johannesburg: Wits University Press.

Ostanel, E (2011) 'Citizenship in the making: Mozambicans in Johannesburg.' Paper delivered at the International RC21 Conference, 7–9 July, Amsterdam.

Parnell, S (1988) 'Public housing as a device for white residential segregation in Johannesburg, 1934–1953.' *Urban Geography* 9: 584–602.

Parnell, S (1993) Johannesburg's Slums and Racial Segregation in South Africa, 1910–1937. PhD thesis, University of the Witwatersrand, Johannesburg.

Peberdy, S (2009) *Selecting Immigrants: National Identity and South Africa's Immigration Policies, 1910–2008*. Johannesburg: Wits University Press.

Prinsloo, I (1993) 'Sixties revisited.' *Architecture SA* July/August: 31–42.

RMP (Rand Mines Property) (1969) *Major Report CMP*. April. Cape Town: Urban Design Consultants.

RMP (1971) 'CMP landscape planning and design.' Consulting report for RMP.

Rubin, M (2005) The Jewish Community of Johannesburg, 1886–1939: Landscapes of Reality and Imagination. Masters thesis, University of Pretoria.

Spit, T (1976) *Johannesburg Tramways.* London: Light Transport League.

Stals, ELP (1986) *Afrikaners in die Goudstad, Deel 2 1924–1961*. Pretoria: HAUM.

Stats SA (Statistics South Africa)(1998) *Census 1996* (online document).

Stats SA(2012) Census 2011.

Stewart, P (2004) *Segregation and Singularity: Politics and its Contexts amongst White, Middle Class English Speakers in Late Apartheid Johannesburg*. Pretoria: UNISA Press.

Teppo, A (2004) *The Making of a Good White: The Historical Ethnography of the Rehabilitation of Poor Whites in a Suburb of Cape Town*. Helsinki: Helsinki University Press.

Van Jaarsveld, F (1982) *Die Afrikaner se Groot Trek na die Stede*. Johannesburg: Perskor.

Vandeyar, S and Jansen, J (2008) *Diversity High: Class, Color, Culture and Character in a South African High School*. Maryland: University Press of America.

Viljoen, M (2009) 'The life, death and revival of the Central Rand Goldfield.' Paper presented at the Southern African Institute of Mining and Metallurgy World Gold Conference, 26–30 October, Johannesburg.

Visser, Wessel (2005) 'Urbanisation and Afrikaner class formation.' In S Salm and T Falola (eds) *African Urban Spaces in Historical Perspective*, 131–163. New York: University of Rochester Press.

The decanting of acid mine water in the Gauteng city-region

Analysis, prognosis and solutions

PROVOCATIONS

by Prof Terence McCarthy

School of Geosciences,
University of the Witwatersrand,
Johannesburg

CONTENTS

ABOUT THE PROVOCATION SERIES

Provoke | *to stimulate, incite, stir up, challenge, irk, exasperate, vex*

The Gauteng City-Region Observatory's Provocations is an on-going series of think-pieces that give a platform to cutting edge thinking on current issues of the day, written and presented in non-academic style and format. Each Provocation is offered by an academic or practitioner for reading by a wide audience, with the hope of shedding light on key topics relevant to researchers, policy-makers, business people, activists and members of the public.

The series aims to challenge conventional understandings, stimulate new thinking, stir up debate and incite readers to respond with interpretations of their own. At times, the thoughts offered will exasperate, perhaps even anger. Each piece goes through rigorous editing, but the analysis, views and opinions presented are solely those of the author.

FOREWORD

As early as 1987, the US Environmental Protection Agency recognised that "...problems related to mining waste may be rated as second only to global warming and stratospheric ozone depletion in terms of ecological risk. The release into the environment of mining waste can result in profound, generally irreversible destruction of ecosystems."[1]

In 2011, possibly 2012, acid mine drainage (AMD) will seep up through the main shaft at Gold Reef City, and the underground facility will be forced to close. At the same time, Boksburg could see AMD rising up through drainage points, spewing toxic filth into the town. The 'void' – the large hole left by mines stripping out rock, and formerly kept in balance by pumping out water – will have filled, and water carrying sulphuric acid, heavy metals and any number of toxins, will spill out and could compromise our cities and towns, our economy and environment, our reputation and, arguably, our future.

There is still time to act – though not much. There seems also to be a will to act. This brief piece aims to clarify the scientific facts behind the issue of decanting of acid water from mines on the Witwatersrand. It goes further and makes recommendations for action. The basic thrust is that what matters now is action, not talk.

Mining has long been a cornerstone of South Africa's economy, although its economic power is slowly waning. In particular, gold mining in the Witwatersrand has been a key sector in the province since 1886 and was the initial reason for Johannesburg's existence. Mining made Johannesburg 'the city of gold' and helped make Gauteng a wealthy province. A century of mining has had many positive economic impacts – some individuals, shareholders and companies became spectacularly wealthy, the state gained significant revenue through taxes (on companies and workers), jobs were created, and militant and organised trade unions were a focal point of resistance - but not all its impacts have been positive. The social and environmental impacts were not

[1] http://www.csir.co.za/nre/docs/BriefingNote2009_2_AMD_draft.pdf

given much focus in the past, written off as a necessary cost of business. And not all the problems were immediately visible.

An unsustainably managed mine will see future generations having to deal with the impacts. We are that generation, and right now, rising water levels in the mine void and the looming threat of decanting acid water in the Gauteng city-region is the problem we have been bequeathed.

The problem is not new for Gauteng. While there have been numerous news reports on acid mine drainage for over a decade, it has been difficult and confusing to separate fact from fear tactics.

Recent news reports on acid mine drainage in Gauteng have given wildly conflicting views from being the 'single most significant threat to South Africa's environment'[2] to mere hysteria by 'private sector interests'.[3] Some reports suggested that "the immediate crisis with AMD in the Witwatersrand started in 2002 with the flooding of the western basin at a rate of 20-million litres a day".[4] In 2009, it was reported that the liquidation of Pamodzi Gold had led to the shut down of mining activities and thus acid water problems were experienced at the East Rand operations.

The Water for Growth and Development Framework (WGDF), launched in March 2009 by the Department of Water Affairs highlighted that AMD from abandoned mines could result in catastrophic ground and surface water pollution. In October of 2008, East Rand Propriety Mines Ltd. (ERPM) ceased pumping and the void – the space underground created by extracting rock, and kept in balance by pumping out water - began to fill. Since then the water level in the void has risen and currently lies at a depth of about 600m below the surface. This could rise faster as we enter our rainy summer season. The average rate (across the year as a whole) is about 15m per month. At this rate of rise, the void will be completely filled in about two and a half years from now. At that point, decanting of acid water will be a widespread reality.

Given the urgency as well as the possible threat to the economy, health and environment, decant of acid water in Gauteng is indeed an appropriate starting point to launch the Gauteng City-Region Observatory (GCRO) *Provocations* series. The purpose of the series is to foster open and frank debate on current issues, by making expert academic views accessible to a wide audience. Each 'provocation' is meant to

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2 http://www.miningweekly.com/print-version/in-the-midst-of-a-disaster-2009-05-08
3 http://www.newstime.co.za/SouthAfrica/Trevor_Manuel_calls_for_rational_debate_on_acid_mine_water/9100/
4 http://www.miningweekly.com/print-version/in-the-midst-of-a-disaster-2009-05-08

provoke a response from the reader while simultaneously providing clear information. The series is commissioned and edited by GCRO but does not necessarily reflect the views of the GCRO.

In this first edition of our *Provocations* series, Professor Terence McCarthy of the School of Geosciences at the University of the Witwatersrand provides a clear description of filling and decanting of the mine void in Gauteng, including a detailed description of AMD, its formation, the affected areas, an assessment of the threat, and what needs to be done. Appropriately, some of the arguments are provocative and worthy of further discussion and debate.

The first is related to the solutions being proposed. The Department of Water Affairs has agreed to put one new pumping station[5] and upgrade a high-density sludge treatment operation to stop acid mine water rising up in Johannesburg and causing an environmental disaster. McCarthy argues that at least two pumping stations are required to pump the water to the surface for treatment – the proposed solution, in his view, falls short.

According to McCarthy, we need one pumping station in the Germiston area and another in Florida, so that the water level is maintained at 300m below surface at these two points. He also suggests that a private contractor be appointed to establish and carry out the pumping, allowing for proper performance and cost auditing.

...the void will be completely filled in about two and a half years from now.

But the 'one pump or two' debate should not obscure the fact that long-term, integrated solutions are needed – the problem will not respond to once-off band-aids, however expensive they happen to be. An integrated range of measures would include active water treatment, passive water treatment systems, and controlled placement of acid-generating mine waste, amongst others. According to Mariette Liefferink,[6] AMD water can be treated by reverse osmosis - another extremely expensive process – but one that mines can afford to pay, in her view. Here she differs markedly from McCarthy.

[5] Pumping is not time-delimited and will have to continue indefinitely.

[6] Liefferink is chief executive of the Federation for a Sustainable Environment and was quoted in http://www.mg.co.za/article/2010-09-07-mines-must-take-prime-responsibility-for-acid-drainage

The measures proposed may amount to more than R2,5 million a month for a treatment plant.[7] McCarthy argues strongly that the cost should be borne by the state. Government has for decades been paying pumping subsidies to mines to cover the cost of pumping inflow from defunct, adjacent mines as it is; and he notes that "Government is invariably the largest single beneficiary of mining ventures through the state share of profits formulae, taxation of company profits and taxation of salaries paid to workers."

However, civil society activists believe that mines have enriched themselves without any acknowledgment of the costs to the environment, and are continuing to enrich themselves while doing little for the environment – damage is a 'cost of business'. Many believe that a policy of 'the polluter pays' should apply.

While these arguments are morally sound, McCarthy asks the question: which mines should pay? AMD is the result of a century and more of environmental damage, and hundreds of mining companies have long closed down - so which companies must be held accountable for centuries of pollution? Mines in many affected areas are no longer operational, making it difficult to enforce compliance. But if we accept McCarthy's point, how then must government ensure that companies currently mining are not allowed to sidestep culpability for the destruction of the environment because some of their predecessors are not around to foot the current bill? Again, an integrated and balanced solution (with state and existing mines contributing) rather than an 'either/or' approach seems most appropriate.

...government has had AMD on its 'urgent' agenda since 2009, but has yet to act.

A third issue raised in the document alludes to what is seen as slow action by government. The flurry of press coverage in 2010 has seen a seemingly quick response by government, but there is considerable scepticism regarding the gap between words and deeds, and the speed with which government will transform the former into the latter. An inter-ministerial committee was established and a task team convened in 2009. In addition, mining companies and the Department of Water Affairs have agreed to co-operate to 'fight' acid mine drainage. In February 2010, it was reported that a contract to deal with mine pollution between government and the mining houses had been signed and funding would be apportioned between the parties.[8] In August 2010 it was reported that the Minister of Water Affairs had been mandated to urgently convene a special task team to investigate acid water drainage in some provinces. In other words, government has had AMD on its 'urgent' agenda since

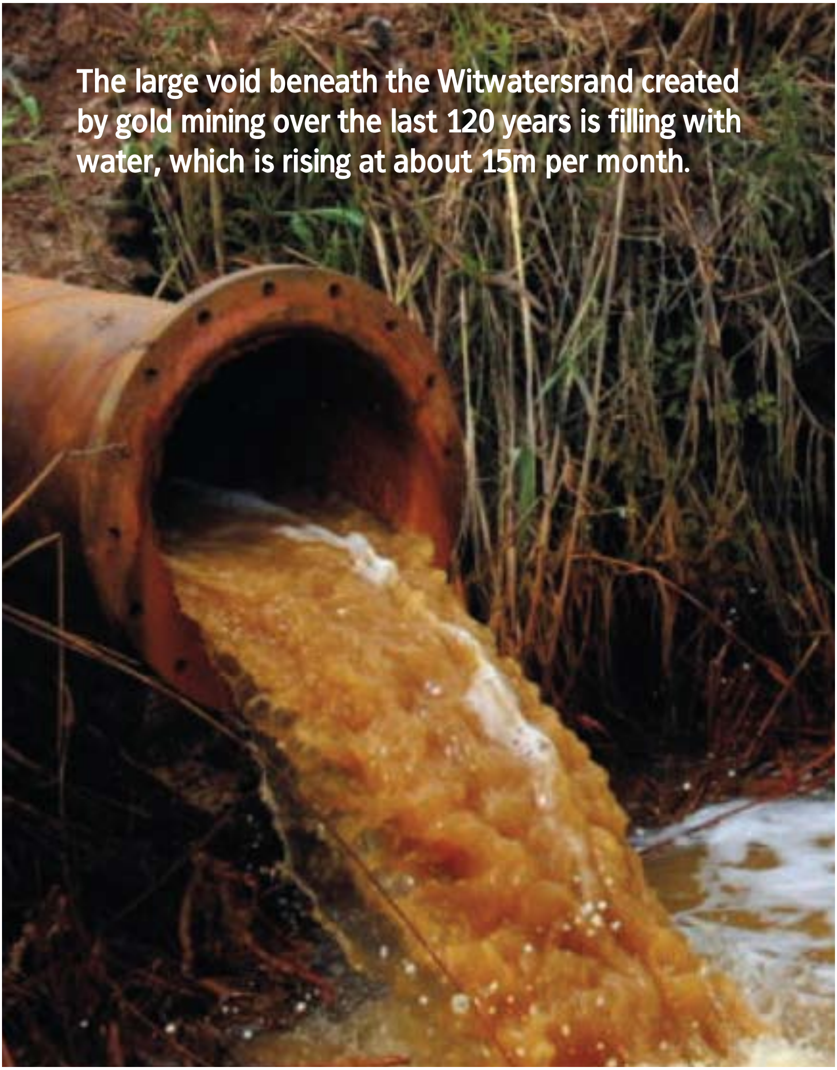
7 Ibid.
8 Ibid.

2009, but has yet to act. Whether this is due to the nature of government, or the proximity of government to mining companies and their revenue, or the impact of BEEllionnaires in the mining sector, is beyond the scope of this brief piece to argue, but these issues deserve attention – and resolution. Mining must be regulated, efficiently and effectively. Action cannot be delayed.

The threat of decant in Gauteng should be an eye-opener for all stakeholders – business, government and civil society. The way we work must be proactive and not reactive. The continued stripping of ore-bearing rock and leaving behind a destroyed environment and a shrinking, often ill or injured labour force - year after year – is not a sustainable or a desirable way of operating. The sooner we move the economy of the Gauteng city-region (GCR) onto a sustainable (environmentally, socially and economically) footing, the sooner we will find long-term solutions to our problems, not just stop-gaps that buy time.

GCRO

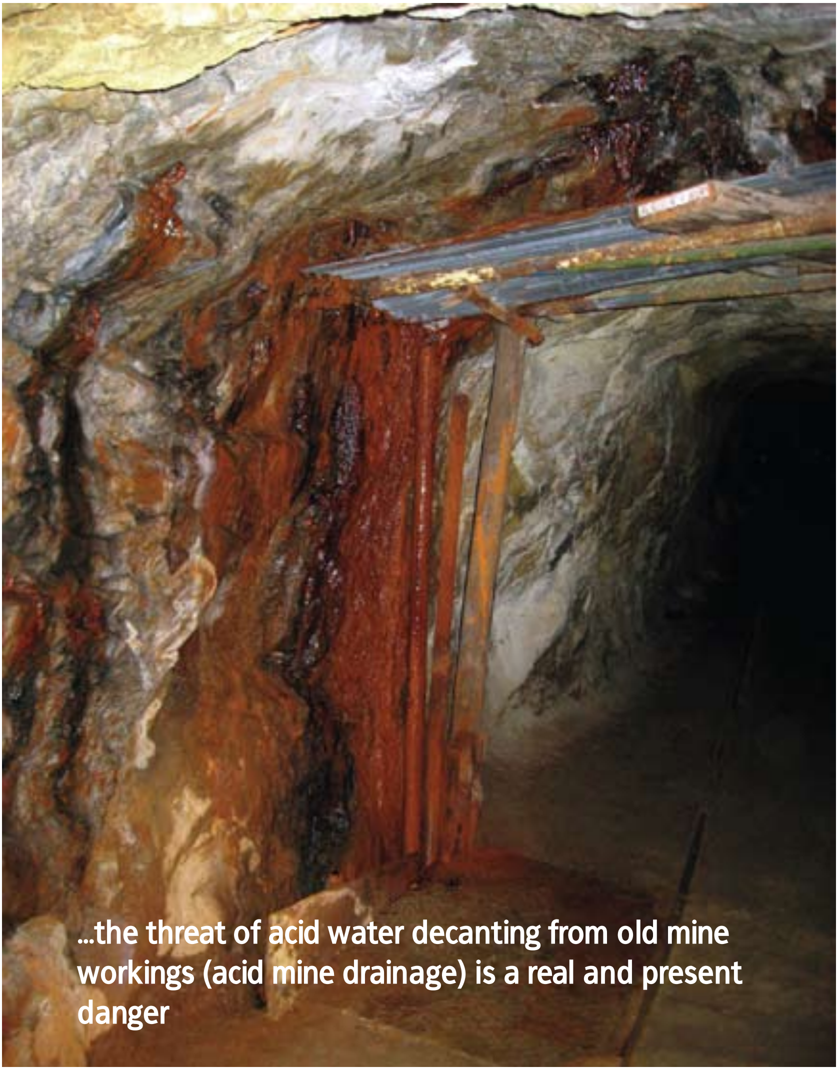
November 2010


The large void beneath the Witwatersrand created by gold mining over the last 120 years is filling with water, which is rising at about 15m per month.

EXECUTIVE SUMMARY

The large void beneath the Witwatersrand created by gold mining over the last 120 years is filling with water, which is rising at about 15m per month. The void will fill and water will begin to leak out (decant) on surface in about three years from now. It is likely that multiple decant points will develop in municipal areas across the Witwatersrand from Roodepoort to Boksburg. Experience on the West Rand has shown that the quality of the water is likely to be poor and toxic. The prime risk area where decant points are likely to develop is in a zone about 500m wide straddling Main Reef Road and the M2 motorway, plus a secondary zone some two kilometres to the south. Deep basements of buildings and other sub-surface infrastructure in the risk zones could experience flooding and the underground facility at Gold Reef City, a national treasure, will be lost.

The problem can be solved by establishing pump stations at shallow depth in the mining belt to keep the water at a safe depth below surface. A depth of 300m is recommended in order to protect the Gold Reef City facility. The technological capability to do this is readily available, and the necessary water treatment processes are well established. Although initially expensive, the pumping operation may ultimately generate a profit. Moreover, the cost of not pumping may ultimately vastly exceed the cost of timely intervention. Establishing the necessary pumping and water treatment infrastructure will take considerable time, and therefore immediate action is required.



...the threat of acid water decanting from old mine workings (acid mine drainage) is a real and present danger

INTRODUCTION

There has been extensive media coverage recently concerning the rising water level in the mine void beneath Johannesburg and neighbouring municipalities and the threat of flooding that this now poses to buildings and other infrastructure in the city-region. There has been some disinformation, some accurate information, some understanding of the urgency of the problem and some attempts to write off the issue as ‘alarmist’. There has also been some understandable confusion. This brief piece aims to summarise what we know, to highlight what we don’t know but need to find out, and recommendations for action across different spheres of government, and society more generally.

The basic argument put forward here is that the threat of acid water decanting from old mine workings (acid mine drainage) is a real and present danger. It poses a threat to our economy, environment, health and history. The solutions are expensive, though not technically daunting – and must be implemented within a matter of months, if we are to prevent acid mine water at different points in the GCR.

Finally, while it would be easy to point fingers at the mining sector, the present problem is the result of over a century of mining by literally hundreds of companies, the majority of which have long since ceased to exist. Clearly, they cannot be held responsible (and financially liable) for footing the bill. In reality, taxes on past mining activities have benefitted all of us – the infrastructure we enjoy in the GCR has been funded in no small part by mines that are now defunct. As such, the bulk of the bill must come from the national fiscus – existing mines that continue to contribute to the problem must also contribute on a *pro rata* basis, as must local and provincial spheres.

THIS BOOKLET

In the general media coverage of the issue of acid mine drainage, what has been lacking is a concise explanation of the origin of the problem, how it may unfold and which areas are potentially at risk. There has also been much disinformation circulating, making it difficult for citizens and policy-makers alike to distinguish fact from fiction. It is in everybody's interests that there is a general understanding of the nature of the problem, which is what this article sets out to achieve. Although at first glance the issues involved may appear to be technical, they are actually quite simple and straight-forward.

There are several facets to the problem that need to be explained in order to understand what is happening and how it will unfold. These include how the gold occurs, how it was mined, how water gets into the mines and why this has only now become a potential problem more than 120 years after mining started.

THE OCCURRENCE OF GOLD ON THE WITWATERSRAND

Witwatersrand gold occurs in layers of pebbly rock called **conglomerate** that were deposited as river gravels about 2 800 million years ago. These were termed **reefs** by the early prospectors, a name that is still used today. The Earth's atmosphere at that time was different from today in that it contained no oxygen. This is important because of the effect oxygen has on minerals. Certain minerals deposited along with the gold decompose in today's atmosphere and dissolve, either wholly or partly. These minerals include iron sulphide (called **pyrite**, also known as **fool's gold** because of its resemblance to gold), other minor heavy metal sulphides and uranium oxide (**uraninite**).

Not all of the conglomerate layers or reefs carry economic concentrations of gold. On the Witwatersrand, only three or four of the reefs contained significant gold, and even then not everywhere. The important gold-bearing reefs were the Main Reef, Main Reef Leader, South Reef and the Kimberley Reef. The thickness of the gold-bearing reefs varied from a few centimeters to a few metres, but average about a metre.

...important gold-bearing reefs were the Main Reef, Main Reef Leader, South Reef and the Kimberley Reef.

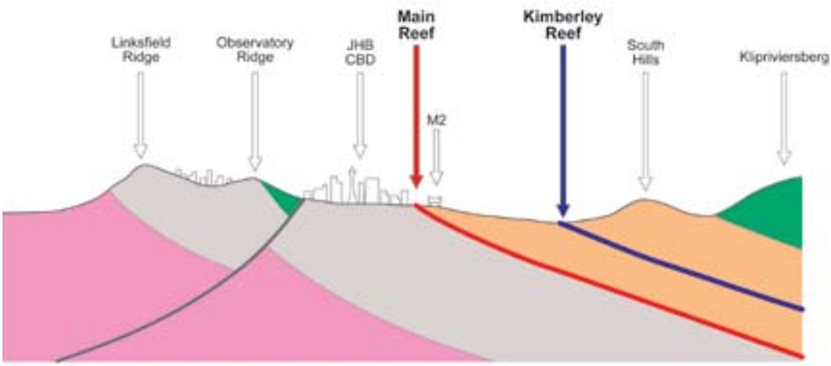
The conglomerate layers are separated by layers of a rock called **quartzite**, which were originally deposited as layers of sand. Cementation and heating of the sand over millions of years converted it into hard, quartzite rock. In addition, layers of **shale** (formerly silt and mud layers) were also laid down between the layers of sand. These various sedimentary rocks were deposited on a floor of rock consisting mainly of granite. The combined thickness of the quartzite, shale and conglomerate layers is approximately seven kilometres. The gold-bearing conglomerate reefs occur in the upper two kilometre portion of the package. The sedimentary layers were buried by lava that rose up from deep in the Earth along cracks known as **dykes** some 2 700 million years ago, terminating the gold-forming event.

The layers of rock later became tilted and were partly eroded, and they now dip towards the south at angles varying from 20° to about 80° from the horizontal, but averaging about 30°. They extend from Randfontein in the west to Boksburg in the east. Some of the quartzite layers are very hard and they form ridges such as the low range of hills which forms the Witwatersrand escarpment extending from

Krugersdorp to Germiston (including Northcliff and the Brixton–Observatory ridge). The lavas are also quite resistant and form the Klipriviersberg hills along the southern margin of the city. The other quartzites generally form less prominent topographic features (Figure 1, 2).

Figure 1: *Simplified geological map of the Witwatersrand showing the distribution of the main rock types. The red and blue lines mark the outcrop positions of the main gold-bearing reef layers.*

Figure 2: *Geological cross-section orientated in a north-south direction showing southerly dip of the layers of sedimentary rock which host the gold-bearing reefs (shown in red and blue). Most of the mining activity was centred along the Main Reef layer with more limited mining of the Kimberley Reef.*



GOLD MINING ON THE WITWATERSRAND

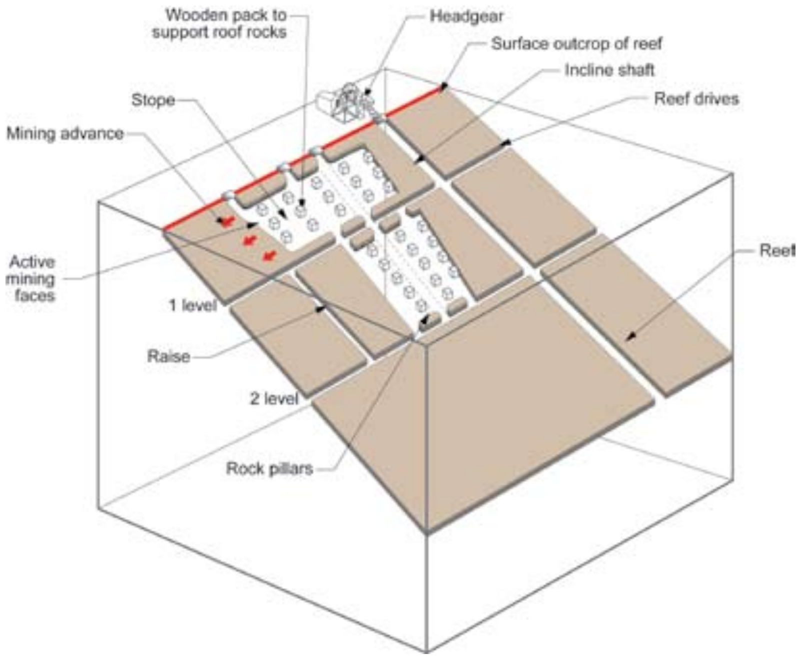
Gold was discovered in one of the conglomerate reefs at Langlaagte in March 1886. Within a few months, the gold-bearing reefs had been traced the full 50km length of the Witwatersrand from what is now Roodepoort in the west to Germiston in the east. Mining commenced in about September of that year.

The mining method used to extract the gold-bearing rock was very simple. A tunnel, or more correctly a shaft (called an **incline shaft**), was sunk down on the plane of the reef. At vertical depth intervals of about 50m (called **levels**), horizontal tunnels (called **reef drives**) were dug perpendicular to the shaft along the reef plane. Tunnels (called **raises**) were then dug up the reef plane at intervals to meet the reef drive on the level above. The walls of the raises were then mined sideways creating open spaces called **stopes** and the broken reef rock passed down to the reef drive below where it was loaded into wagons (**cocopans**) and transported to the shaft for removal to the surface.

...the gold-bearing reefs had been traced the full 50km length of the Witwatersrand...

Pillars of reef were left adjacent to the reef drive to support the roof. The roof rock in the stopes was supported by **wooden support packs** (Figure 3). The minimum width of the mine opening is one metre, because people cannot work in a narrower space. Where the conglomerate layers were thinner than one metre, a one metre opening was made nevertheless. Where the conglomerate was thicker, the entire layer was usually mined, sometimes up to two metres or more. The average width of the mined layer was of the order of a metre.

Figure 3: *Mining methods used in the early days of gold mining on the Witwatersrand. A shaft was sunk down on the gold-bearing reef layer and at intervals (called levels) horizontal tunnels were dug laterally on the reef. From these, tunnels (called raises) were dug up to the level above. These raises were then widened sideways on the reef to create stopes. The broken reef rock was fed down to the level below and taken to surface where the gold was extracted.*



As the mines grew deeper, incline shafts became inefficient and were replaced by **vertical shafts**. Horizontal tunnels were dug from the shaft to the reef (called **cross-cut drives**) where reef drives were dug as before. For safety reasons, reef drives were eventually abandoned in favour of tunnels dug parallel to, but below, the reef layer. As mining progressed, further shafts were sunk from underground (called **sub-vertical or sub-incline shafts**) ultimately taking mining to depths more than 3 000 m below surface (see Figure 4 and Figure 5). In the process, the layers of gold-bearing reef rock were extracted, and an extensive cavity was created which is known as the **mine void**.

Figure 4: *As mining progressed to deeper levels, vertical shafts replaced incline shafts. The layers of gold-bearing reef rock (shown in red and green) were extracted in the process, leaving behind open space which is known as the mine void.*

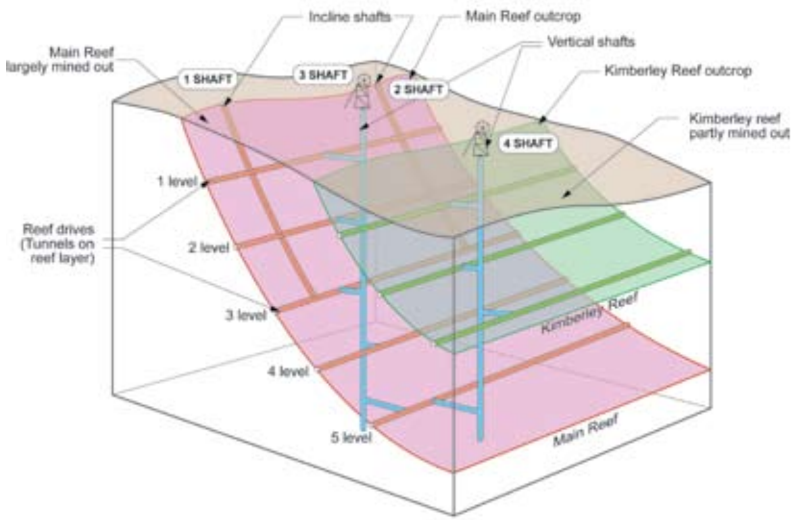
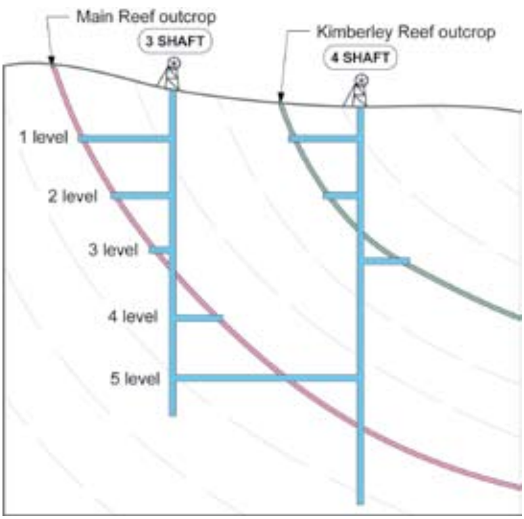


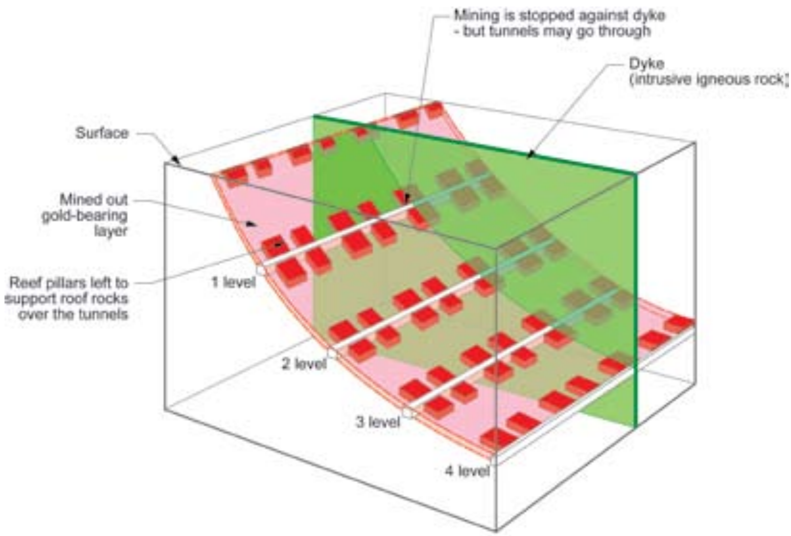
Figure 5: *Cross-section through a typical Witwatersrand mine (such as the one shown in Figure 4) illustrating the manner in which reefs were accessed from the vertical shafts. Shafts and the reef layers were extensively inter-connected underground.*



Supplying fresh air to workers underground is an obvious necessity. To achieve this, the flow of fresh air to, and stale, dusty air away from the working areas is carefully planned. Control of the movement of air requires the erection of barricades in the old workings, and some parts of the void are used to channel fresh air to the workers and others for removal of stale air. The air-flow paths are constantly changed to keep pace with the mining as it advances; so new barricades are constantly being erected.

Along most of the Witwatersrand, more than one reef was mined – some extensively, others more sporadically because of less favourable gold content. The reefs that were mined were a lower group consisting of the Main Reef, Main Reef Leader and South Reef, generally located within a zone a few tens of metres apart, and the Kimberley Reef a few hundred metres above. The Main Reef Leader was particularly extensively mined. Dykes that cut across the reef layers were not mined as they contained no gold (Figure 6).

Figure 6: *Dykes cutting across the reefs contained no gold and consequently were not mined, as is illustrated in this diagram. Excavation ("stoping") was stopped when a dyke was encountered. Tunnels were usually extended through the dykes, however, and stoping resumed on the other side as illustrated here.*



In the past, it was theoretically possible to walk underground all the way from Roodepoort to Boksburg, because adjacent mines generally interconnected their workings. In practice, however, this was not possible because reef drives and other tunnels that were no longer needed were blocked off with brick walls or wooded barricades. This was done to prevent workers from straying into old and dangerous areas, and especially to restrict air-flow to the active working areas. The tunnels were generally not completely sealed, however, as drain holes were left at the base of the barricades to allow water to flow through. What was a safety and efficiency measure in the past has come back to haunt us now.

In order to keep track of the mining, plans of the mine workings were kept by mine surveyors. A **mine plan** is a projection of the underground excavations onto a horizontal surface as is illustrated in Figure 7. An example of portion of a mine plan is shown in Figure 8. A plan of the entire mined out area on the Witwatersrand is shown in Figure 9.

Figure 7: *Accurate plans of underground workings are produced by projecting the mined areas onto a flat, horizontal surface, as illustrated here.*

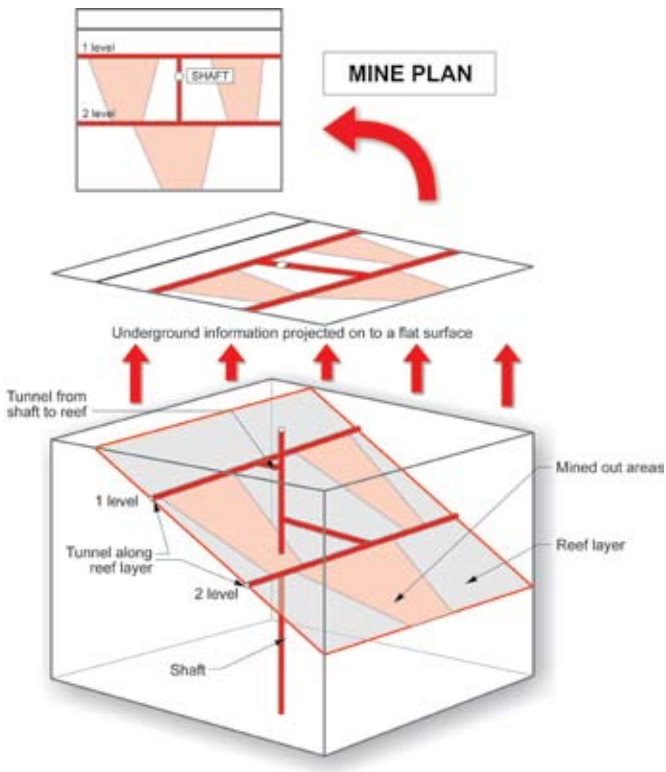
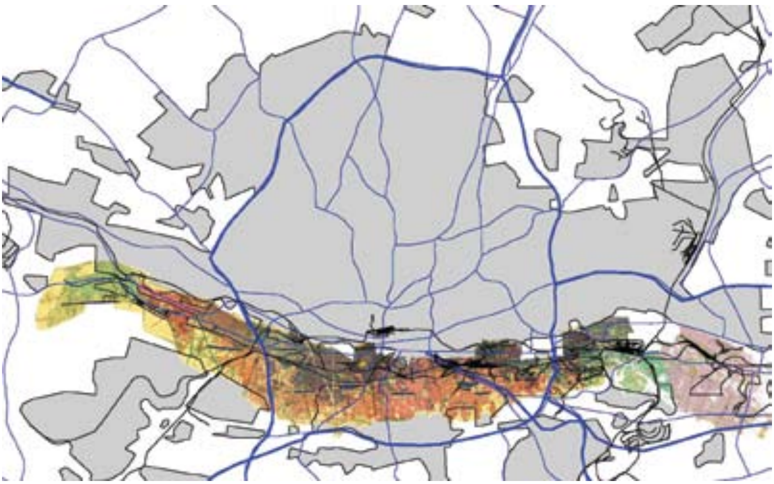


Figure 8: *Portion of the mine plan of the East Rand Proprietary Mines Limited (issued in 1982). Areas coloured pink and pale greens represent reefs that have been mined out (each reef mined is designated by a different colour); yellow areas represent patches of economic reef that have yet to be mined; and dark green stripes crossing the mined out areas represent dykes [source: ERPM Ltd.].*

Figure 9: *Map showing the mined out reefs across the entire Witwatersrand from Roodepoort to Boksburg.*



Over the life of the Central Rand mines, a total of 1 300 million tones of rock was brought to surface from underground, and from this rock, 12 220 710kg of gold was extracted. The volume of rock mined amounts to a cube 800m x 800m by 800m. In crushed and processed form the rock volume becomes even larger, which is why there are so many large dumps of mine waste along the Witwatersrand.

The iron pyrite and other sulphide minerals were not extracted, however, nor was most of the uraninite, and these went onto the dumps. Decomposition of the sulphides and the uraninite in these dumps is producing acidic water, which is enriched in uranium and other heavy metals such as cobalt, nickel, manganese and aluminium. Seepage of this polluted water (Acid Mine Drainage) from the dumps is a serious problem on the Witwatersrand and other mining areas.

...a total of 1 300 million tones of rock was brought to surface from underground, and from this rock, 12 220 710kg of gold was extracted.

During mining, the roof rocks above the stopes were supported by wooded packs (Figure 3). These were left in place as the mining advanced. As time passed, the wood decayed and the roof rocks eventually collapsed and broke up into large blocks. When mining was close to surface (generally less than 200m deep), collapse of the workings sometimes caused **surface subsidence**, and often cracks appeared in the ground above the workings due to the breaking up of the rock mass below. Erection of buildings immediately above old workings is therefore problematic, and building restrictions have been imposed in this zone across the Witwatersrand.

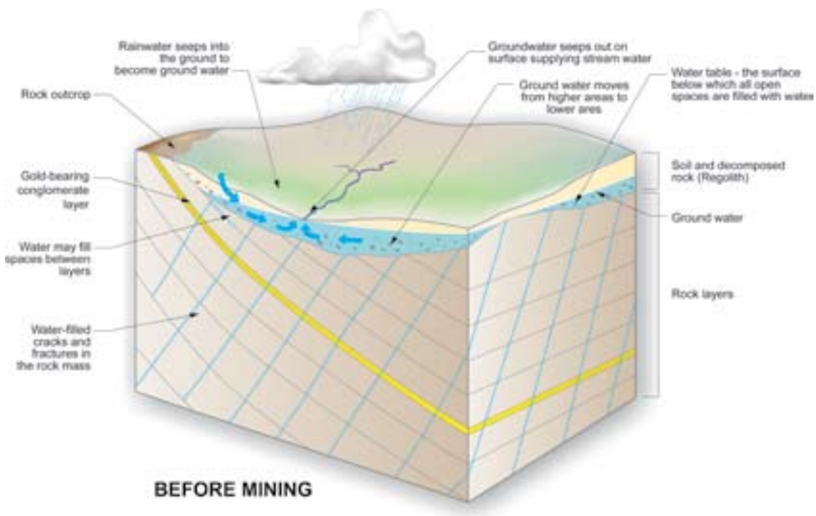
GROUNDWATER

The rock mass down to a depth of several kilometres is usually cut by cracks and zones where the rock has been crushed or fractured (called **joints** and **faults** respectively) which are formed as a result of earth movements. Occasionally rock may extend all the way to the surface, resulting in rocky outcrop. More commonly, however, the rocks closer to the surface have decomposed to form a loose, granular material and soil layer. This layer of soil and fragmented, partly decomposed rock is known as the **regolith**.

Rain falls on the surface and about ten percent of it runs off and collects in streams, eventually flowing to the ocean. The rest soaks into the ground, but most of this does not penetrate very deeply and is returned to the atmosphere by **evapotranspiration**. About five percent of the water soaks deep into the ground to become **groundwater**.[9]

Deeply penetrating water percolates downwards filling all available open spaces and thus all cracks and fractures become filled with water. The water also collects in the openings between the grains in the regolith that overlies the solid bedrock. All openings are filled up to a certain depth, called the **water table**. The water below the water table and the material that hosts it, is called an **aquifer**. We often divide the aquifer into two parts: the **regolith aquifer** above and the **fractured rock aquifer** below. In rural areas, boreholes are drilled down into these aquifers to obtain groundwater (Figure 10).

Figure 10: *Some rainwater soaks into the ground to form groundwater, which fills all available open spaces. Some of the water fills cracks in the rock mass, whilst some fills spaces in the layer of decomposed rock near the surface (called the regolith).*



9 These proportions vary with the climate and the nature of the soil: the figures given are more or less appropriate to the Witwatersrand.

The water table generally follows the land surface, although it tends to be slightly deeper below hills and shallower in valleys. The water table may come to surface, which creates **springs**. It also usually comes to the surface in river valleys, where groundwater leaks out to form streams. Groundwater seeping out on the surface in valleys causes streams and rivers to flow throughout the year. Rainwater soaking into the ground replenishes (**recharges**) the groundwater, which slowly flows from higher areas to lower areas, where it **discharges** into streams.

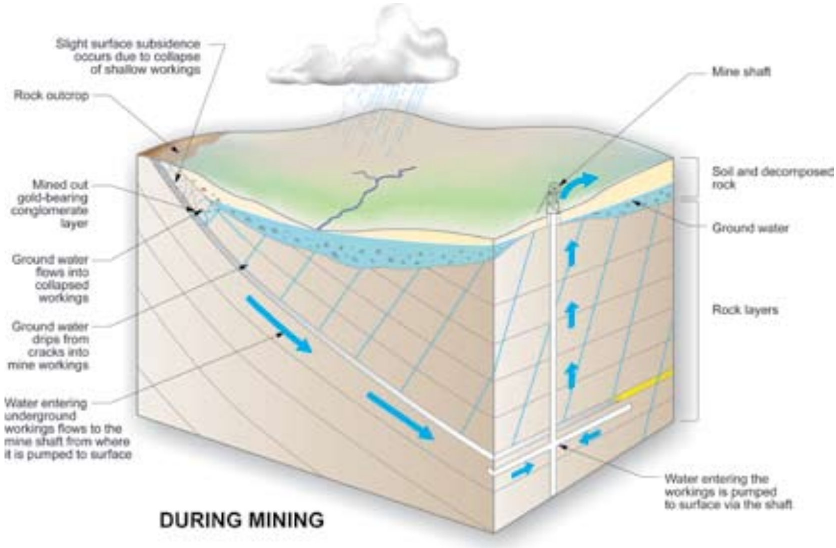
GROUNDWATER AND MINING

Mining involves the creation of open spaces below ground. In the course of mining, water-bearing fractures are intersected and near the surface the water-bearing regolith may also be intersected by the mining activity. Water therefore flows from these openings into the mine workings. Where the water flow is particularly strong, such as from heavily fractured rock zones, the inflow can be reduced or even stopped completely by drilling holes into the fracture and pumping in concrete under very high pressure – a process known as **grouting**. The water that seeps in more slowly, generally from narrower cracks, is channelled into gullies and eventually into ponds called **sumps** from where it is pumped to the surface via the shafts. The rate of pumping must obviously equal the rate of flow of water into the mine otherwise the mine workings will become flooded.

During mining of the Witwatersrand reefs the zone of surface disturbance was relatively narrow and severe inflows were curtailed by grouting and water inflow was relatively modest. Although groundwater did seep into the mine workings there was sufficient water available to maintain the regolith and fractured rock aquifers essentially in their pre-mining condition. Streams continued to flow and normal groundwater conditions prevailed above the deeper mine workings.

The miners created a void by extracting the gold-bearing rock, and by continuous pumping they ensured that the void remained filled with air. In doing so they in effect created an air bubble inside the fractured rock aquifer which grew ever larger as mining progressed (Figure 11). However – and this is where our current problems become clearer - to maintain the bubble required continuous pumping because water was seeping into the void. A balance was required to keep the water at bay. That balance has now been disturbed.

Figure 11: *During mining, water entering the mine void is channelled towards the shaft and pumped to surface to prevent flooding of the workings. If pumping were to stop, the void would slowly fill with water.*



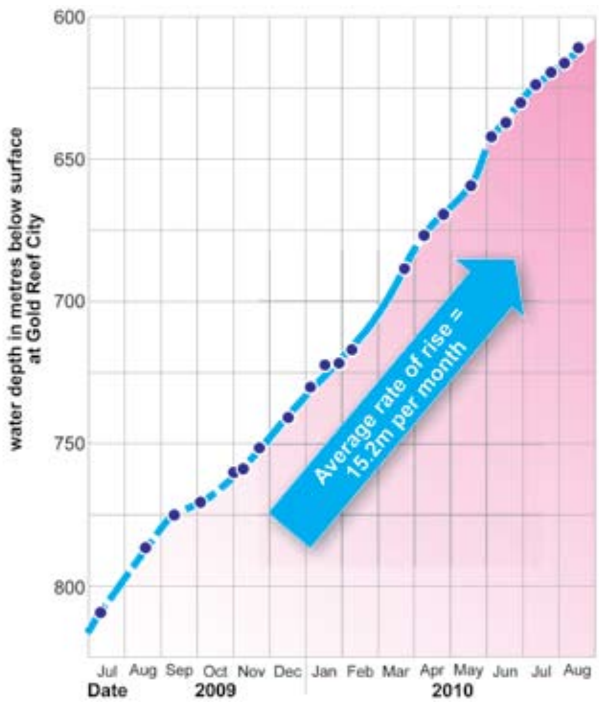
THE END OF MINING AND FILLING THE VOID

The mines on the Witwatersrand began to close in the late 1950s due to declining profits. Closure of a mine meant that pumping of water from the mine void ceased and water started accumulating in the deeper underground workings. From there it began to flow into adjacent mines, which took up the pumping responsibility of their defunct neighbours. Eventually, only one operating mine was left – East Rand Propriety Mines Ltd. (ERPM), which is situated on the eastern extremity of the Witwatersrand mining belt in Boksburg. This mine had to carry the burden of pumping out water that flowed from all of the defunct mines.

ERPM maintained the water level in their mining area at 1200 m below the surface. In order to do this it was necessary to pump an average of 40 million litres of water per day from underground. At that time, the water level 50km away at the western end of the Witwatersrand mine void (at the Durban Roodepoort Deep mine) had risen and stabilised at a depth of about 500m below the surface. Although the underground excavations were continuous from Durban Roodepoort Deep to ERPM, the fact that an approximately 700m difference in water level was maintained across the mine void indicates that obstructions underground stopped the free flow of water through the void. These obstructions are provided by natural dykes and by barricades in the tunnels. Had the void been completely open, permitting free flow of water, the water level would have been the same throughout the void, because of course *water always seeks its own level.*

In October 2008, ERPM finally ceased pumping - and the void began to fill. Since then the water level in the void appears to have levelled off and currently lies at a depth of about 600m below surface. The water level in the mine void is regularly monitored at Crown Mines 14 Shaft (Gold Reef City) and is rising at a rate of 15m per month (Figure 12). At this rate of rise, **the void will be completely filled in about three years from now.**

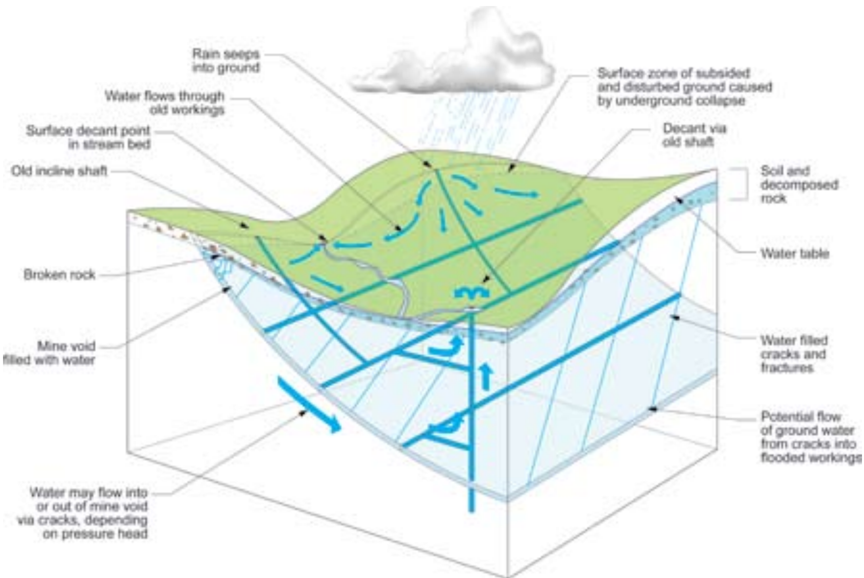
Figure 12: *Graph showing the rise of water level in the mine void, as recorded at 14 Shaft, Crown Mines (Gold Reef City).*



Once the void has filled, the water will begin to emerge from underground - **decant** will commence. Decant will occur because the mine void and openings connected to it, such as shafts, occur at a variety of elevations (Figure 13). Water will flow into the void in higher areas (called recharge areas) and decant at low (discharge) points. The inflow of water to the void before it became filled amounted to about 40 million litres per day, and the volume of decant water can be expected to be similar (probably slightly less).

The lowest large opening connected to the void is **Central Shaft** of **ERPM** in Boksburg, and if free flow of water through the void was possible, decant would take place only at this shaft. However, we have seen that the flow of water through the void is restricted, which will allow the water level in the void to stabilize at different levels in different parts of mining belt, as illustrated in Figure 13. Decanting water may emerge close to recharge areas or it may come from great depth via deep shafts.

Figure 13: *Diagram illustrating the processes causing decanting of water from a water-filled mine void. Inflow (recharge) will occur in the more elevated areas and water will emerge (decant) in the lower-lying areas such as via certain shafts and places where valleys cross the old working areas.*



THE NATURE OF THE DECANT WATER

We spoke earlier about 'fools gold' or iron pyrite, which can be found in the mined rock. When pyrite is exposed to oxygenated water, it forms sulphuric acid. In the acidic water, other minerals also break down and their metals dissolve into the water. Water draining or being pumped from the mines is thus often acidic with high concentrations of dissolved sulphate and metals - such as the water that is decanting from the flooded mines in the Western Basin. **The water is toxic and corrosive**.

exceptions could occur where water rises in shafts from great depths...

Water filling the deeper parts of the mine void eventually runs out of oxygen and the chemical reactions cease, capping the level of pollution. This situation will only occur in the very deep workings, however. Surface leakage will occur mainly from water entering and flowing through shallower mine workings. Exceptions could occur where water rises in shafts from great depths such as would occur via the shaft system as depicted in Figure 13.

Eventually, all of the sulphides in the rock will oxidize and the resulting dissolved material will be flushed out, so the quality of the water will steadily improve. Ultimately the decant water may become of sufficiently high quality that it could be used to augment the region's drinking water supply. **However, we have no idea how long this will take and could extend over many decades or longer.** In the immediate term, the water that will decant is potentially toxic.

AREAS OF POTENTIAL RISK

Although the void is very extensive, as shown in Figure 9, most of the excavations lie deep below the surface. This deeper part of the void will fill with water, but it will stay there and will not impact on the surface. The major risk is the region where the workings are relatively shallow - within about 200m of the surface. This will be where rainwater and water from other sources (e.g. leaking pipes and sewers) enters the workings, from where it will flow to discharge points at low elevations. The majority of discharge points will be **low-lying parts of the disturbed zone, especially where streams cross**. However, **many buildings have deep basements**, some of which could function as discharge points, susceptible to flooding when the mine void fills. Deep service tunnels may also be at risk from flooding.

The most important **risk zone** extends along **the Main Reef** and from there in a southerly direction over a width of about of about 500m. As a rough guide, it more or less follows Main Reef Road and in central Johannesburg, it runs along the northern side of the M2 motorway.

There is a **second risk zone** associated with the Kimberley Reef which lies approximately two kilometres to the south of the main risk zone. This reef was only sporadically mined and the zone is not continuous. Outside of these two zones, the flooding risk is low to negligible.

WHAT WE NEED TO KNOW

It is possible to compile a detailed risk map by combining information on the old mine workings (most of which were accurately surveyed), surface topography and the plans of buildings and other sub-surface structures in the risk zone. However, such a compilation has not previously been undertaken so at present we can only define the risk zone in fairly general terms.

Clearly, developing a detailed and accurate risk zone profile should be considered a priority for government and the mining industry.

THE SOLUTION TO THE PROBLEM

It would be very, very unwise to allow the mine void to fill, as flooding of buildings and strategic facilities could have serious economic consequences for the private sector and municipalities on the Witwatersrand, as well as negative socio-health consequences for the people living in the area.

...involves the establishment of pumping stations to pump the water to the surface for basic treatment.

The uncontrolled drainage of toxic water within the local municipal boundaries would be a major blow to our claim that Johannesburg and neighbouring municipalities are ‘world class African cities’ and a great embarrassment to South Africa internationally. Moreover, the underground mine at Gold Reef City will be lost, which is a unique and historic asset to the City of Johannesburg and the country as a whole.

The solution to the problem is relatively simple, however, and involves the establishment of pumping stations to pump the water to the surface for basic treatment. The shallower the depth from which the water is pumped, the lower the cost. Old mine shafts could be refurbished to access the water. The water treatment required has been carried out at Grootvlei, ERPM and at Randfontein for many years, and is well tried and tested. Although it does not produce good quality water, it greatly reduces or eliminates the toxicity.

The depth at which the water level should be stabilised needs to be carefully considered.

- To ensure **the security of the Gold Reef City** underground facility, the water level would need to be maintained at a depth of **at least 250m below surface** at this location.
- **Lateral flow** of water in the mine void is restricted, so for safety, it is recommended that **two pump stations** be established, one in the Germiston area and one at Florida, and that the water level be maintained at 300m below surface at these two points.
- This depth should ensure that the water level in the void along the entire risk zone remains deeper than 250m below surface.[10]
- It is also recommended that a private contractor be appointed to establish and carry out the pumping, allowing for proper performance and cost auditing.

Time is of the essence. The water level will reach the 300m mark in 20 months from now so it is essential that steps be taken immediately to start preparing the pumping and treatment infrastructure.

Pumping is not a once-off activity, and will have to continue indefinitely. Initially, this will involve considerable financial outlay to establish the pumping and treatment facilities, and an ongoing cost to maintain the pumping and water treatment. The cost will have to be borne by the state. It should be noted that much of this expense will not be new, as the government has for decades been paying pumping subsidies

10 Note that detailed hydrological modelling calculations still need to be carried out to define the optimum depth more precisely.

to mines to cover the cost of pumping inflow from defunct, adjacent mines. These so-called pumping subsidies are derived from taxation. The cost of not preventing decant may ultimately be greater than the cost of pumping: the degree of damage to infrastructure may be such that pumping will become an absolute necessity after decant commences, and will then have to be done under extremely unfavourable conditions.

Pumping will not necessarily be a perpetual cost. In the long-term, the quality of the pumped water will improve to the point where the water will become saleable. Treatment costs will then be substantially lower and the pumping operations will probably generate a profit.[11]

The complaint is often made that current taxpayers should not be held liable for costs incurred by previous generations. But government is invariably the largest single beneficiary of mining ventures through the state share of profits formulae, taxation of company profits and taxation of salaries paid to workers. The revenue thus obtained is ploughed back in the form of infrastructure and services, which citizens enjoy. Those who complain that they are paying for a liability that was not of their making need to be aware that the infrastructure such as road networks, schools, hospitals and the like from which they benefit were partly paid for by taxation of now defunct mining companies.

CONCLUSION

Mining invariably creates environmental problems. Some are immediate; others appear years or even decades after mining ceases. Amongst the latter category is the leakage of acidic water contaminated with heavy metals from closed and abandoned mines. The problem is well known and affects mining districts around the world, but very seldom does it occur within a major metropolitan area. The Witwatersrand conurbation is now faced with the prospect of such uncontrolled leakage of polluted water from old mines that lie within the city limits.

11 It is cheaper to pump water from 300m below surface in Johannesburg than to pump it to the city from Vaal Dam 80 km away, which also involves lifting the water about 250m.

There is currently a window of opportunity during which steps can be taken to prevent the situation getting out of control. The technology required to control the problem is well established and there are many companies in the private sector that have the necessary expertise to implement the solution. It is essential that we act immediately and decisively if we are to avoid catastrophe.

GLOSSARY

- **Aquifer** Zone below the surface capable of holding groundwater.
- **Cocopan** Small wagon running on rails used to transport broken rock on a mine.
- **Conglomerate** Sedimentary rock consisting of pebbles and sand fused together.
- **Cross-cut drive** Tunnel leading from a shaft to the mining area.
- **Decant** (in mining) Surface discharge of water from an abandoned mine.
- **Discharge** Seepage of groundwater at the surface.
- **Dyke** Vertical, planar body of igneous rock formed by the solidification of molten rock in a crack.
- **Evapotranspiration** The process of transfer of water to the atmosphere by evaporation and transpiration by plants.
- **Fault** Crack in the Earth along which differential movement of the rock mass has occurred.
- **Fool's gold** The common name for the mineral pyrite (iron sulphide).
- **Fractured rock aquifier:** a water-bearing rock mass (aquifer) in which the open spaces that accommodate the water are the result of cracks in the rock
- **Groundwater** Water occupying openings below ground.
- **Grouting**: the pumping of concrete into open spaces underground in order to seal them
- **Incline shaft** An inclined tunnel on a mine.
- **Joint** A planar crack in the rock mass.

- **Level (in a mine)** A near horizontal surface on which mine tunnels are opened.
- **Mine plan** Accurate drawing showing the positions of mine excavations. **Mine void:** the underground cavity created by mining
- **Pack (in a mine)** Stack of wooden logs used to support the rock mass above an underground excavation.
- **Pillar (in a mine)** Rock column left in place to support the rock mass above an underground excavation.
- **Pyrite (also pyrites)** A mineral consisting of iron and sulphur.
- **Quartzite** A hard sedimentary rock made of grains of the mineral quartz that have been strongly bonded together.
- **Raise (in a mine)** An inclined tunnel excavated upwards from a lower to a higher level.
- **Recharge** The inflow of water from the surface to the groundwater.
- **Reef** Term used on the Witwatersrand mines for conglomerate.
- **Reef drive** Horizontal tunnel excavated along a reef.
- **Regolith** Soil and partly decomposed rock lying above the bedrock.
- **Shale** Sedimentary rock composed of mud and silt particles.
- **Spring** A point where groundwater seeps out at the surface.
- **Stope** Open space left after mineral-bearing (e.g. gold) rock has been extracted.
- **Sub-vertical shaft** A mine-shaft that commences far below the surface.
- **Sump (in mining)** A depression excavated to collect water in a mine.

- **Surface subsidence (in mining):** sinking of the land surface due to collapse of underground mine workings
- **Uraninite** A mineral consisting of uranium and oxygen.
- **Water table** The surface in an aquifer below which all voids are filled with water.

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True blue

South Africa proudly flies Blue Flags on many of its popular beaches. From Clifton 4th beach to Umhlanga Rocks beach in KwaZulu-Natal, sun seekers in their hundreds of thousands descend onto these beaches every year

AROUND EASTER 2008 the media throughout the country was awash with reports of the loss of Blue Flag status on a number of Durban's beaches. At the same time, significant column inches were devoted to a major sewage spill in the sea at Isipingo, south of Durban. As holiday-makers were heading to the coast to enjoy the holidays, this was exceptionally bad timing for these events to occur. Telephones kept on ringing in the tourism offices in KwaZulu-Natal as holiday-makers attempted to find out whether it was safe to swim in the sea in Durban.

The withdrawal of Blue Flag status on Durban's beaches was largely as a result of the sea water not meeting the health requirements of Blue Flag. While the Blue Flag program recognises that there are times when water quality is compromised, e.g. at the start of the rainy season or when spillages occur from time to time, the permissible number of samples over the standards may be no more than 20%. Over the past three years on many of Durban's beaches, the fortnightly tests undertaken by the eThekwini laboratory have shown deterioration in water quality and increasingly higher levels of bacteria resulting in over 40% of samples exceeding the accepted standards. More recent results indicate that on many of Durban's beaches the bacterial levels are 25 times that of the standards for South African bathing water quality set by the Department of Water Affairs & Forestry (DWAF).

Blue Flags have been flying over beaches throughout the world for more than 20 years and, according to the World Tourism Organization (WTO), Blue Flag is the most widely recognised eco-tourism label in the world. This is hardly surprising when one considers that there are Blue Flags flying over almost 3 500 sites in 38 countries. It is interesting to reflect that the program had its origins in France and the Mediterranean region in the 1980s when there were grave concerns about the impact of deteriorating water quality on tourism to the region.

BLUE FLAG A STANDARD OF EXCELLENCE

A Blue Flag flying over a beach is an indication that the beach and surrounds are managed according to world-class standards. For a beach to fly a Blue Flag, the beach must achieve standards of excellence in four main areas:

- water quality management
- environmental management
- safety and service
- environmental information for the public

These areas of compliance rely on infrastructure and services put in place by the engineering, and health and sanitation departments in municipalities.

It has been suggested that the Blue Flag program is a critical tool to measure success of water and effluent management in catchment areas. Coastal management is synonymous with catchment management. In South Africa, some of our best swimming beaches are in close proximity of estuaries and rivers that often bring poor water quality down to the coast. Whatever discharges into the sea is the final culmination of a journey through a catchment area. Should the infrastructure and services within a catchment area be compromised, the consequences will definitely be experienced at the end of the journey. Coastal municipalities have to implement comprehensive and effective catchment management programs in order to ensure good, healthy water quality at their beaches. Managing what comes out on the beaches requires interventions throughout what could be a large catchment area. This is probably the greatest challenge facing coastal municipalities when implementing the international Blue Flag program in South Africa.

ENGINEERING INTERVENTION ESSENTIAL

The reasons for the deteriorating water quality in the eThekwini area appear to be complex and will require significant and innovative engineering interventions. The events causing major sewage spills, the poorly performing sewage treatment facilities, and even the DWAF standards for effluent released from sewage treatment plants, all have to be investigated and better managed.

It is probably true to say that the average South African is not aware of the vitally important role engineering plays in ensuring that our cities are healthy and well managed. Water and sanitation issues lie at the heart of our quality of life. For Durban, interventions to improve sea water quality will be essential and will require immediate responses. Poor management of sewage infrastructure and storm water systems poses major health risks for both beach-goers and those living in close proximity of polluted rivers and ineffective sewage plants. The solutions will have to draw on a variety of sub-disciplines in the engineering field: environmental engineering, coastal engineering, construction engineering, and a multi-disciplinary approach is going to be necessary throughout the eThekwini catchment area to sort out the problems being manifested on the coast.

The city is obviously taking these issues seriously. City officials have already started implementing measures to better manage infrastructure in the city. Sumps are being put in place within the storm water system to redirect potentially compromised water away from the coast. This is good news.

It is interesting to note that in the majority of countries participation in the Blue Flag program requires that there may not be any storm water outlets on Blue Flag beaches! South Africa is exempt from this requirement.

eThekwini is not the first municipality to have Blue Flag status withdrawn owing to poor water quality. Margate beach on the KwaZulu-Natal south coast also lost its Blue Flag status, yet within twelve months the Hibiscus Coast municipality had implemented measures to improve sewage management and the beach once again received Blue Flag accreditation.

WORLD-CLASS DESTINATIONS

Tourism research indicates that our beaches are major draw cards for both domestic and foreign visitors. Durban's economy is inherently linked to its beaches and rapid interventions will be required to improve water quality on it's beaches, and in so doing, restore public confidence in the water quality along the beachfront.

Notwithstanding the challenges of meeting international standards on Durban's beaches, more and more municipalities are subscribing to the Blue Flag program here in South Africa. In order to ensure compliance with standards, municipalities have to apply annually for the accreditation on their beaches. As South Africa prepares for the 2008–2009 Blue Flag season, twenty-six beaches from around the country have applied for the acclaimed Blue Flag status. In the current season there are eighteen beaches in the program.

One only has to see the volumes of traffic heading towards the coast at the time of the summer holidays to know that South Africans enjoy their holidays on the beach. For local visitors, holidays are synonymous with fun in the sun on the beach. With weather that allows all-year-round tourism and a booming tourism industry, we would like to see more and more Blue Flag beaches flying flags of excellence in future, assuring beach-goers that the water quality is being well managed and is healthy, that the beach and facilities are clean, and that the services in place will offer them a world-class beach.

Visit www.blueflag.org for more information. ◻

1 Blue Flag flying at Kelly's Beach south of East London

2 Blue Flag beaches – 2008 season

3 Sound water quality management is a must on Blue Flag beaches – Marina Beach, KwaZulu-Natal south coast. Note Blue Flag

4 Storm water discharging onto beach in close proximity of beach-goers

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An engineering response to the sea water quality issues in Durban

BEFORE DEALING WITH the engineering side of this issue, I believe it is important to first examine the science behind the decision taken by Blue Flag to withdraw status from certain of Durban's beaches. The quality of sea water is impacted primarily by storm events which have the effect of washing pollution from the land into the sea. For a short period after these storm events, the quality of sea water can be impacted negatively in areas immediately adjacent to river or storm water drain discharge points. The impact of this pollution is short-lived because of the ability of sea water to destroy pathogens within a few days.

Given that the viruses and other pathogens which cause infection cannot easily and cost effectively be detected in the sea water, indicators such as E. coli, Enterococcus and other bacteria are used. These indicator bacteria are themselves not harmful – in fact the World Health Organisation describes them as "harmless organisms". Provided that the indicators which are used have a life similar to that of the pathogens and exist in numbers that are in proportion to the level of pathogens in any sample, they can be used to determine the level of pollution of a water body.

A number of papers exist which show that, in tropical waters, Enterococci are not suitable for use as indicators of the existence of pathogens in water because the Enterococci are able to multiply on their own in the favourable environment which exists. Equally E. coli die off at a rate faster than the pathogens and may therefore under-report the degree to which a water body is polluted. The World Health Organisation, in one of its most recent publications, entitled "Monitoring Bathing Waters – a Practical Guide to the Design and Implementation of Monitoring Programmes", states that "the lack of a strong relationship between faecal indicators and health outcomes in a number of epidemiological studies in warm tropical waters may, in part, relate to the inappropriate nature of E. coli or faecal streptococci as indices of water-borne pathogens in these recreational waters. In this context an alternative index group, sulphite-reducing clostridia or spores of Clostridium perfringens, have been proposed and are used in Hawaii."

BLUE FLAG STANDARDS

Blue Flag in setting their standards require the E. coli count to be less than 100 colonies per 100 ml and the Enterococcus count to also be less than 100 colonies per 100 ml sample. From 2009, the Enterococcus level is to be reduced to 50 colonies per 100 ml sample.

Epidemiological studies have then been undertaken in the past to link the number of indicator colonies present in a specific volume of water, to the level of infection of bathers in contact with the water. At the time of most of these epidemiological studies, bacteria colonies were grown on media which gave far lower counts of colonies than the modern day media which are more sensitive and which give higher colony counts. Recent studies indicate that the bacteria colony counts detected using the more sensitive techniques of today, can be 50% to 100% higher than those detected in the past.

The Blue Flag literature does not prescribe a single method of testing for these indicator bacteria and until now has not responded to the statement from the World Health Organisation that Enterococci are not suitable for use as an indicator in tropical waters.

A CITY'S TASK

Having said that, it is clear that the aim of any city should be to minimise the levels and frequencies of pollution of its beaches to the absolute minimum.

Pollution of Durban's beaches has a number of causes:

- river flows carrying sewage downstream from developments that are not yet connected to an acceptable sewage disposal system
- illegal interconnections of the sewer and storm water drains by residents on private property and abuse of the sewerage system
- the recent pumping of sand from the harbour itself onto our beaches
- pollution flowing down nine storm

water drains from the central city region and onto the central beaches
- sewers that leak into rivers after damage by severe storm events, or vandalism

Some of these causes are the result of our rapid growth as a city and the high levels of poverty we face. These issues cannot be resolved overnight, as to do so would burden the ratepayers excessively with the cost of the additional capital needed. As an example, to ensure that every family without access to sanitation receives access to an acceptable basic sewage disposal system, will cost over R1,5 billion.

The upgrading of the city's sewerage system takes the form of extending the sewerage service to all communities and this work will not be completed until 2012 or 2013. In 1996, 250 000 families in the municipality did not have access to acceptable sanitation. Since that time over 20 000 families have been connected each year. This service delivery has been offset to some extent by the large inward migration of families into the municipality seeking access to basic services and employment. By photographing the municipal area every year and counting the houses on the ground, it has been possible to measure this influx, which has reached 30 000 families in a single year on occasions.

To respond to illegal connections between sewer and storm water systems on private property, we have started to make use of smoke generators which pump smoke into sewers and this smoke will exit from any storm water drain that is connected to it, making detection somewhat easier. It is almost impossible to detect intermittent interconnections that are made during storm events when sewer manholes are opened to relieve local flooding.

Sand from the harbour itself has recently been pumped onto the beaches, instead of sourcing sand from the open sea south of the south pier, as used to be the case. It is necessary to continually pump sand onto the central beaches to prevent them from eroding away. Reports were received from the public that this sand smelt of sewage and it was found to be contributing to the contamination of the sand on the beaches. Since January, this pumping has been stopped and the sand quality will improve over time.

To reduce the impact of storm water drains discharging onto the beaches of the golden mile, we have begun to construct sumps in all nine of these drains and pump the contaminated low flows that arise from time to time into the nearest sewer. Two of these drains already have the sumps in place. It is a reality in a large city like ours, that poor people and vagrants do not always have ready access to toilets, or do not make use of these facilities when they are available. This drain intercept initiative will enable us to wash the city streets more often, knowing that the effluent that is generated will be collected and treated properly.

The frequency of testing of the water and sand microbiology has been increased to once a week and shortly we will display the results of these tests on notice boards on our beaches, as well as on the internet on a weekly basis, together with a litter index to indicate the cleanliness of all our beaches. These results continue to show compliance with DWAF (Department of Water Affairs and Forestry) water quality standards, except for a few days after significant storm events at beaches close to rivers or storm water drains. □

IMESA establishes
Saldanha Bay Forum

1 The plan for the Langebaan beach restoration, starting with the first groyne
2 The first temporary groyne at the Langebaan Lagoon
3 Close-up of the first temporary groyne at the Langebaan Lagoon

WITH PLACES OF natural beauty in high demand for both residential and commercial reasons, and following an environmental impact study, IMESA (Institute of Municipal Engineers of Southern Africa), in conjunction with the municipality of Saldanha Bay, has established the Saldanha Bay Forum. This body was created to preserve Saldanha Bay, the Langebaan Lagoon and the immediate inland surrounds, and also to promote sustainable development for the bay and coastal areas.

According to Piet Fabicius of Environmental Health Services (Saldanha Bay Office), environmental scoping had indicated the need for a forum to monitor the environmental impact of users on the bay. However, it was felt that such a forum need not be a formal statutory authority. Therefore the Saldanha Bay Forum is an ad hoc, consensus-seeking body performing an advisory function.

The proposal to construct a temporary groyne at Langebaan and the need for beach dredging to combat beach erosion were both instigating factors surrounding the establishment of the Forum. According to Fabicius the founding of the Forum was met with much support and enthusiasm by stakeholders and users of the bay.

The Forum focuses on several geographical areas, including the water area of Saldanha Bay and the Langebaan Lagoon, the coastal zone, as well as the immediate hinterland and inland areas where there may be issues that could impact on the bay and it surroundings.

The Forum's main objectives are to:

- be a vehicle which is representative of all the bay stakeholder groups
- provide a mechanism for the exchange of information
- monitor the management and health

of the bay area, as well as initiate and guide research on it

- provide a forum for dialogue and debate
- provide advice and support to regulatory and governmental bodies responsible for the management of the bay

The bay is used on a daily basis for different purposes – industrial, business, tourism, marine-culture, recreation – by various groups of people. These groups greatly benefit from the many opportunities that the bay has to offer, including export and import, harvesting of seaweed and shellfish, and water sport.

However, these users' diverse needs in turn have a diverse impact, both existing and potential, on the bay environment. The bay, with its highly industrialised Port of Saldanha, is a marine-protected area and forms part of the West Coast National Park. The environmental consequences of users' activities have led stakeholders and users to identify the need for urgent joint and strategic integrated management of the bay.

According to Martiens Victor of IMESA in Saldanha Bay, IMESA encourages endeavours such as the formation of the Saldanha Bay Forum and would like to see more municipal initiatives nationally around environmental impact and sustainability.

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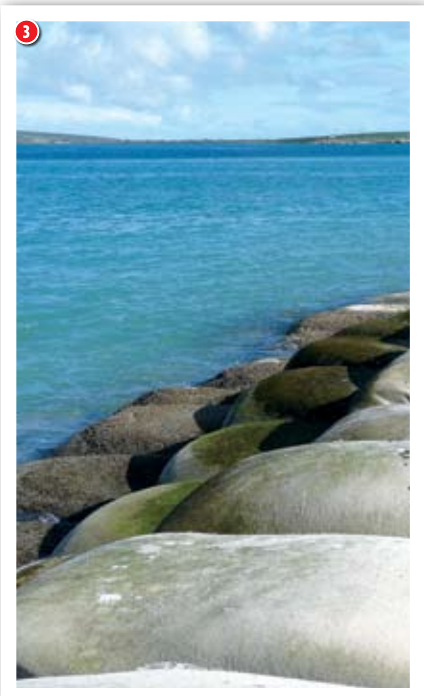

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Legal obligations regarding the lifecycle of a **mine tailings storage facility**

Increasing pressure is being placed on mining companies to improve their environmental performance. The abundance of abandoned mine sites and large tracts of unrehabilitated mine land on the Witwatersrand and the Natal and Mpumalanga coalfields testify to the fact that mining companies have in the past failed to apply sustainable closure principles, particularly regarding tailings deposits. To be successful in an increasingly competitive global market, it is vital that mining companies subscribe to the principles of sustainable development. The very finite nature of mining requires responsible planning and effective management to meet sustainable closure objectives. The prevailing legislation specific to the lifecycle of a mine tailings dam is summarised here

BACKGROUND

Since the promulgation of the Minerals Act in 1991, all mines have to a large extent been forced to act with greater responsibility to address and mitigate all the potential impacts their activities may have on the environment. The National Environmental Management Act (NEMA) and the National Water Act (NWA), promulgated in 1998, have given further impetus to this national drive.

The principle of 'Duty of Care' enshrined in Section 28 of the National Environmental Management Act (No 107 of 1998), enjoins a statutory obligation on companies and operations to take reasonable measures to prevent pollution or degradation from occurring and, if it cannot reasonably be avoided or stopped, to minimise such pollution to the environment.

In addition, Section 38 of the Mineral and Petroleum Resources Development Act (MPRDA), 2002, makes provision for the directors of a company or members of a close corporation to be held jointly and severally liable for any unacceptable negative impact on the environment.

It is clear then that there is an urgent need for mining activity to be planned in such a way as to ensure the minimum impact on the environment. Arguably, the greatest potential source of mine-related pollution is mine tailings dams.

Let us examine briefly all the legislation relevant to the lifecycle phases of a typical mine tailings dam. The principal phases are:

- Planning
- Design and construction
- Commissioning and operation
- Decommissioning
- Rehabilitation and closure
- 'Post-closure' management of residual and latent impacts

LEGAL RESPONSIBILITY

A weighty responsibility is placed on company directors, managers and even personnel to act in an environmentally responsible manner at all times. Of particular significance is what has come to be commonly known as the 'polluter pays' principle which is contained in Chapter 1 of the National Environmental Management Act, 1998 (NEMA) and endorsed in Section 37 of the MPRDA: "The costs of remedying pollution, environmental degradation and consequent adverse health effects and of preventing, controlling or minimizing further pollution, environmental damage or adverse health effects must be paid for by those responsible for harming the environment."

LEGAL OBLIGATIONS PERTINENT TO THE VARIOUS LIFECYCLE PHASES

Planning

First, a preferred site for the tailings dam must be selected according to criteria specified in MPRDA Regulation 73, followed by geotechnical and ground water investigations. No person may temporarily or permanently deposit any residue stockpile or deposit on any site other than on the one demarcated for that purpose (MPRDA Section 42).

There are also restrictions on cultivating virgin soil (Conservation of Agricultural Resources Act, Act 43 of 1983 (CARA) and amended Regulations); on cutting or damaging protected tree species (National Forests Act, 1998, and Govt Notice No 897 of 8 September 2006); on siting with regard to the 1:100 year flood-line or a specified horizontal distance from any water resource; on disposal of residue in any place likely to cause pollution of a water resource; and on the use of materials for constructing a tailings dam that are likely to cause pollution of a water resource (the last three stipulated in Govt Notice 704, June 1999).

Concerning Environmental Impact Assessments (EIAs) and the Environmental Management Process (EMP), the National Environmental Management Amendment Act, 2004, enables a system of EIAs and related management tools to be regulated in terms of NEMA, in addition to the impact assessment requirements of the MPRDA 2002. Regulations pertaining to the NEMA EIA process and addressing the process of either basic assessments or EIAs were published as Govt Notices R385; R386 and R387 in April 2006.

Obligations for public participation are likewise contained in the relevant sections of the MPRDA and regulations.

Design and construction

Govt Notice 704 of June 1999 stipulates that every person in control of a mine or activity must confine any unpolluted water to a 'clean water system', operate such a system at the mine so that it is not likely to spill into any dirty water system more than once in 50 years, and collect the water arising within any dirty area, including water seeping from mining operations, into a 'dirty water system'. The serviceability of conveyances for such flows must also be guaranteed.

MPRDA Regulation 73 deals with the management of residue stockpiles and deposits. The assessment of impacts relating to these must form part of the EIA and EMP. Mine residue must be characterised to identify any potentially significant health or safety hazard and any environmental impact of the stockpiled or deposited residue. A risk analysis must be carried out and documented on all high-hazard residue stockpiles and deposits. Furthermore, a design report and operating manual must be drawn up for all residue stockpiles and deposits.

The National Water Act defines different water uses in Section 21 and water use licences and the registration of dams with a safety risk in Section 22.

Commissioning and operation

Occupational health and safety plays a major role during commissioning and operation and is regulated in terms of the Mine Health and Safety Act, No 29 of 1996 (MHSA).

According to the MPRDA Regulations, the holder of a mining right must conduct monitoring on a continuous basis, conduct performance assessments of the EMP as required, and compile and submit a performance assessment report to the Minister (Regulation 55). The principles of pollution control and waste management are covered in Regulations 63 to 73, which deal with the management of air quality, noise, water and pollution control.

Other legislation relevant to commissioning and operation is contained in the National Water Act (emergencies, security, temporary or permanent cessation of a mining operation, and technical investigations and monitoring); the National Environmental Management Act, 1988; the National Nuclear Regulator Act, 1999 and the Atmospheric Pollution Prevention Act, 1965. The National Environmental Management: Air Quality Act, 2004, deals with the control of dust and rehabilitation when mining operations cease.

This is not the end of the list! Also to be adhered to are the appropriate chapters and regulations of the Conservation of Agricultural Resources Act, No 43 of 1983 (CARA) and amended Regulations (15 and 16) of March 2001 and the National Environmental Management: Biodiversity Act, No 10 of 2004, both of which cover the management of alien and invasive plant species. The National Veld and Forest Fire Act, No 101 of 1998, governs requirements for firebreaks and the Hazardous Substances Act, 1973, and Regulations contains requirements pertaining to the use of artificially produced isotopes, typically as density gauges in residue disposal pipelines. Additionally the MHSA 96 requires mandatory Codes of Practice for mine residue deposits and cyanide management.

1 and 2 Top of a typical operational tailings dam
3 View of a tailings dam showing daywall and side slope

Decommissioning, rehabilitation and closure

Statutory obligations in terms of the approved EMP and closure plan have to be abided by. The transfer of environmental liability is covered in Section 43(2) of the MPRDA, which, in contrast with its predecessor, the Minerals Act, 1991, makes provision for the transferring of environmental liabilities to a "qualified person" (Regulation 59). Liabilities in terms of the EMP/closure plan may be transferred, provided an application is lodged with the Minister for approval and subsequent to endorsement in writing by the Department of Water Affairs and Forestry (DWAF) and the Chief Inspector of Mines.

Further, all the acts and notices referred to above also contain provisions relevant to decommissioning and closure of mining operations.

Post-closure management

The granting of a closure certificate as contemplated in Section 43 of the MPRDA does not imply that a 'walk-away' will be possible. Section 43(6) stipulates that: "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

2

3

A weighty responsibility is placed on mine management to ensure that the use and exploitation of non-renewable natural resources is responsible and equitable, and takes into account the consequences of the depletion of the resource within the framework of sustainable development

permit concerned, but may retain any portion of such financial provision for latent and or residual environmental impact which may become known in the future".

Socio-economic impacts

Responsible closure, concomitant with the MPDRA, also requires that the socio-economic impacts be addressed, managed and wherever possible, mitigated and eliminated. Regulations published in terms of the MPDRA require that all mining companies have a Social and Labour Plan in place. This plan should consider the development of a mining operation in the context of generally recognised standards of sustainable development by integrating social, economic and environmental factors in planning the mining operations throughout the life of the mine, and on closure. Sustainable closure therefore involves far more than mitigating or eliminating the risks and impacts on land, water, the atmosphere, micro-organisms, and plant and animal life. Closure can never be sustainable if socio-economic impacts are not identified, addressed and accounted for.

CONCLUSION

A weighty responsibility is placed on mine management to ensure that the use and exploitation of non-renewable natural resources is responsible and equitable, and takes into account the consequences of the depletion of the resource within the framework of sustainable development.

Turning these potential liabilities into a sustainable asset after closure probably presents the biggest challenge to mining companies. Responsible and active planning for closure during the life of the operation, with the active implementation and management of engineering and environmental controls, is probably the only way to ensure that post-closure liabilities are quantified, fully understood and managed both responsibly and cost-effectively.

The original paper on which this article is based, was presented at the 4th International Conference on Mining and Industrial Waste Management, held in Rustenburg from 11 – 12 March 2008

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South African mine residue disposal practices in a global context

South African mining and construction companies have become subject to international standards for the planning, design, construction, operation and closure of mine residue storage facilities. With the increasing consciousness worldwide of sustainability, environmental, health and safety issues, the international standards themselves are becoming far more onerous on the owner, designer and operator of these facilities than has previously been the case. In this article some of the aspects of where South African mining companies and their designers and operators have had to modify their previous approaches in order to comply with the standards commonly enforced in the USA, Canada, Australia and the European Union are discussed

IN RECENT DECADES the detrimental environmental effects of uncontrolled disposal of tailings and the occurrence of several major failures have led authorities worldwide to demand that residue storage facilities should be properly designed, operated and closed. Ever more stringent standards have been imposed on mine owners worldwide. Foreign owners sometimes insist that the standards applicable in their home countries should be applied also in South Africa, despite our well-established mining traditions and legislation, resulting in unnecessarily conservative or expensive facilities. This does not imply that standards should be lowered just because a mine is situated in a developing country, rather it is advocated that the most appropriate standards for a particular situation be used.

A selection of published guidelines is available from the editor.

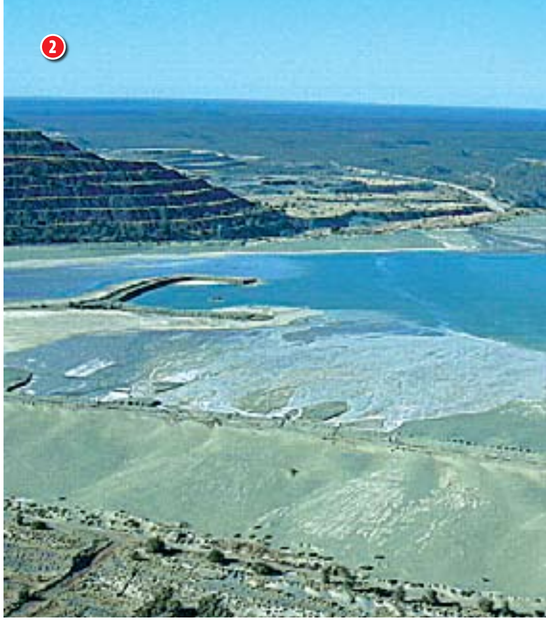
REGULATORY ENFORCEMENT AND ENVIRONMENTAL PROTECTION STANDARDS

Mine waste facilities in South Africa are required to be constructed and operated in accordance with several different acts of legislation, some of which may at times appear to be contradictory. There is no single statute, act or regulation in South Africa dealing specifically with the construction, operation and decommissioning of mine residue facilities. Legislation that must be observed includes the Mine Health and Safety Act, the National Water Act, the Mineral and Petroleum Resources Development Act and the National Environmental Management Act.

Mine waste disposal in South Africa is generally carried out in accordance with SANS 10286, (previously SABS 0286), the Code of Practice for Mine Residue. SANS 10286 provides a guideline as to what legislation must be complied with, summarises the key legal requirements pertaining to mine residue and outlines the principles to be followed in the management, planning, siting, design, construction, operation, decommissioning and aftercare of residue deposits.

South African authorities generally adopt a risk-averse approach in granting licences to mining developments, bearing in mind the fact that such developments should be socially, economically and environmentally sustainable. This same approach should be adopted elsewhere on the African continent. The principle frequently applied to mine waste management is the BATNEEC principle: Best Available Technology Not Entailing Excessive Cost.

Whatever legislation and environmental protection standards are applied in a particular country should take into account the overall economic situation and objectives of that country, in addition to the primary concerns of safety and protection of the environment. The published guidelines generally note that the solutions to be applied must be site-specific.



1 Gold tailings dam in Peru, fully lined and with decant pumps on barge
2 Tailings dam near Phalaborwa, upstream of the Kruger National Park in the distance

DESIGN LIFE

The design life for operation of a mine waste facility is generally taken as no more than 20 years, sometimes less, irrespective of the mineral or resource reserve available. It is unrealistic to forecast the economic viability of a mine beyond a 20-year horizon. However, when environmental effects are considered, due attention must be paid to the sustainability of the facility after closure and for the long-term future. In South Africa we are used to thinking in terms of 50 or 100 years, but in countries like Canada and the USA a time horizon of 1000 years is mandated.

STABILITY CRITERIA

Factors of safety

In South Africa it is common to design for a minimum factor of safety (FoS) of 1.3 against slope failure under static conditions while the facility is in operation and under regular surveillance, increasing to 1.5 after closure. For transient or seismic conditions, a minimum FoS of 1.1 is usually specified, but may be modified under particular circumstances.

These criteria are not out of line with generally accepted international standards. In most of South Africa, however, the climate is temperate semi-arid to arid and seismic risk is generally low, which means that the required FoS can be achieved with simpler methods of construction than in regions with significantly higher rainfalls, more extreme temperatures and higher seismic risk.

Acceptability (or otherwise) of upstream construction

Most South African tailings storage facilities are constructed by the upstream method, in which the outer confining wall or embankment is constructed over previously deposited tailings. In most cases the confining wall itself consists of tailings, whether it is constructed by cycloning, spigoting or by the ring paddock system.

Because of their experience in their home countries, overseas-based mine owners are sometimes reluctant to accept upstream-constructed tailings storage facilities, even where the method can be demonstrated to result in a stable deposit, despite the lower capital cost usually associated with this type of facility.

Seismic loading

The Design Basis Earthquake (DBE) is commonly specified as that seismic event with a 10% probability of being exceeded in 50 years (or 100 years in some standards) – equivalent to a recurrence interval of 475 years (or 950 years) for the DBE. Under these circumstances the slope must remain fully stable. Sometimes, even though the minimum specified FoS of 1.1 is not achieved, the design may be satisfactory, provided that it is shown that the estimated deformations due to seismic loading are acceptably small.

Under the Maximum Credible Earthquake (MCE), which may be a 1 in 10 000 year event, some damage would be acceptable, but not complete failure of the slope or any other component of the tailings storage facility.

WATER MANAGEMENT SYSTEMS

Storm water management in the South African mining industry is regulated by Government Notice R704 of June 1999 under the National Water Act, and by Government Notice R577 of April 2004 under the Minerals and Petroleum Resources Development Act.

GN R704 states, inter alia: "Every person in control of a mine or activity must … design, construct, maintain and operate any clean (and dirty) 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; and … 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…"

GN R577 states, inter alia: "Design considerations as applying to the particular type of stockpile and deposit that must be incorporated include –

- the control of storm water on and around the residue stockpile or deposit by making provision for the maximum precipitation to be expected over a period of 24 hours with a frequency of once in 100 years."

Australian practice is to design for the 1 in 100 year 72-hour rainfall event. In the Americas return periods of up to 1 000 years have been specified.

Because the confining walls of most South African tailings storage facilities are constructed of the tailings material itself by the upstream method, the freeboard is usually relatively small and it is not considered good practice to retain large quantities of water on such facilities. It is therefore necessary to remove supernatant and rain water from the facility and store it elsewhere, usually in a separate return water dam which is specifically designed for that purpose. The return water dam is constructed and operated so as to ensure that there

is always sufficient spare capacity to contain storm water runoff from the tailings storage facility, as required by GN R704 and GN R577.

In South Africa it is common for the decanting system to be by means of a gravity penstock discharging through a pipe through the confining wall. Pumping systems are less commonly used. In many parts of the world, however, it is considered poor practice to have any kind of pipe penetrating the confining wall and pumped decant systems are almost always used, with the water returned directly to the process plant. In high rainfall zones where the confining walls are built ahead of the tailings beach and pool, the design may allow for large quantities of water to be held on the tailings dam without compromising its stability.

PREVENTION OF SURFACE AND GROUND WATER CONTAMINATION; LINING OF TAILINGS STORAGE BASINS

Major funding agencies in many countries, and South Africa, mandate a policy of "total containment of polluted water". Nevertheless, there can be significant differences in the interpretation of this requirement. Also, account should be taken of the natural background concentration of the elements that could be released.

'Pollutants' need to be clearly defined, as not all dissolved salts are necessarily harmful to the environment. Although, of course, chemicals such as cyanide and arsenic are poisonous, and radioactive wastes from uranium mines are highly hazardous, the World Health Organization (as well as South African regulations) has specified concentration limits for most substances, below which they can be regarded as not injurious to health.

What is the design implication of "total containment"? In South Africa, GN 704 permits spillage of dirty water to the environment no more than once in 50 years, which is based on the premise that for a rainfall event with a recurrence interval exceeding 50 years there will be sufficient water in the receiving environment to ensure adequate dilution of any pollutants. However, there is the view that "dilution is not the solution". Although the immediate concentration of a particular pollutant may be below the specified limit, certain substances can be very persistent and their concentration in the receiving body of water may increase with time to hazardous levels.

When applied to groundwater seepage, the principle of "no release of pollutants" implies that there should be a fully effective barrier beneath a tailings storage facility to prevent seepage. Although this has not been the case in South Africa, the provision of synthetic liners has been common practice overseas for several years. The choice of barrier depends on the chemical constituents in the seepage, the geological environment, the available liner materials and their properties. Bear in mind that all liners (natural or synthetic) leak to a greater or lesser extent and will only reduce the seepage.

FULL CLOSURE DESIGN

The approach to designing for closure of a mine waste facility is in essence the same – whether it is done in South Africa or overseas. The difference lies in the 1 000-year and 50-year recurrence interval design criteria. Capping designed for 1 000-year recurrence interval rainfall will need to be thicker and more robust than capping designed for 50-year rainfall. The design of erosion-protection measures and storm water channels must fully consider climatic factors, bearing in mind the high flows associated with the greater intervals and that maintenance and repair of the facilities cannot be assured over such a long period.

CONCLUSION

As a whole, the design standards and criteria used internationally are becoming far more onerous on the owner, designer and operator of mine waste facilities than has previously been the case. In the long term, the adoption of these criteria in new African mining developments can only benefit the mining industry and environment. However, it is important that overseas or First World standards be implemented judiciously, and that they be applied in a manner appropriate to the particular situation.

REFERENCES

Please contact the editor for the list of references

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Addressing the social impact of mining activities on communities for sustainability

It is very important to consider the social impacts of mining activities on the surrounding socio-economic environment, and to incorporate Social Impact Assessment (SIA) into the operational activities of a mine as a management tool. However, the practice of SIA by mining companies is often largely lacking, especially in the developing nations of the world. To avoid such socio-economic marginalisation by mining companies, the government of South Africa requires mining companies to develop and implement Social and Labour Plans (SLPs), which focus on promoting the long-term development of their workforces, employee households, communities and regions

FROM THE DAY a mining operation starts, it is immediately in a closure phase, counting down the clock until that inevitable day when the doors will close. Once mines close, the social impacts on employee households, communities and regions are mostly severe and long-term. Ghost towns develop in areas that were once heavily reliant on mining for economic sustainability. The majority of the people who were dependent on the mining operation for income are usually left stranded in an area that they cannot escape from.

There is also often a lack of proper planning in the placement and rehabilitation of mine infrastructure, land and waste dumps in considering the future social and economic impact on communities and development for the region. After closure, mine waste deposits and unproductive, disturbed land are often left behind, which precludes the productive use of economically valuable land for the socio-economic development of communities over the long-term.

Aggeneys – mine town of Black Mountain Mine in the Northern Cape

IMPORTANCE OF THE SOCIAL IMPACT ASSESSMENT (SIA)

Mining development in the past has characteristically been synonymous with a disregard for its social impacts and affected communities. In many instances, mining companies have invested huge amounts of capital in African countries for mining development, openly stating that they are contributing to socio-economic development at a grass roots level. In reality, however, communities in the developing world have usually been completely bypassed by any development benefits from the project and are often left in a marginalised state, in which they are far worse off than before the mine opened.

Surrounding communities generally develop around a mine and become dependent on the economic opportunities generated by it, especially within isolated rural areas. Apart from these dependencies and economic impacts, the social impacts are usually felt even more, i.e. squatting and low living standards, social ills, disruption of traditional lifestyles and livelihood systems, increase in violence and crime, idleness and a disregard for traditional culture.

The challenge is to come up with innovative land uses, closure scenarios and waste management solutions that can promote sustainable development in affected communities.

Recent legislation in South Africa, such as the Broad Based Socio-Economic Empowerment Charter (BBSEEC) for the Mining Industry and the Mineral and Petroleum Resources Development Act (MPRDA) have confirmed the requirement for mining companies to assess the social impacts of their activities from start to closure, and beyond. Unless a mining operation has considered the social impact and documented it, the Department of Minerals & Energy (DME) will not issue a mining right to the applicant (MPRDA Regulations, 2002). Mining companies also have to compile and implement a Social and Labour Plan (SLP) to promote socio-economic development in their affected communities and to prevent or lessen negative social impacts. Moreover, monetary institutions, such as the World Bank, will also not fund mining projects unless detailed social studies are undertaken.

These are key challenges for the mining industry, which must be incorporated into each mine's planning and operational processes.

KEY ASPECTS OF A MINING SIA

Some of the potential socio-economic impacts resulting from new and existing mining operations and from eventual mine closure are:

- The extent of general development in the area as a result of infrastructure and services provided by the mining operations, e.g. electricity, healthcare and transport
- The economic changes that may occur or have occurred as a direct result of the opening of the mine, e.g. economic returns to local settlements through royalties and mine taxes
- The likely direct economic changes that may occur as a result of the mine closure, e.g. loss of jobs at the mine and the impact of such changes on the local community
- The extent to which skills and enterprises in the local economy are dependent on the mine and its activities; influences from outside; interventions by government, industry, NGOs, etc
- Cumulative impacts on the regions, i.e. the impact of the migrant labour system on labour-sending communities
- Cumulative impacts due to the development of numerous mining waste deposits in a given area
- An analysis of alternatives for closure regarding infrastructure, livelihood projects, etc, and for land use for the establishment and re-mining of tailings disposal facilities

PURPOSE OF AN SIA

The SIA focuses on the identification and mitigation of both positive and adverse social impacts that may arise from a given project, such as the establishment of a mine. It usually forms part of the Environmental Impact Assessment (EIA) process, but has often played much less of a role than the biophysical assessments.

The main aims of an SIA are:

- To understand the socio-economic characteristics and baseline of the area that will be impacted by a given mining project and how these relate to the dynamics of affected communities and economies
- To identify the stakeholders, including landowners, farm residents, government and tribal institutions, businesses, NGOs, etc
- To undertake a detailed Public Consultation Process (PCP)
- To describe the socio-economic issues that may become problematic if not adequately addressed
- To quantify and assess the socio-economic impacts likely to

result from the construction, operation and closure phases of the project and to develop relevant mitigation and management measures to be implemented
- To describe the existing opportunities for socio-economic upliftment, sustainable enterprise development and community livelihood development, which may act as a trade-off against any socio-economic impacts
- To provide sufficient information for the compilation of a realistic and logical Social & Labour Plan (SLP)

THE FOUR BASIC STEPS IN A MINING SIA

Step 1: Preliminary assessment and identification of communities (scoping)

During this phase the mine should undertake a broad analysis of the social environment affected by its operations. All relevant stakeholders within the mine-affected regions should also be identified, i.e. government authorities, NGOs, industry, community-based organisations, etc. A consultation process with interested and affected parties should be initiated in this phase to record the key social issues. A preliminary description of the socio-economic environment, potential social issues and likely socio-economic impacts should be provided, as well as a detailed plan for what will be investigated during the 'profiling' stage (or Baseline Socio-Economic Study-Survey).

Step 2: Baseline Socio-Economic Study-Survey (BSESS) and profiling of the community

The baseline will indicate the 'true' needs and factual information on the mine-affected communities, thereby enabling appropriate identification and quantification of the social impacts, as well as enabling the planning of community development interventions and livelihood-creation initiatives. A BSESS will focus on the mine's defined employees and households, on its affected communities (including surrounding and labour-sending communities), identified in Step 1, and on the municipal and provincial regions of location.

For the BSESS a questionnaire or interview survey is conducted to collect qualitative and attitudinal data with key individuals, informal leaders, focus groups and others, i.e. a survey with the workforce, a survey with affected community households, etc. The study should provide baseline socio-economic information on local conditions, local knowledge, local attitudes and perceptions. All of this is necessary to be able to assess the potential short and long-term positive and negative effects of the various project alternatives. This step will also include a detailed analysis of the current socio-economic conditions of the broader municipalities and regions impacted by the mine, as well as current sustainable development strategies or initiatives and programmes within these regions.

The information should then be captured into a socio-economic database, which will be used as the basis for analysing the social impacts and for managing and monitoring future development programmes. The database will contain the profiles of the affected communities, relating to: socio-economic status and livelihood profiles; household economic profiles; employment status; agricultural involvement; income streams, home ownership and the state of loan repayment on these homes; household assets; education and skills profiles; health and welfare status; cultural background; demographic information on the population; and perceptions and aspirations.

Step 3: Assessment of impacts

Based on the outcome of the BSESS and the issues arising from the community participation process, the positive and negative potential socio-economic impacts are assessed. These impacts should be quantified in terms of:
- extent (local, immediate surroundings, regional)
- nature (what causes the effect, what will be affected, how will it be affected)
- duration (short term < 5 years, medium term = 5–20 years, long term > 20 years, permanent)
- probability (improbable, probable, highly probable, definite)
- status (positive, negative, neutral)
- significance (no effect, low, medium, high, severe).

Apart from a quantitative assessment of the impacts, most of the assessment should focus on providing a clear, descriptive indication of the social impact relationships due to the nature of the data, which are qualitative and based primarily on people. As such, it must be emphasised that it is not easy to measure social impacts and to apply Environmental Impact Assessment methodologies to people.

Step 4: Formulation of a Community Development Action Plan (CDAP) or Local Economic Development Plan (LEDP)

Based on the BSESS and the impacts identified in the SIA, a detailed CDAP/LEDP should be formulated indicating how the mine will implement sustainable community development and social upliftment in its affected communities. In the South African context, the CDAP/LEDP will fall under the prescribed SLP, which is required by the MPRDA and BBSEEC for companies undertaking mining projects. The CDAP/LEDP is usually prepared along with the SIA in order to provide a social plan with initiatives that will promote the ongoing sustainability of the community during the window of opportunity created by the mining operation.

The CDAP/LEDP is formulated in conjunction with government authorities, local communities, other stakeholders and the mining company. The implementation of the CDAP/LEDP should continue after mine closure into the monitoring phase. It should identify opportunities for social development and propose specific projects that may lead to long-term sustainable development in mine-affected communities. Projects should focus on the provision of infrastructure and basic services, and on the eradication of poverty or livelihood development.

CONCLUSION

The SIA should not be regarded by mining companies as a moral responsibility, but as a tool to promote sustainability for both the mining company and the affected communities. Managing and assessing the social impacts of mining operations will ensure strong relationships with affected parties and also ensure favour with the governments of those countries, which will equate to economic benefits for all stakeholders. If mining activities are to contribute to sustainable development in their affected communities/regions, the basic SIA methodologies explained here have to be considered as a starting point.

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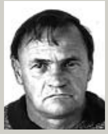

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Some rehabilitation issues on Witwatersrand gold tailings dams

The four fundamental environmental aspects that are important in the mining industry are aesthetics, air quality, water quality and soil quality. There are various designs and management options that could contribute to a greener and better-stabilised tailings residue dam and its surroundings after mine closure. In the case of gold tailings residue dams, slope geometry, acidification and other environmental factors must be considered and these aspects require further investigation

FOR MOST MINING operations, water and soil quality are the two most difficult environmental aspects to address when one takes the wealth of South Africa's mine-relevant legislation and the total extent of both water and soil on a mining operation into consideration. Although our legislation focuses much more on water quality than on soil quality, that is no excuse for neglecting soil quality. If one starts by visualising the end-product of the tailings residue dam (post-closure land use) during the design phase of a mine, it is so much easier to consider alternative design and extraction methods.

TYPICAL PROBLEMS AND THREATS IN GOLD TAILINGS DAM REHABILITATION

What are the real objectives of rehabilitation?

- Surface stability (resistance to wind and water erosion, and spreading of pollution), either permanent (in the operational and closure phases) or temporary (in the operational phase)
- Appropriate post-closure land use (PCLU), which must be: sustainable, cost-effective and financially viable, and resistant to any form of degradation or pollution

Identifying those tailings characteristics that pose a threat to the environment or that could jeopardise the objectives of the rehabilitation and PCLU is a tall order for any environmental practitioner. However, if one distinguishes between the causes, pathways and receptors of the various threats, it becomes easier. A typical example of such a concept is:

Pyrite is the cause, oxidation the pathway and the slopes the receptor

Table 1: Pyrite – threats, causes and solutions

Threat	Cause	Solution
Acidification	Oxidation of pyrite	Neutralisation of acid
Salinity	Oxidation of pyrite	Leach the salts or counteract the effect by using compost
Heavy metals	Heavy metals in tailings and low pH (caused by acidification)	Raise the pH to precipitate the heavy metals
Wind erosion	Specific particle size of tailings and lack of cover material	Establish a proper cover system
Water erosion	Chemical characteristics of tailings, long and steep slopes	Establish a proper cover system and/or flatten the slopes

of acidity and salinity. The acid slopes (receptor) can be treated by means of liming (pathway), but the pyrite (cause) has to be removed or isolated to prevent acidification.

Therefore one has to address both the oxidation of pyrite (acidification problem) and the steep slopes (pathway and receptor) in the case of old gold tailings dams (see Table 1).

PHYSICAL AND CHEMICAL ENVIRONMENTS OF GOLD TAILINGS DAMS

Slope geometry (length and slope angle) and acidification were identified in this investigation as the two most significant negative aspects of gold tailings dams.

Influence of slope geometry

Case study 1: Tailings dam 6 (FS6S) (north slope)

The steepness of the northern slope of the gold tailings dam was decreased from 32˚ to 18˚. However, this increased the slope length from three slopes of 16 m to one slope of 80 m. Although erosion was not measured, it was concluded from observations made over a period of 9 years that the amount of erosion was insignificant because very little sediment accumulated in the toe paddocks. Results from the USLE model (which calculates potential soil loss) showed that a flatter slope is far more stable with regard to sediment transport (erosion), water run-off, vegetation quality and overall stability.

Case study 2: Tailings dam No FS6S (west slope)

This was a gold tailings dam with a 32˚ slope angle and a slope length of 16 m. Three cover types were considered: vegetation, rock cladding (with no geotextile under-cover) and a no-cover design. The run-off and erosion rate were measured for five rain events, and these were extrapolated to 600 mm/year rainfall/hectare.

In this case the results showed that vegetation cover would be more successful than rock cladding with regard to soil retention, but the rock cladding produced less water run-off. However, these differences are insignificant compared with what would occur if the slope had no cover.

Flatter slopes have various advantages:

- It is possible to cultivate the slopes of the tailings dam mechanically, so the amelioration is more effective.
- The seeding process is also mechanical and the seed of species with woolly seed (e.g. Cenchrus ciliaris – blue buffalo grass) can be compacted after being sown.
- Rainfall is more effective on flatter slopes (13% less at 30˚ compared with 15˚).
- The erosion rate increases with increasing slope angle and slope length.
- Water run-off increases with increasing slope angle.
- There is less wind due to wind amplification increase on steeper slopes.

Table 2: Comparison of cover types for gold tailings dam

	Cover type		
	Vegetation	Rock cladding *	No cover
Water run-off (kl/ha/yr)	561 (9%)	390 (7%)	1 458 (24%)
Soil loss (t/ha/yr)	1.5	18.9	176

Influence of acidification

Acidification in gold tailings is manifested in many forms. Investigations and research into acidification continuously reveal new problems that have not been encountered or known before. Through assaying, the Fraser Alexander Tailings Environmental R&D team and their main supplier in this field (Geolab), have identified an additional source of acidification in the gold tailings termed 'latent acidity'. Additional acidification species derived from residual acidification have also been identified.

Active and potential acidity

Titration of a filtrate after H20 or KCl extraction of soil acidity is globally the standard procedure for determining active and potential acidity in agricultural soils and also for acid sulphate soils in Australia. This method was tested on Witwatersrand gold mine waste but severely underestimated the lime requirement in a mine waste sample when compared with a laboratory incubation of a mine waste sample with lime. Field observations confirmed this underestimation of active acidity. It is therefore not common practice to analyse for these two acid species in the case of tailings material if pyrite is present.

Residual acidity

Sulphuric acid derived from the oxidation of pyrite has been identified by many researchers in the past. The double-buffer incubation analytical method was developed and used by Envirogreen until 2005. Our follow-up research work identified additional acidity from solutions and oxidation products of secondary minerals, e.g. jarosite and schwertmannite. Theoretically, there could be additional sources from other unidentified ferrous sulphate minerals, too. The extraction method for quantifying the extended residual acidity was changed from the double-buffer incubation method to a newly developed method. The new information and procedures led to the

1 Well vegetated gold tailings dam facility

identification of additional knowledge gaps in the complex behaviour of geo- and pedo-chemistry of the gold tailings.

Latent acidity

A study by Gillman & Sumpter (1986) found that the lime requirement was equal to the active acidity (determined by standard filtrate titration) in granite and metamorphic soils, but two to three times higher in the case of basaltic (variable charge) soils. This is explained by the contribution of protons from the clay crystals when the pH of the soil solution increases and in the process the net negative charge of the clay lattice increases. Soils exhibiting this property are often referred to as 'variable charge soils' or 'pH-dependent charge soils'. The material or 'soils' from the tailings are very much prone to these phenomena and side-effects when the pH is increased by liming. Similar reactions could also occur wherever rehabilitation of gold tailings footprints is done. To accommodate the neutralisation of this source of acidity, an alternative analytical procedure is required (such a project is in progress).

Follow-up work and research has also revealed that additional electrolytes, i.e. salts (very common in gold tailings), also contribute to the decrease in pH. This is caused by the H+ ions associated with the freshly prepared minerals derived from the electrolyte (salt) by means of dissociation and hydrolysis, e.g.

$CaSO_4 . H_2O – Ca 2+ + SO_42- + 2H+ + O2-$ [1]

These H+ ions are not released from the original chemical reactions, i.e.

$FeS_2 + 3.5\ O_2 + H_2O = FeSO_4 + H_2SO_4$ or [2]

$FeSO_4 + 0.25\ O_2 + 1.5\ H_2O = FeOOH + H_2SO_4$ [3]

The H+ ions could also derive from the fresh but immature edges of the newly formed crystals, e.g. jarosite, or from the broken edges of matured crystals, e.g. weathered mica or feldspars, in the tailings. Both these two phenomena are based on the thickness of the so-called 'diffuse double layer' which is dependent on the electrolyte concentration.

The formation of oxide minerals, i.e. ferrous oxides, is very common in gold tailings, e.g. goethite (FeOOH) and hematite (Fe_2O_3). Unfortunately, they have amphoteric properties, that is to say, depending on the pH of the total system, they could be either negatively or positively charged. If negatively charged, they could adsorb H+ ions from water hydrolysis and exhibit additional sources of acidity.

These three newly identified acid species have what is termed 'latent acidity' due to the fact that the chemical behaviour of the system (pH-dependent charge), the electrolyte concentration and the presence of oxide minerals could change from time to time, hence the variability in the production of acid from these sources.

Field studies reveal that real acid mine drainage (AMD) from tailings dams is restricted to the outer superficial rind of the tailings dam, as shown in Diagram 2. Modelling shows that the oxidation rate in the core could take more than 1 000 years to reach the bottom of the tailings dam. This phenomenon results in extreme infiltration and seepage of AMD around the toe of gold tailings dams, with a relatively inactive core. If one could counteract the infiltration of AMD into the ground-water system around the toe by using dolomite or artificial liners, the main problem would be solved for many years.

Influence of other environmental factors

A number of other environmental factors influence the rehabilitation design:

- The type of soil on the proposed footprint – the infiltration rate, pH, EC, clay content, buffer capacity and neutralisation effect
- In the case of bedrock – the infiltration

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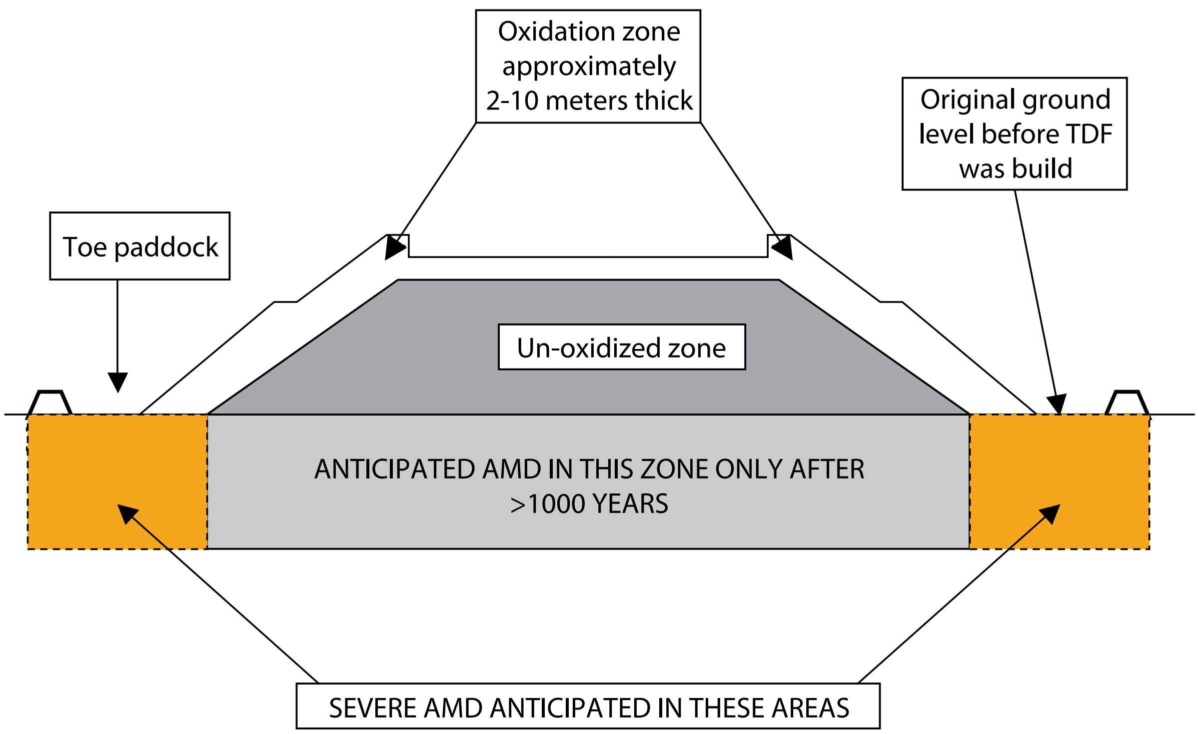

rate, preferred pathways, lithology (carbonate or not), solution cavities, CCE and heavy metals
- Tailings mineralisation – the pyrite content, heavy metals content, etc
- Unsaturated flow in tailings dams (dormant or abandoned dams) – such flow by means of diffusion is poorly defined at present, but may have significant negative effects

MAJOR KNOWLEDGE GAPS

The rehabilitation of a tailings dam creates a new ecosystem. Since the new ecosystem (which requires monitoring and maintenance programmes) will have specific or unidentified plant dynamics, microbial activity starting from zero, ongoing active geochemical reactions and soil physical processes, it will be a more complex system than many natural ecosystems.

Such a new system is extremely dynamic and vulnerable to internal and external changes. The influence of steep slopes on vegetation performance, e.g. its wind tolerance, has not been very well investigated and needs more attention. A major mindshift is required to understand the whole picture, e.g. unsaturated water flow in the tailings complex, ongoing geochemical reactions and the interaction of these with vegetation and microbial activity. A series of geochemical reactions supported by soil physical processes (new in the case of tailings deposits) has resulted in many tailings dam failures and, if they are hidden from all, these failures will continue and create more conflict than ever before between mining houses, consultants, contractors and legislators. It is recommended that everybody in the gold tailings industry should familiarise themselves with the scientific realities and realise that long-term ongoing acidification and salination are inherent in gold tailings in South Africa.

CONCLUSIONS AND RECOMMENDATIONS

These can be summarised as follows:
- Identification and evaluation of all attributes, material characteristics and design parameters should be done upfront to determine the environmental risks associated with a tailings residue deposit.
- Interaction between the different attributes could amplify some of the other attributes; therefore potential interactions should be scrutinised to identify and evaluate other negative characteristics of a tailings residue deposit.
- Existing knowledge gaps should be identified and research programmes should focus on these issues.
- All the interested and affected parties involved with a tailings residue deposit (mines, environmental scientists, designers, engineers, metallurgists, etc) should be part of the final design and rehabilitation of such deposits to ensure that rehabilitation is feasible in the long term.

REFERENCES

Gillman & Sumpter (1986). Surface charge characteristics and lime requirements of soils derived from basaltic, granite and metamorphic rocks in high rainfall tropical Queensland. Aust. J. Soil Res. 24 (2) 173 – 192.

The original paper on which this article is based, was presented at the 4th International Conference on Mining and Industrial Waste Management, held in Rustenburg from 11 – 12 March 2008

2 Diagrammatic illustration of the oxidation and un-oxidized zone on a gold TDF and the zones of anticipated AMD

3 Poorly vegetated gold tailings dam with severe erosion and AMD seepage

4 Well exposed oxidation zone on a gold tailings dam facility

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Selecting the right tailings disposal solution – a case study

The optimal tailings disposal solution for a mine is not always straightforward or necessarily what has been done before. After completion of a feasibility study based on past practice, a comparative study of alternative tailings disposal systems was done for a proposed medium-sized platinum mine considering uniquely developed spigot, cyclone and paste disposal options. The comparative study dictated the consideration of total tailings disposal costing over the proposed life of the mine, revealing the real costs. In this instance, make-up water costs were found to be the most significant, and consequently the paste option was favoured. The lesson learnt from the study is that the right choice is not obvious and that relatively detailed studies are needed

THE REGULATORY PROCESS to exploit a mineral resource requires, amongst others, a mining authorisation. The process of obtaining such an authorisation is initiated by the submission of a Mine Works Plan (MWP) and to ensure timely authorisation, relatively comprehensive scoping of the proposed project has to be done before the full optimisation studies on possible alternatives. This is particularly true of the tailings disposal, where the 'site' is often designated by the mining team on the pretext that it is just 'preliminary' to get the MWP into the system. The downside of doing this is that changing from the 'preliminary' site (and method of disposal) at a later date is difficult as mindsets and expectations have already formed and sometimes the authorisation has to be amended.

The second sacred cow of mining projects is 'proven technology'. Very few are willing to be a 'technology guinea-pig', requiring their projects to be based on proven, conservative technology. The downside to this is that a number of potentially beneficial opportunities for improvement, or a competitive edge, are missed.

Both initially and ultimately, the proposed development of the medium-sized mine project was no different, but circumstances allowed the investigations into the development of the tailings solution to take a different course during the study phase.

PROCESS OF SELECTING THE TAILINGS SOLUTION

After initial planning, a site selection process and feasibility study for the tailings disposal was commissioned by the prospective owners. The feasibility study proposed a conventional spigot tailings dam as has been used on most platinum mines in South Africa for the past four decades.

Since this was an underground mine, the project had a long lead time which allowed another look at the tailings disposal. The owners were persuaded to allow a comparative study of alternative tailings disposal solutions for the project to be undertaken.

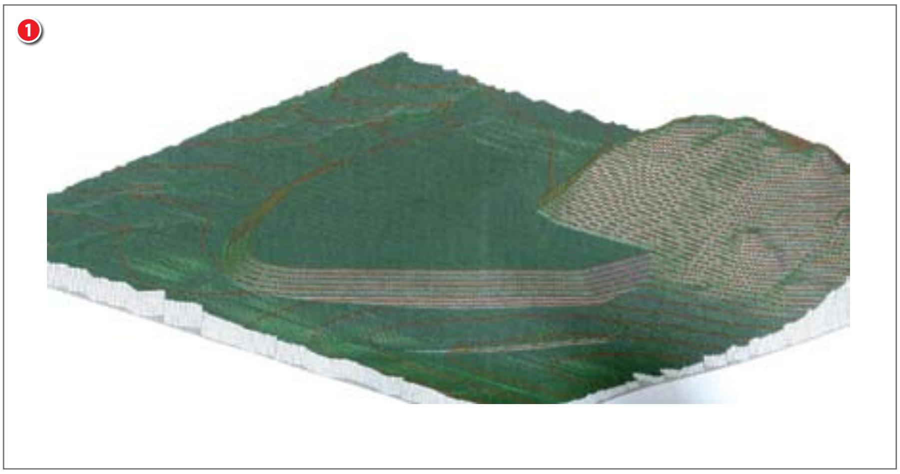
COMPARATIVE STUDY

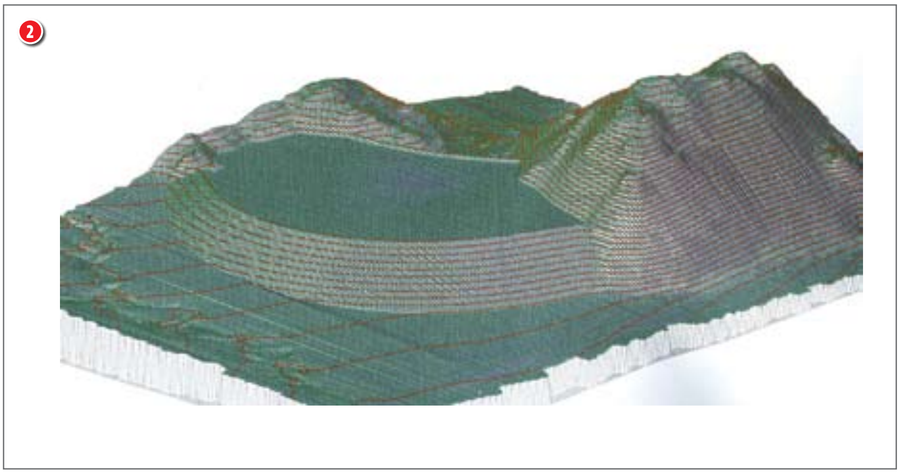
The ore body in question and the exploitation plan are predicted to sustain the mine for about 20 years at 115 000 tpm, making it a small to medium-sized underground operation. The operation will be sustained with water from the irrigation canal emanating from the Loskop Dam, making the water a limited and costly commodity.

Three alternative solutions were considered, namely:

- a redevelopment and optimisation of the spigot solution to ensure a relevant base case
- a cyclone dam
- a paste solution

The cyclone dam wall was designed and analysed to ensure the viability of a combination of upstream and downstream phases, so creating a wall of adequate dimension over the life, which ensures stability and freeboard while maximising the rate of rise





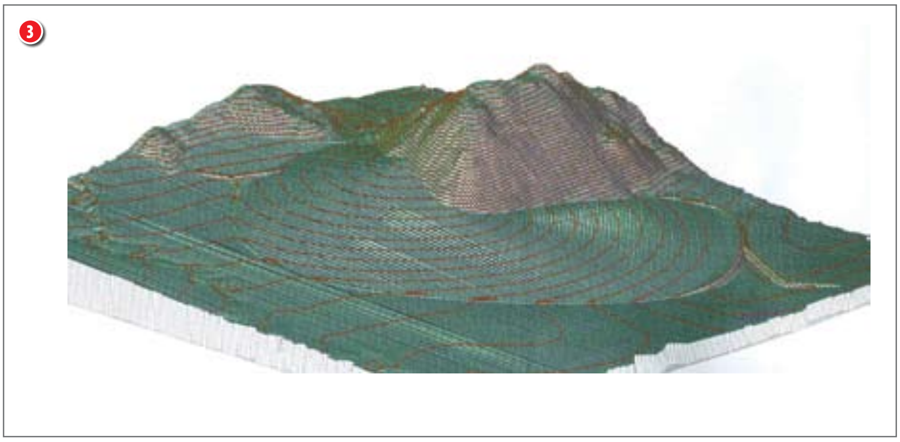


Table 1: Alternative options statistics

Aspect	Spigot	Cyclone	Paste
Footprint area	123 ha	55 ha	165 ha
Total height	39 m	50 m	100 m
Maximum depth	32 m	42 m	30 m
Slope	1:3	1:4	1:15
Av. rate of rise	1.6 m/yr	2.2 m/yr	1.5 m/yr

Site location

A gently sloping (5%) colluvial plain adjacent to the proposed process plant had been selected as the most suitable site for a spigot dam and this site was retained for the comparative study.

The objective of the fourth-generation cyclone solution was to take advantage of the higher possible rate of rise to minimise the footprint and so reduce surface area and evaporative losses. The particle size distribution indicated only about 20% of >75 micron material suitable for the development of an underflow wall. This would usually be insufficient to develop even an upstream ringdyke dam, so advantage had to be taken of the natural topography to provide containment where possible. Consequently, the cyclone option was tucked into a corner of the plain abutting some of the surrounding steep hills, thereby saving about 40% of the walls.

Owing to the 'unproven' paste transport technology, paste was only considered in this instance because the topographic setting could eliminate pumping. The relatively high, steep hills adjoining the gentle plain would allow discharge of the paste from the paste thickener directly above the tailings disposal area without the need for positive displacement pumps. The paste thickener was therefore strategically located on the side of a hill with the projected tailings disposal facility (TDF) fanning out around the hill and across the plain below.

Thus a unique optimal location was identified for each option, illustrating the way in which the different disposal options are specific to the different topographies.

Landforms

The footprint of each solution was optimised on the selected sites to ensure no bias in the comparisons. The spigot dam was sized to accommodate the required disposal volume and a dual-compartment facility was proposed to optimise the volume of the starter wall earthworks in relation to the rate of rise. The plan was for the upper compartment to be overtaken by the lower one to optimise operating costs over the life. The final landform would be a sidehill dam with 1:3 slopes and an almost level upper surface, as shown in Figure 1.

The cyclone dam wall was designed and analysed to ensure the viability of a combination of upstream and downstream phases, so creating a wall of adequate dimension over the life, which ensures stability and freeboard while maximising the rate of rise. A circular wall, in plan, was specified to blend into the landscape. Side slopes of 15° (1:4) overall were selected and a rear wall to close off the saddle was also required (see Figure 2).

Bench-scale tests were done on samples of the proposed tailings to establish the feasibility of pursuing paste as a viable option. The tests indicated 68% solids as a feasible underflow density and, together with a specific gravity of 3.5, a hypothetical slope of 1:15 was adopted for the TDF modelling. The optimal position for the central discharge was determined, together with a secondary discharge point some 300 m downslope, which could be reached with centrifugal pumps, to provide operational flexibility to control the drying of alternately deposited layers. The resulting deposit wraps around the hill, spreading out over the plain, as shown in Figure 3. Table 1 compares the options.

Comparative water balances

The average, maximum and minimum monthly rainfalls for the area were superimposed on the geometry at different stages of development over the life. For comparison, battery limits had to be inclusive, commencing with the slurry leaving the process plant before any thickening. The water balances were expressed in terms of water losses. The hydrological models were developed on a comparative basis, with the spigot option perhaps being the most optimistic when compared with actual water recoveries on other spigot dams. The results are shown in Figure 4.

Infrastructure

The infrastructure that would be necessary to implement the solution (access roads, earthworks, electrical power reticulation, etc.) was 'designed' to a comparable level for each option.

Rehabilitation and closure

The closure objective for each option was set to just return the final surfaces to wilderness areas, requiring topsoil stripping, stockpiling, replacing and vegetating.

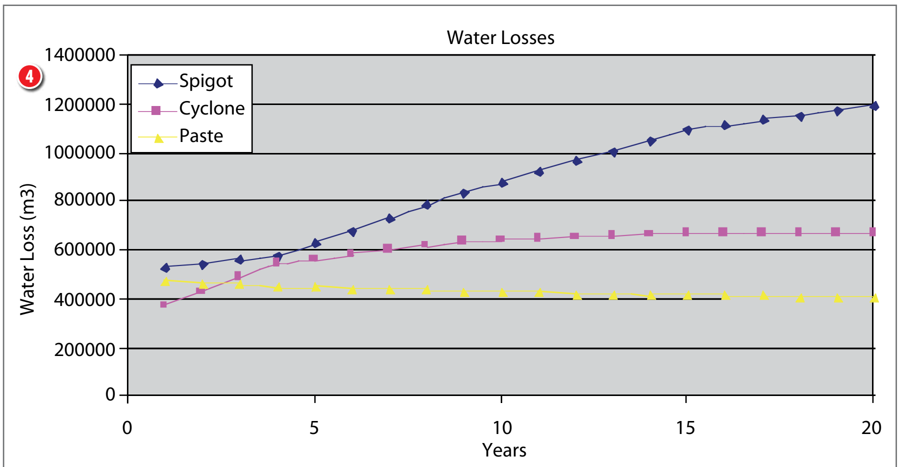


Table 2: Comparative life of TDF total costs (rand – 2006 terms)

Item	Spigot	Cyclone	Paste
Design	2 095 000	2 095 000	2 095 000
Prof. oversight	3 452 000	3 668 000	4 906 400
Construction	46 646 194	36 393 113	44 530 654
Maintenance	35 633 408	43 636 797	33 593 589
Flocculent	8 942 400	8 942 400	8 942 400
TDF Operation	52 650 864	57 867 264	31 646 160
Rehabilitation	4 261 000	3 053 400	5 662 500
Power	7 458 429	7 524 119	12 395 304
Water make-up	60 653 568	42 847 808	31 034 534
Total	R221 197 863	R205 432 901	R174 211 541
Water losses m^3	15 163 392	10 711 952	7 758 633
Cost/ton	R8 01	R7 44	R6 31
	100,00%	92,87%	78,76%

COST COMPARISONS

This was the acid test for the comparative study. Most such studies limit the cost estimating to the TDF design and operating costs are generally rough estimates which exclude power consumption, reagent and water make-up costs, thus very rarely indicating the total cost of tailings disposal for a mine. For a true comparison, the study costs had to be fully inclusive.

Quantities for the infrastructure were determined from typical details and general layouts. Capital construction costs were provided by a contractor experienced in this field, but based on off-the-shelf vendor prices. Operating costs included projected maintenance and replacement of all mechanical and electrical equipment over the life, as well as outsourced management costs. Rehabilitation costs were based on specifications of soil coverage, conditioning and vegetation. Power costs were based on the calculated consumption at a specified project kW/h rate. Water make-up costs were also based on a project-specified unit cost of R4/m^3 and the losses determined from the water balances.

The comparative costs are indicated in Table 2.

DISCUSSION

Table 2 and Figure 5 reveal some interesting information. Perhaps most significantly, the original projection of the tailings costs based on the feasibility study was in the order of R30 million. Operating costs were estimated at about 75 c/t, giving a total cost of just less than R50 million. However, it was found that the more realistic total cost would be in the region of R200 million, or between R6 and R8/t, and this changed the mindset of the project team, enabling more accurate financial modelling.

Furthermore, over the life, the significant costs were revealed to be the construction and operating costs (commonly understood) and the maintenance and water make-up costs (very rarely considered in the cost of the solution).

1 Final landform of spigot tailings dam
2 Landform for the cyclone dam
3 Landform for the paste tailings deposit
4 Comparative water losses per year over the life

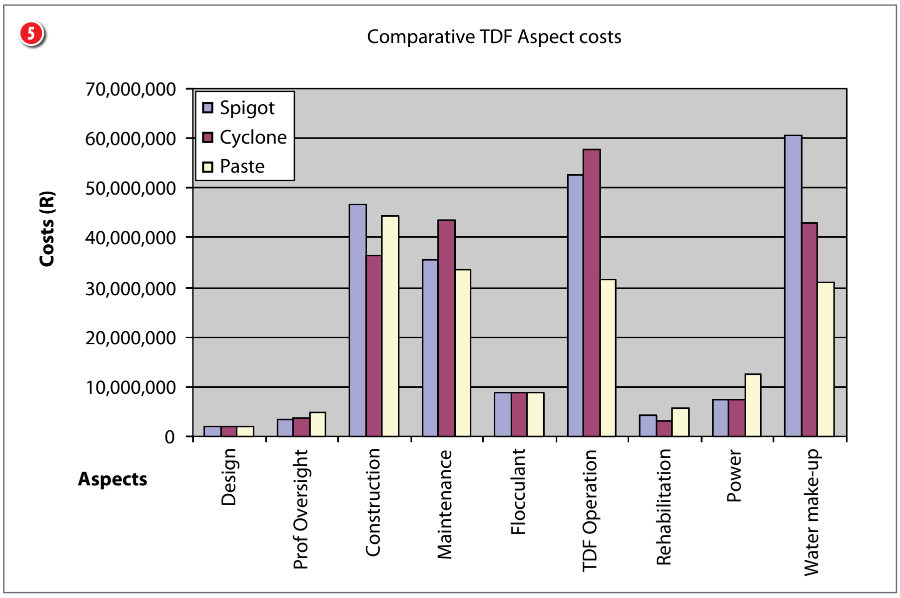
5 Comparative costs of different aspects of the tailings disposal per year over the life

All things considered, only the water make-up costs really make the difference. On a cost/ton basis the difference is only R1.70/t between the spigot and paste options. At the mine production rate of 115 000 tpm, this amounts to only R195 500/month or R2,35 million per year. Even for relatively small platinum mines, such an annual saving is not that significant, bringing into question the need for such optimisation.

The potential benefit of the paste, however, should not be judged solely on the limited annual saving since the water cost is likely to escalate over the life of the project. The paste option gives the mine the greatest protection against this potential escalation.

The spigot option theoretically consumes 0.55 m^3/t processed, whereas the paste option theoretically consumes only 0.28 m^3/t. So, for the same water licence quota, the mine could process nearly twice as much ore and benefit from the sale of the additionally recovered PGMs by adopting the paste option. The paste option is therefore far more environmentally responsible.

However, an unexpected obstacle arose in that the process design engineers argued that the reduction in make-up water could lead to salt build-up in the circuit, which could affect the process plant equilibrium and would not 'guarantee' the process. The owner was not prepared to take this risk and consequently elected to pursue the conventional spigot tailings disposal route.



CONCLUSIONS

The surprising results of the inclusive comparative study were:

- The total cost of tailings disposal for the mine is substantially more than just the construction and contractor's operating cost.
- There is not really a significant difference in the cost of the different options over the life of the mine, and these are not sufficient to motivate deviating from proven technology.
- The differences occur mainly in the cost of make-up water and would hence be a function of the specific water balance of the mine and the make-up water unit cost.
- Paste emerged as the preferred option in this case for various reasons.

The first lesson learned from the comparative study is that the results were not a foregone conclusion and depended on the unique, relatively detailed, pre-feasibility design for each option. If optimal solutions are to be engineered, such comparative studies should be done at an early stage in the project.

Secondly, for new technology to be accepted, all affected parties need to be considered and supportive. In this case, the process design house was not part of the tailings solution and consequently resisted its acceptance. This emphasises the importance of including the tailings disposal in the early overall strategic planning of a mine.

The original paper on which this article is based, was presented at the 4th International Conference on Mining and Industrial Waste Management, held in Rustenburg from 11 – 12 March 2008

Increasing emphasis on environmental protection at all stages of engineering projects

Many companies have become aware of the need for early environmental input, often beginning in a meaningful way at the pre-feasibility stage and continuing throughout the construction process. This has been the experience of SRK Consulting who are becoming more and more involved in projects from the outset, at the request of the client, in assessing environmental risks and identifying fatal flaws as opposed to simply conducting Environmental Impact Assessments (EIAs) for the purposes of obtaining environmental authorization, often once the detailed design stage of the project has been completed. At times, this involvement then continues throughout the construction phase. Two specific examples of this involve the world's largest producer of cement, French-based Lafarge, and Petroline, a company planning the transportation of petroleum products from Matolo in Mozambique, to Kendal in Mpumalanga, with a view to connecting with an existing pipeline to Gauteng

THE ROUTE TAKEN by Lafarge in the selection of a site for the construction of a cement grinding plant on the West Rand, goes well beyond legislative requirements. Six sites were identified by Lafarge, and then SRK was called in much earlier than would normally be the case so that they could be involved in a site selection process. Criteria taken into account resulted in Lafarge being able to meet market demand without compromising environmental standards. Of the six sites originally identified, the screening process undertaken by SRK resulted in the identification of environmental fatal flaws for three, avoiding the possibility of these sites being found to be fatally flawed only after a full environmental process had been initiated, hence a saving to the client from both a cost and programme perspective. In a similar exercise Petroline, while proceeding directly to the scoping and EIA phase of its proposed Matolo-Kendal pipeline, included several different

routes in the study undertaken by SRK, with equal weight being given to environmental and engineering considerations in the site selection process.

This approach provides both an indication of the culture of the organisation adopting it and of the current trend in South Africa and globally, with industry becoming conscious of its obligations in relation to the protection of the environment and the business risks involved in ignoring these obligations.

CRADLE TO GRAVE

The ideal of 'Cradle to Grave' management of the environment may now be a step closer as a result of this trend. Lafarge has taken this philosophy to the next level and SRK continues to be involved in the West Rand Grinding Plant Project by providing the services of an Environmental Control Officer, required as a condition of the environmental approval for the project and ensuring that decisions taken in the EIA are implemented in construction. The same philosophy can now be implemented by Petroline, secure in the knowledge that environmental measures contained in the Environmental Management Plan for the project are based on environmental optimisation of the route selection in the first place. This included full public consultation at which all routes were presented and Petroline can rest assured of credible responses to any criticism of the final route selection.

While these two examples serve as an indication of a shifting corporate mindset, there are numerous other indications of the same trend. SRK is finding that it is not uncommon to be called in to participate

1 Lafarge's Randforntein grinding plant under construction

in high level risk assessments prior to, or very early in, the development of an EIA. In this process environmental risks emerge, sometimes under different headings. For example water scarcity for mining operations may be identified by engineers as a risk, and even a potential fatal flaw, when the reason for the risk is environmental. It may be linked to the possible over-utilisation of an existing water source, an issue that would arise from an environmental study. Addressing this risk often becomes the responsibility of the environmental team, working in close association with the design engineers. Similarly, SRK has found that project developers are referring to the environmental team for the identification of sensitive landscapes and exclusion areas as part of their own site selection process.

It is clear that these trends reflect a rapidly increasing environmental awareness, but they do not negate the reality that sound environmental management, far from simply addressing an emotional and topical subject, also reflects good business sense. At least in the mining industry, SRK is finding that environmental management is increasingly being driven by the investment community in addition to the relevant environmental regulators. It is now a reality that, if you are serious about raising money for a project at an international scale, you also need to be serious about your environmental management. Several financial institutions, including Nedbank in South Africa, have become signatories to the Equator Principles, a set of guidelines introduced to establish an industry benchmark for determining, measuring and managing environmental risk in project financing.

The trend is now well established and SRK is in a position to assist companies such as Lafarge and Petroline, to ensure that their projects are in a position to benefit.

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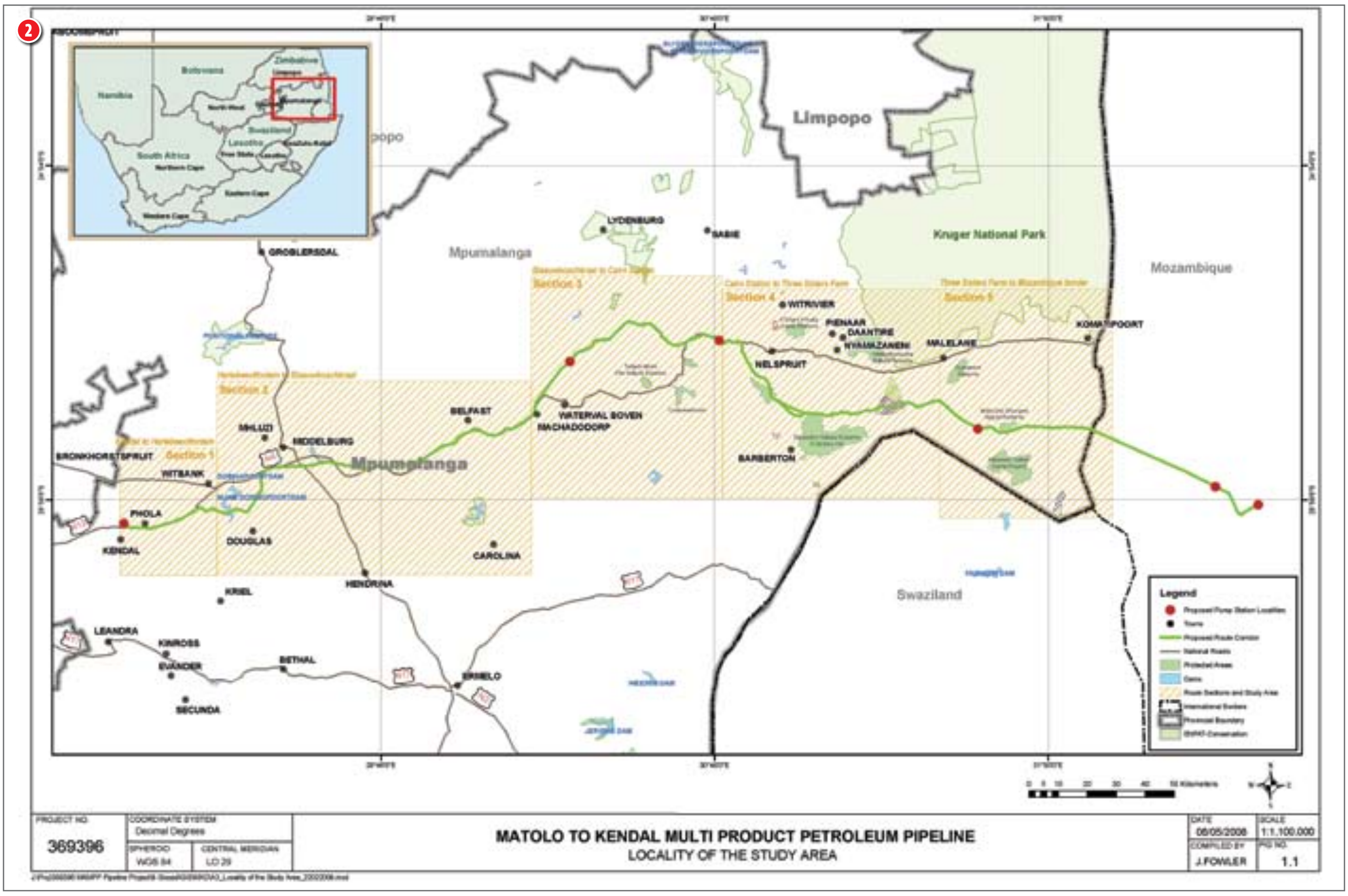
2 Locality map of the proposed Matolo-Kendal multi-product petroleum pipeline



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Oostenberg integrated **waste management facility**

THE CITY OF Cape Town is developing the first integrated waste management facility in South Africa, comprising a refuse transfer station, a compaction hall, container handling operations, garden refuse chipping facilities, materials recovery facility, workshop, wash bay, diesel storage, domestic recycling centre and a public drop-off, security building, entrance building, weigh bridges, with provision for a future 'resource park' and accommodation for future 'alternative technologies'.

Jeffares & Green, in joint venture with GJA Consulting Engineers, has been appointed to undertake the civil, mechanical and electrical design and implementation of the proposed Oostenberg Refuse Transfer Station and Materials Recovery Facility (ORTS and MRF).

The site is located in Kraaifontein, in the Cape Metropole, just off the N1 national road, and is approximately 15 ha with the ORTS portion of the site being approximately 3,5 ha, the balance being reserved for the future facilities.

The layout of the facility has been planned for a containerised bi-modal transport system (i.e. road and/or rail), although initially the transfer of containers will be done by road only. The rail infrastructure will be provided at a later date.

The design capacity currently allows for a 100 tonnes/day MRF (or 200 tonnes/day for a double 8-hour working shift) and a 1 000 tonnes/day refuse transfer station. It is not expected that these volumes will arrive at ORTS from the outset, as a host of factors come into play, for example the extent to which the City of Cape Town can manage the waste collections (i.e. routing/beats, vehicles, private contracts, and minimisation strategies) to take advantage of this facility. Tariffs and by-laws will also need to be examined and amended to promote the diversion of recyclable wastes.

The City of Cape Town's Solid Waste Department will be the owner of the facility and it is currently envisaged that the function of the RTS and secondary facilities (workshop, wash bay, diesel tank, office block, control room/entrance building, security) will be operated by the City of Cape Town, whilst the MRF and drop-off will be operated by a private contractor.

Over and above the extensive engineering input into the design of this facility, the design team is spending time on 'green engineering' opportunities for this development, such as:

- rainwater harvesting, due to the extensive roof area
- supplementary supply of water harvesting by borehole or usage of clean storm water runoff from the site and/or from the existing municipal storm water pond across the road.
- low-energy lighting
- solar energy
- water-wise indigenous greening of the area
- specially designed oil traps
- site-specific litter traps and silt traps (a design that will be used by the City of Cape Town for research)
- maximising of natural ventilation opportunities
- maximising of natural lighting opportunities

▶ Oostenberg site map on page 38

PROJECT TEAM

Jeffares & Green (Pty) Ltd
G Johardien & Associates
in association with
DPE Consulting Engineers
DV CAPE
Cook Lipschitz Partnership

PROJECT STATUS

Currently the estimated R160 million project is in the detailed design phase, preparing for the tendering stage. The team is aiming to be out to tender in August 2008 and to have the facility completed by early 2010.

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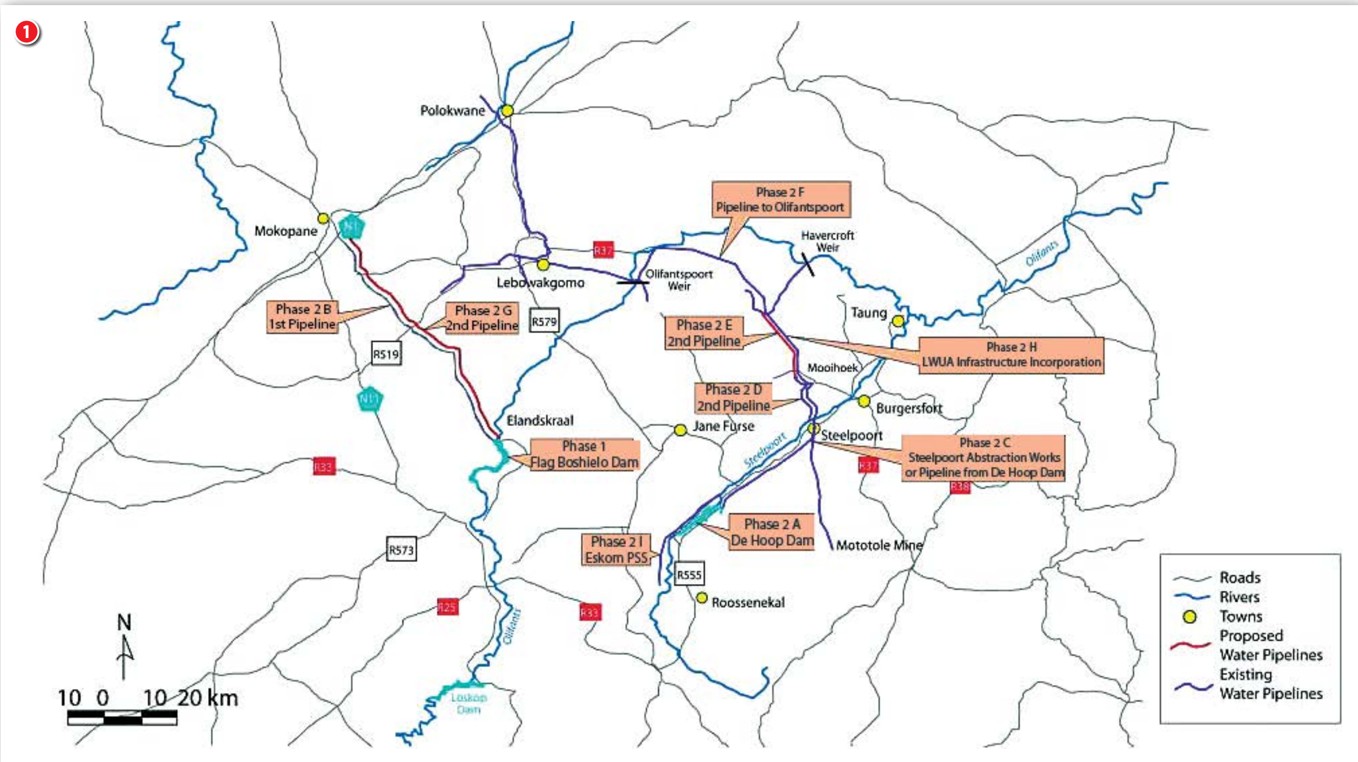
De Hoop Dam brings hope



1 The ORWRDP area and proposed infrastructure

Dam construction engineering technology is harnessed to ameliorate the socio-economic conditions of a people, while their natural and cultural heritage is respected through the implementation of best practice environmental principles

THE DE HOOP DAM is situated in the Limpopo Province, between the towns of Roossenekal and Steelpoort on the Steelpoort River, a tributary of the Olifants River which runs through the Kruger National Park on its way to the Masinger Dam in Mozambique. The construction of the De Hoop Dam not only brings hope of jobs and economic upliftment to the people of Sekhukhuneland and Limpopo, but also the prospect of permanent water supply to a dry land.

A screening exercise was done to investigate and identify the most suitable alternatives (dam and non-dam) for further development of the middle Olifants River catchment water resource. The dam alternative examined the potential social impacts in detail, and the non-dam alternative considered aspects such as water conservation, water demand management, ground water options and trading water allocations. The assessment of both the dam and non-dam alternatives contributed to a proposed project to facilitate greater water resource availability and stability in an area where the water demand surpasses the available water resources.

After the conceptual design and feasibility studies had been done it was concluded that the most feasible option from a technical, environmental and economical perspective would be the construction of a dam on the Steelpoort River, at the farm De Hoop, and associated infrastructure for bulk water distribution. The latter would include pipelines from a proposed abstraction weir near Steelpoort and from the Flag Boshielo Dam.

On 9 June 2004 Cabinet granted the Department of Water Affairs and Forestry (DWAF) approval for project implementation, subject to obtaining the necessary environmental authorisations. The National Water Act (Act 36 of 1998) states that in each area in the country there will be a number of possible solutions to balance water requirements with water availability.

ORWRDP

The De Hoop Dam will enable new allocation of water to meet the current and future water needs of the area, especially for the benefit of the mining sectors within the middle Olifants catchment, as well as part of the Mogalakwena and Sand catchments. DWAF commissioned the Olifants River Water Resources Development Project (ORWRDP), which comprises two phases:

- Phase 1 involved the raising of the Flag Boshielo Dam by 5 metres. This phase has been completed.
- Phase 2 involves the development of additional water resource infrastructure within the middle part of the Olifants Water Management Area. Phase 2A entails the construction of the De Hoop Dam and the realignment of the provincial road between Steelpoort and Stoffberg (the R555), whilst Phase 2B-2I involves the construction of pipelines and associated pumping stations and balancing dams.

Globally speaking, mitigating the detrimental ecological impacts of dams have by and large met with only a degree of success, as these impacts mostly are difficult or impossible to mitigate. For example, there is no realistic means of preventing the build-up of sediments in an impoundment of these dimensions, and nothing can be done about the riverine habitats that will become inundated. However, in an effort to ensure that the De Hoop Dam environment is protected and preserved as best possible, the environmental authorisation process was followed. Where applicable and appropriate, the requirements of the Environmental Conservation Act (Act 73 of 1989), the National Environmental Management Act (Act 107 of 1998), the National Heritage Resources Act (Act 25 of 1999), the Minerals and Petroleum Resources Development Act (Act 28 of 2002), the Forestry Act and the National Water Act (Act 36 of 1998) were adhered to.

An Environmental Impact Assessment (EIA) was undertaken to establish the potential impacts of the project on the socio-economic and biophysical aspects. The EIA comprised four phases, namely:

- Scoping
- Impact Assessment
- Environmental Impact Report
- Decision Making

International agreements were also considered, including Agenda 21, the Convention of Biological Diversity, the Kyoto Protocol, Helsinki Rules, and the SADC Protocol on Shared Waters. The UNEP Document on Dams and Development (Relevant Practices for Improved Decision Making), refers to the ORWRDP as an example of a large dam project where internationally agreed development goals are pursued in an effort to reduce poverty through environmentally and socially sustainable development of water resources. This is being done within the framework of DWAF's sixteen principles of the guidelines for public participation, including consultation with stakeholders such as NGOs and interest groups, and stakeholder communication via an issues-and-response report and feedback process.

During scoping, as part of the EIA, six key issues were identified which needed to be further assessed and clarified, namely:

- impact on quantity and quality of river flows
- aquatic and terrestrial ecology
- long-term sustainability and water demand management
- capacity of the receiving environment
- minimising construction-related impacts
- land acquisition and compensation

It was also broadly agreed that a seventh issue, cooperative governance, needed consideration for future planning and implementation of Phase 2.

The De Hoop Dam study area is an ecologically sensitive region and required extensive environmental investigations before a Record of Decision (ROD) was issued by the Department of Environmental Affairs and Tourism on 21 November 2005. This was followed by five appeals against the decision which had to be investigated and responded to by DWAF, before the Minister of the Department of Environmental Affairs and Tourism on 16 October 2006 made a final decision in terms of Section 35 of the Environmental Conservation Act (Act 73 of 1989) – that is, the revised Record of Decision – in support of the project, but incorporating more stringent environmental requirements.

This revised ROD has many conditions of authorisation which DWAF has to comply with to minimise the potential impacts as anticipated by the appeals, including a suite of Environmental Management Plans (EMPs) to be prepared, namely:

- Pre-construction EMP
- Construction EMPs (7 different EMPs)
- Post-construction EMP
- Operational EMP

In compliance with the requirements of the revised ROD, the ACC (Authorities Coordinating Committee) and the EMC (Environmental Monitoring Committee) have been established. There is also a full-time Environmental Control Officer (ECO) on site, as required by the ROD.

On 19 March 2007, during a sod-turning event, the project was launched at Maseven. Prior to the commencement of construction, the De Hoop Dam Charter was also signed, containing the social and economic development and procurement targets of Government. The 347 million m^3 of water will be impounded by an 88 m high roller-compacted concrete wall.

On 26 May 2008 a Memorandum of Agreement (MOA) was signed between the Minister of Water Affairs and Forestry, Mrs Lindiwe Hendricks, twenty-three individual mining houses, and the Joint Water Forum (JWF), a representative body of associated mines involved in exploiting the mineral resources of the Eastern Bushveld Complex in the southern part of the Limpopo Province. This MOA paved the way for R7,4 billion of water supply to Limpopo. It essentially encapsulates the principles to be distilled in the individual off-take agreements with the mines and is the founding agreement for the implementation of the ORWRDP for the needs of the mining users located in the project area.

The Trans-Caledon Tunnel Authority (TCTA) was requested to develop a financing proposal for the project, subject to the approval of DWAF and the National Treasury. It has been Government policy since 1997 that all commercially viable projects have to be funded off-budget by making use of private sector funds with loan repayments from the revenue of the water tariffs. The off-take agreements with the mines will provide the necessary channel for private sector funding required for project implementation.

As there are two main end users in the project – the mines and the social users – DWAF, in consultation with the TCTA, negotiated the MOA with various mining institutions represented by the JWF, in terms of which the mines commit to taking all their future water requirements, specific to the project area, from the project. The MOA also enables the mines to continue with their mining license applications.

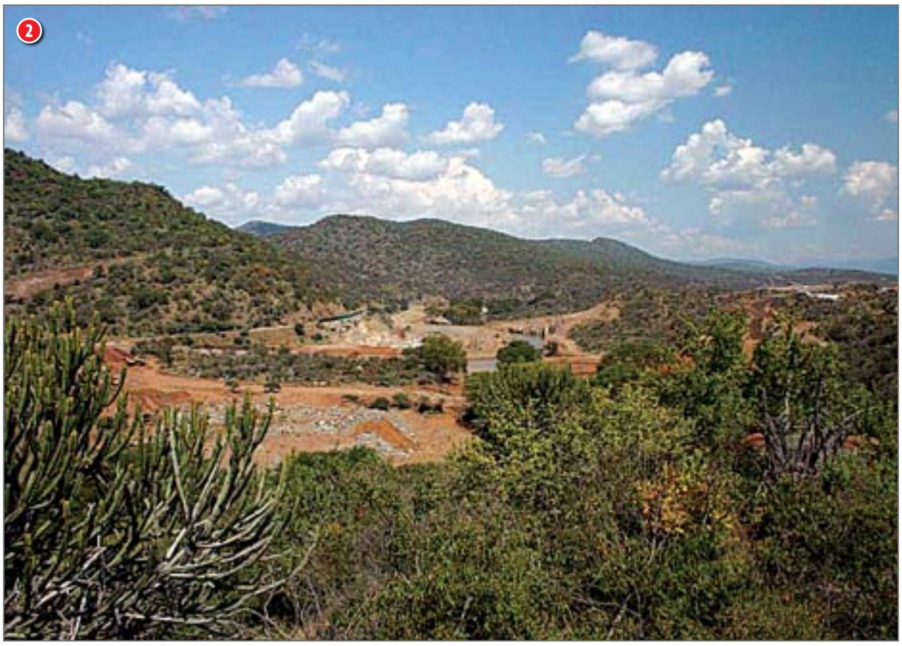
In terms of the MOA, Government will fund the social users' portion of the infrastructure, which will be recorded in off-take agreements with the relevant municipalities. The tariff structure will vary for the two end users in that the commercial users will pay a Capital Unit Charge (CUC) whereas the municipalities will pay a Return on Asset (ROA) charge on the capital investment.

Other users include ESKOM (for their proposed pumped storage scheme) and a host of water supply authorities who will be responsible for the treatment and distribution of water to the domestic sector.

In an effort to keep to the social and economic upliftment objectives of the project, the Charter requires that the contractors recruit 60% of the labour locally. This labour may be recruited from three local areas in prescribed percentages, and preference is given to women and people with disabilities. The contractors should also provide generic and entrepreneurial training so as to leave behind a workforce with enhanced skills.

Construction on the project started in June 2007.

The geology of the area includes the mineral-rich Bushveld Igneous Complex. Mining activity is rapidly expanding, requiring water and power. At the same time, approximately 800 000 people are residing in the near vicinity, without recourse to a safe and reliable water supply. Government hence views the early completion of the dam as of major importance.



2 A view towards the dam wall construction area

3 *Boscia Albitrunca* (Shepherd's Tree) being transplanted during landscaping

4 Archaeological excavation next to the R555 road diversion

NATIONAL CONSERVATION FOREST

According to the specialist vegetation study reports on the project area, 295 plant species were recorded in the proposed dam basin, of which nineteen are highly sought after and widely used in the Steelpoort Valley as medicine, for food and firewood, and in traditional customs. Of these species, four are in such high demand that they are now considered endemic or near-endemic by the Sekhukhune Centre of Plant Endemism (SCPE), and one is a Red Data species.

Measures were introduced to ensure the protection of the fauna and flora in the project area for future generations. Accordingly, before the commencement of construction work SANBI (South African National Biodiversity Institute) carried out the identification and removal of endangered plants in the prioritised areas. The flora was moved to the National Botanical Gardens in Pretoria, and some unique seeds were sent to the Millennium Bank in Kew Gardens, London. The SCPE plants were used in the landscaping of the De Hoop Dam Information Centre, and the Boscia Albitrunca (Shepherd's Tree) was transplanted from the dam basin area to the garden of the Information Centre. The Information Centre will provide the community and visitors with information on dam development activities and water resource management, as well as on the cultural (archaeological) and natural heritage aspects of the project area.

The project area was approved as an off-site mitigation area, and was consequently declared a National Conservation Forest. It was gazetted as such on 6 July 2007 under the National Forest Act. This land is now protected under state law, and no wood harvesting, or any other type of harvesting, is allowed. The protection of plant species (near-endemic, endemic and common) benefits not only Sekhukhuneland and its inhabitants, but also the greater region, as it preserves a unique floristic area for future generations. The sustainability of these initiatives will greatly depend on the cooperation of locals and visitors.

ARCHAEOLOGICAL SITES

During the Heritage Impact Assessment, the presence of a large number of iron-age sites was recorded. One of the requirements of the ROD was that these archaeological sites would be researched and recorded before construction work could advance. This work is well advanced under the leadership of Professor Johnny van Schalkwyk, with the research team painstakingly digging, trowels and brushes at hand, uncovering secrets of the past. A substantial number of graves had to be relocated – 118 of the 209 on the register were relocated after consultation with the affected families.

PROGRESS

The housing and site services contracts, as well as the P169-1 road realignment, are continuing and some contracts are nearing completion. The pouring of concrete for the dam has already started, while work on the right flank of the excavation is progressing.

The design of phase 2B, 2C, 2D, 2H and 2I (the bulk distribution system) will commence off-budget via the funding obtained by the TCTA from the private sector. However, the scale and scope of construction will depend on the number of off-take agreements signed. Discussions with the JWF, ESKOM and the Water Services Authorities will continue in all earnest in order to conclude the above-mentioned off-take agreements.

DWAF is committed to appropriate international best practice and, in line with this aim, external review panels were appointed to both the technical and the environmental suite relating to the dam. As the ECO is also monitoring and reporting on the social and environmental impacts of the project, a holistic assessment of both negative and positive impacts on society and the natural environment will take place by ensuring this process continues after project completion. These study results will shape the project's future operation and maintenance plan to minimise any possible negative impacts.

Acknowledgement

Published with permission from the Director-General of the Department of Water Affairs and Forestry. ◻

THE ORWRDP PROJECT TEAM

Clients DWAF
Consultants DHDC (Dam)
VELA VKE MMA JV (Road)
Africon (Infrastructure)
Contractors DWAF (Dam)
HLE (Road)
Several BEE contractors (Infrastructure)

Rebuilding and Upgrading

THANKS TO THE expertise Degrémont has acquired through its works with existing installations, the company's water treatment engineers are able to propose effective solutions for aging installations, including the following:

- Ascertaining which treatment processes should be instituted
- Optimization of operating and constraint-related costs
- Rebuilding and upgrading existing installation processes, while still retaining as many existing structures as possible and keeping construction engineering costs to a minimum

Degrémont has built more than 1000 water treatment plants in Africa and 120 plants in South Africa and therefore have many requests for rehabilitation in this country.

To cite a few plants, which have been recently rehabilitated in Africa:

1 in Niger, 2 in the Democratic Congo, 3 in Tanzania and 3 being upgraded for the moment in Nigeria.

Degrémont South Africa can assist the client with a complete assessment for the refurbishment of water treatment plants, spares supply, support and training for operation optimization.

Degrémont's various technologies can be proposed, depending on client requirements and site constraints: compact units, such as lamellar modules or membrane technology to optimize the performance, or conventional treatment to reduce costs, this either in drinking water treatment or waste water.

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1 Damaged filter Dar es Salaam
2 Replacing nozzles Dar es Salaam
3 Replacing nozzles finished Dar es Salaam
4 Filter finished Dar es Salaam




World-class tunnel lining

THE GAUTRAIN TUNNEL Boring Machine (TBM) is a colossal moving factory that is boring a 3 km section of tunnel from Rosebank Station southwards, while at the same time lining the tunnel behind it with pre-cast concrete segments that are installed within the protection of the tail shield of the TBM.

The inner diameter of the 3 km tunnel is 5,86 m and the outer diameter 6,46 m, giving a thickness of 300 mm to the tunnel segmental lining. All elementary rings are identical and 1,5 m long, measured along the axis of the tunnel, with each ring consisting of 6 segments, namely:

- 3 standard segments (S1, S2, S3)
- 2 counter-key segments (S4, S5)
- 1 key segment (S6)

To navigate curves the segmental rings are tapered. This allows for the geometric control of the general alignment with a theoretical radius of 750 m, by rotating the rings relative to each other. The segment length along the tunnel axis varies between 1,49 m at the key segment and 1,51 m at the directly opposite standard segment, S1.

To ensure a watertight tunnel lining, a compressive gasket is installed around the whole perimeter of each segment, in a specially formed rebate. In order to temporarily stabilise the segmental ring, temporary bolts are used to connect the newly installed segments with the previously erected ring. The segments incorporate box-outs and built-in plastic sockets to facilitate bolt installation. Segments are installed using a vacuum lifting device situated in the tail of the TBM.

The gap between the extrados of the ring and the soil is filled by mortar injected through the tail shield to form an intimate contact between the tunnel lining and the ground to limit settlement and ensure even load distribution on the tunnel ring.

DESIGN CRITERIA

The segment reinforcement design is based on maximum ring loads, allowing the use of identical rings throughout the whole bored tunnel length. The reinforcement design is based on two loading conditions, the first being the construction phase, catering for loads from the manufacturing to the final placing of the segments within the TBM, including the forces exerted by the thrust-jacks when the TBM is advancing (4 000 t). The second load case is the permanent phase, with allowance for all loads created by the geological ground conditions and by live loads during operation.

Since much of the tunnel is located beneath the ground water table, a stringent quality control system is being implemented to assure the water tightness of the final tunnel lining.

PRE-CAST FACTORY

The pre-cast concrete segments are manufactured by Southern Pipeline Contractors (SPC), at a factory located approximately 25 km east of Johannesburg. Concrete is produced at the factory owned batching plant with a production capacity of 18 m^3 per hour. Forty-two

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2

expertise

sets of segment formwork (constituting 7 rings with 6 segments each) have been supplied by the French tunnel engineering group CBE, a world leader in the highly specialised market of steel moulds for tunnel concrete segments. Each mould is equipped with pneumatic vibrators and is required to produce concrete segments to the very tight tolerances of +/-1,0 mm. The dimensional tolerances of the moulds themselves are +/- 0,3 mm and these are checked regularly with appropriate templates.

CBE also supplied parts for the mould evacuation line, such as two vacuum lifting devices hooked to the factory's gantry cranes to extract the segments from the moulds and transport them inside the factory, the segment rotation machine to turn the segments around from the production position to storage position, and the gasket bonding frame which applies pressure on the gasket after it has been glued into the purpose-formed recess in the segment. The completed segments are then lifted by locally manufactured grabs and transported to the factory's storage area.

PRODUCTION CYCLE

The production cycle commences with the preparation of the 42 moulds, including cleaning (removal of concrete, dust and other residue from previously produced segment casting), assembly of moulds (including periodic checking of tolerances), and application of release agent to the surface of the moulds. Completion of preparation requires acceptance by a quality controller before proceeding further.

The pre-assembled reinforcement cages (welded on specialised jigs) are placed with spacers fixed at defined positions. The cover to the reinforcement is checked by quality control. Cast-in items, such as bolt sockets, are installed before the pre-concreting final check and closure of mould.

Concrete is manufactured on site at the factory by an accredited batching plant according to an approved mix design. Slump tests are performed on every batch before casting of segments. Overhead concrete skips pour concrete into the steel shutters whilst vibrating the moulds, but in order to prevent segregation, vibration is not permitted to exceed 300 seconds per mould per pour.

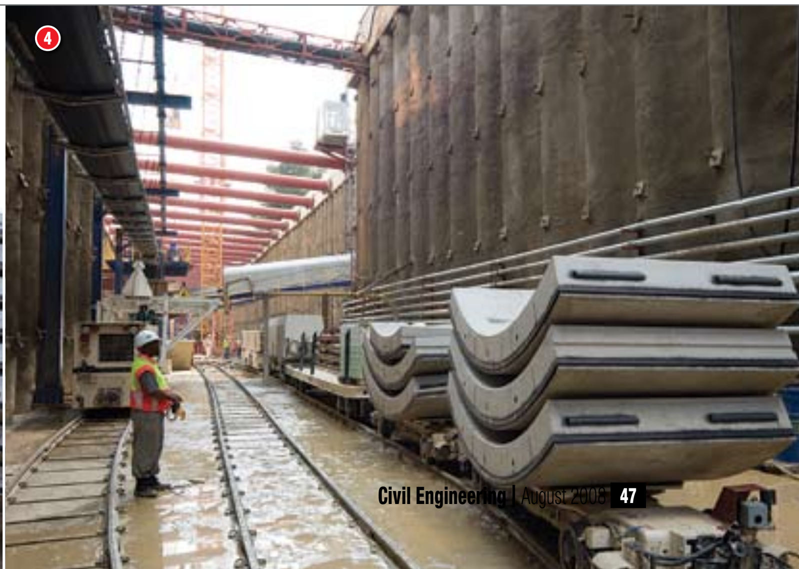
Fifteen minutes after the concrete has been placed and compacted, the cover of the mould is opened to allow concrete surface finishing and application of an approved curing compound to the extrados. To prevent dehydration of the fresh concrete the opened mould is covered with a tarpaulin.

1 Placement of pre-assembled reinforcement cages onto steel moulds for the manufacturing of concrete tunnel lining segments

2 Tunnel lining segments in the pre-cast factory

3 Tunnel lining segments stacked, ready for transportation to the TBM site

4 Tunnel lining segments on site, ready for transportation to the TBM point of installation inside the tunnel



Twenty-four hours after casting, and provided that an early-age strength of 15 MPa has been reached, demoulding of segments takes place. After the sides of the moulds have been removed the segment is vertically removed out of the mould with a vacuum lifting device, suspended from a gantry crane, and transported to a temporary storage area for quality checking, which includes inspection of the gasket recess, minimum cover of reinforcement, and extrados surface finishing. At this stage, necessary, permissible concrete repairs are carried out, according to approved segment repair methods and each segment receives an individual identification mark which relates to its production history.

For storage, handling and transport reasons the segments are rotated 180° by a segment rotation machine. Once the segments have been rotated so that the intrados surface is face up, the segment is lowered onto the transfer trolley and moved to the next production station where gasket fixing takes place. Before the gasket and guiding rods are placed, the purpose-formed rebates are dusted and glue is applied using an airless spray gun. The guiding rods are fixed to each segment so that they will mate with the corresponding receiving recesses of the adjacent segment in the ring, thus assisting the accurate placement of segments inside the tunnel. After placing the neoprene gasket, the gasket press is lowered and pressure applied to achieve proper bonding.

The next station in the production line applies curing compound onto the exposed concrete surface of the segment before the segment is transported to the temporary storage area and a further quality control check is undertaken.

Although the factory is equipped with 42 moulds, such that 42 segments can be cast simultaneously, the factory possesses one evacuation line which is the 'bottle neck' of the production cycle. The production cycle is designed for a production output of one segment every 10 minutes at the bottle neck, thereby achieving 42 segments per working day. The total period of production planned for the 12 000 segments is approximately 15 months.

MATERIALS

Concrete

In order to achieve the production of one segment per mould per 24 hour cycle the segments require an early-age strength of at least 15 MPa after 20 hours. The segments are required to have a compressive cube strength (150 mm x 150 mm) of at least 50 MPa at 28 days. Before erection in the tunnel, the concrete segment strength requirement is 55 MPa. Therefore, three extra test cubes are cast for each batch of segments and tested at 56 days to check that the compressive strength has reached 55 MPa.

The concrete mix consists of Cement CEM I 42,5 N (350 kg/m^3), blastfurnace slag (100 kg/m^3), fly ash (100 kg/m^3), aggregates (19,0 mm max size), water and plasticiser. Workability calls for 60 mm slump concrete and the maximum water/cement ratio is set at 0,45.

Reinforcement

The segments include 82,5 kg of steel rebar per m^3 with the reinforcement being accurately assembled by means of specialised jigs. The minimum concrete cover to the reinforcement is 30 mm.

QUANTITIES

The 3 km long tunnel will be lined with 1 000 segments, consisting of 17 420 m^3 of concrete and 1 437 t of reinforcement steel. The reinforced concrete volume of one ring is 8,71 m^3, one standard or counter key segment comprising 1,585 m^3 of concrete weighing 4,1 t (concrete density 2,55 t/m^3), and one key element comprising 0,787 m^3 of concrete weighing 2 t.

STORAGE, TRANSPORT & INSTALLATION

Four thousand segments can be stored at SPC's factory at any one time and 50 rings (300 segments) can be stored on site next to the tunnel portal. The segments are transported from the pre-cast factory to the tunnel site on normal road trailers (one ring of six segments per trailer). From the site storage area the segments are lowered into the shaft by a tower crane and transported to the TBM, stacked in pairs on rail wagons, from where they are forwarded to the point of installation on a segment feeder and installed by the TBM's vacuum segment erector. The excavation production is planned on an average rate of 10 m advance per day, i.e. 7 rings.

CHALLENGES

The greatest challenges relate to developing the necessary standards of workmanship and quality assurance to match the specification requirements. This has been successfully achieved by breaking down the production cycle into manageable elements under the control of designated supervisors and implementing strict quality control procedures at each stage in the process. The resultant quality of the product is self evident.

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5 Tunnel lining segments inside the TBM
6 TBM shaft


5


6

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Berg River Dam rushes to completion

THE CONSTRUCTION of the Berg River Dam entered its final phase with the successful release of 200 m^3/s. On 12 June 2008, 1,4 Mm^3 of water was released in the build-up to the 200 m^3/s designed capacity of the 5,5 m diameter conduit conveying the water from the intake tower through the dam wall to the outlet works. This flow is equivalent to a natural 1:2 year flood event.

The 3,4 m by 2,9 m flood release (radial) gate housed in the outlet works was fully opened to release the large volume of water under gravity and a head of 31 m in order to test the 3,8 m by 3,2 m emergency (bonneted sluice) gate housed in the intake tower. The emergency gate was driven down by power supplied by a standby generator. Thus, a full emergency situation was simulated and successfully tested.

The Berg River Dam is a concrete-face rockfill dam with a gross storage capacity of 130 Mm^3. The dam wall is 62,5 m high, 990 m wide and 220 m in width at its base. Currently the dam is 52% full and with average rainfall this winter season it should fill to 100%. The outlet works have been designed to release both low and high flows with provision for a peak release of up to 200 m^3/s.

In terms of the National Water Act of 1998, there is a requirement for the provision of water of a suitable quantity and quality to be released into the watercourse or river below a dam or other works to provide for basic human needs or to protect the aquatic ecosystem. This requirement is known as the ecological reserve and is the right in law.

The Berg River Dam has been designed to cater for low and large volume releases. The system for low releases occurs in the range of 0,3 m^3/s to 12 m^3/s. These releases occur continually and are adjusted in magnitudes as required by the ecological reserve and depending on the inflow into the dam.

The other part of the outlet works which houses the flood release gate is able to control large releases of up to 200 m^3/s. Theses large flow releases will mimic naturally occurring flood events.

During the large volume release, the Emergency Preparedness Plan was implemented and tested by the well organised disaster management centre of the Cape Winelands District Municipality in conjunction with the Stellenbosch and Drakenstein municipalities. With emergency services posted strategically along the riparian area extending from the Berg River Dam to the town of Paarl, the general public was informed regarding the development of a potential hazardous situation downstream of the dam after implementing early warning procedures and evacuation procedures.

The dam forms part of the R1,6 billion Berg Water Project and supplies water to the Western Cape Water Supply System. ☐


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The Berg Water Project supplement scheme

AS THE FIRST LARGE water resources infrastructure development project in South Africa to be designed, constructed and operated within the framework of the National Water Act and in accordance with the guidelines of the World Commission on Dams, a brief overview is given of the Berg Water Project (BWP), with special focus on the Supplement Scheme as part of the broader BWP.

ORIENTATION

The Berg River Dam, Dasbos pump station and pipeline to Dasbos tunnel and adit are situated approximately 6 km northwest of Franschhoek in the Berg River Valley.

The Drakenstein abstraction works and pump station are situated approximately 10 km downstream of the dam site on the right bank of the Berg River on the grounds of Drakenstein Correctional Services, and 1,5 km west of the R301 to Paarl.

The operations offices and control room for the project are situated in the Dasbos pump station, which is on the left bank of the river, approximately 200 m downstream of the dam.

BACKGROUND

In response to the increasing demand for water in the Greater Cape Town region, DWAF initiated the Western Cape System Analysis in April 1989. The BWP, which included inter alia the Berg River Dam (previously known as Skuifraam Dam) and Supplement Scheme, was identified as the preferred new water scheme to augment the water supplies from the Western Cape Water System.

The upper catchment of the Berg River to the south of the dam site is one of the most productive water catchments in the country and the BWP harnesses this resource for the benefit of the water users in the urban and agricultural sectors of the Western Cape. The BWP augments the yield of the Western Cape Water System by 81 Mm^3 (to 523 Mm^3) per year and integrates with the Riviersonderend – Berg River Government Water Scheme.

The project was funded and implemented by Trans Caledon Tunnel Authority (TCTA).

Berg River Consultants, a joint venture between Knight Piésold Consulting, Goba Consulting Engineers and Project Managers, and Ninham Shand Consulting Engineers, were appointed by TCTA in December 2002 as design and construction supervising consultants.

Impounding of the dam started in July 2007 and the pump stations and interconnecting pipework were brought into operation during the middle of 2008.

On completion of construction, the project components will be owned by TCTA, but operated and maintained by DWAF as part of the Western Cape Water System.

GENERAL DESCRIPTION AND MAIN COMPONENTS

In broad terms the components of the BWP are:

- The Berg River Dam on the upper Berg River in the La Motte forest. The dam is a concrete-faced rockfill dam (CFRD) approximately 938 m in length and 62,5 m high. The appurtenant structures include a 65 m high intake tower, a 5,5 m diameter concrete outlet conduit, outlet works and an ungated side channel spillway. The reservoir has a volume of 130 million m^3 and a surface area of 537 ha at FSL. The dam provides an additional 56 Mm^3/a of water to the Greater Cape Town region.
- A pump station (the Dasbos pump station) and a 2,5 km long 1,5 m diameter (Dasbos) pipeline to convey water from the dam to the Dasbos adit of the Riviersonderend Tunnel System and thence into the Western Cape Water System – referred to as the Dasbos System. The system is designed to deliver 3 m^3/s initially, with the option of increasing to 6 m^3/s in future.
- Abstraction works on the Berg River below the Dwars River confluence consisting of a low diversion weir, boulder, gravel and sand sediment traps, a covered diversion canal, a balancing dam and a pump station (the Drakenstein pump station). The water is pumped via a 10 km 1,5 m diameter

(Drakenstein) pipeline to the dam and connected to the pipework at the Dasbos pump station – referred to as the Drakenstein System. The system is designed to extract excess winter water from the Berg River below the confluences of the Franschhoek, Wemmershoek and Dwars rivers and pump it back to the dam for storage, thus supplementing the water stored (25 Mm^3/a) in the dam.

- Wemmershoek Irrigation Release Works on the Wemmershoek River just upstream of the confluence of the Berg River.

OPERATING PARAMETERS AND DESIGN PHILOSPHY

In summarised terms the BWP has been designed to fulfil the following operational requirements:

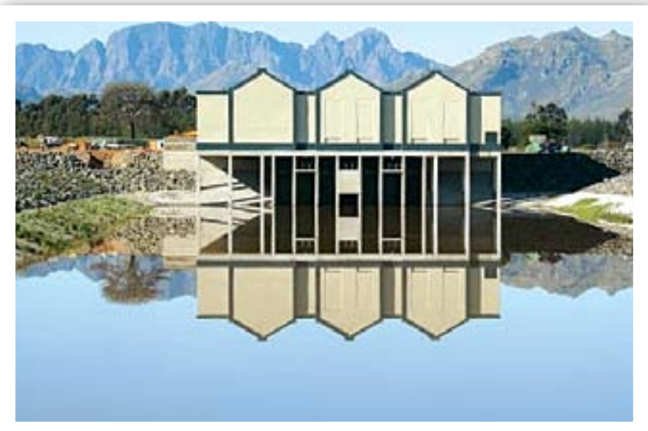
- Flood releases of up to 160 m^3/s through the wet well in the intake tower and the conduit to maintain the ecological status of the Berg River downstream of the dam (the system is capable of releases of up to 200 m^3/s)
- Monthly environmental in-stream flow requirement (IFR) of between 0,36 m^3/s and 8,6 m^3/s released through the sleeve valves at the outlet works
- Draw-off of up to 3 m^3/s (increasing to 6 m^3/s in the future) from the dam through the pipes in the dry well in the intake tower and pumped through the Dasbos System into the Riviersonderend Tunnel System and Theewaterskloof Dam
- Future requirement to feed directly to the proposed Muldersvlei Water Treatment Plant by means of gravity or the Dasbos pump station
- Abstraction of up to 4 m^3/s from the Berg River at Drakenstein Correctional Services in winter and pumped through the Drakenstein System and the dry well piping in the intake tower to discharge into the dam to supplement storage in the dam
- Releases of up to 6,7 m^3/s from the Berg River Dam, or preferably Theewaterskloof Dam, via the Riviersonderend Tunnel System into the Berg River at the confluence of the Wemmershoek River for irrigation purposes in summer

These operational requirements have set a challenge for the designers to economically integrate the requirements with the infrastructure designed and constructed as part of the project.

SUPPLEMENT SCHEME

The Dasbos System is required to transfer water from the Berg River Dam to the Riviersonderend Tunnel System. Furthermore,

Drakenstein Pump Station



1 Dasbos Pump Station
2 Berg River Dam outlet works and Dasbos Pump Station
3 Dasbos Pump Station installations
4 Dasbos tunnel and adit strake D delivery to site

it was recognised that by constructing a diversion weir downstream of the dam at Drakenstein, surplus water from the Franschhoek, Dwars and Wemmershoek rivers could be pumped to the dam to supplement yield of the scheme.

Dasbos System

Dasbos pump station

The pump station has a reinforced concrete substructure (pump well) and a superstructure of reinforced concrete columns and beams, with plastered and painted brick infill wall panels. The pump units are positioned in the pump well on concrete plinths. Provision has been made for five pump sets, but only four sets have been installed. The fifth set can be installed when and if water demand increases beyond present capacity.

Operating staff offices and facilities as well as the project control room overlooking the outlet works of the Berg River Dam are housed in the pump station building.

Four Sulzer SM 501-640/Imp 635 mm single-stage horizontal centrifugal split casing pumps with 3,01 MW ALSTOM motors and controlled by ABB variable speed drives capable of delivering 3 m^3/s now and 6 m^3/s in future, with the installation of a fifth set at 135 m head, are installed. Transformers and switchgear were manufactured by ABB and ALSTOM respectively. The suction and delivery manifolds are situated underground outside the building.

The suction manifold draws water from one of five bell mouth intakes from five levels and either one of two pipe stacks in the dam intake tower and by way of cross-connected pipework south of the pump station. The Drakenstein pipeline is situated to the east of the pump station and is connected directly to one of the pipelines and pipe stacks or via the cross connection to the alternative pipeline and pipe stack in the intake tower. The delivery manifold is connected to the Dasbos pipeline.

The Dasbos – Drakenstein cross connection connects the Dasbos pipeline and the Drakenstein pipeline to the north of the Dasbos pump station.

The Dasbos pump station bypass pipeline is provided to feed water directly by gravity to the future Muldersvlei Water Treatment Works (WTW) bypassing the pump station when the water level in the dam is sufficiently high to allow this.

Dasbos pipeline

This pipeline serves three functions:

- To transfer water from the Berg River Dam to the Riviersonderend Tunnel System
- To transfer irrigation water from Theewaterskloof Dam to the Wemmershoek Irrigation Release Works (via the Drakenstein pipeline)
- To transfer water from the Berg River Dam to the future Muldersvlei WTW

The pipeline to the west of and from Dasbos pump station to the Dasbos adit and tunnel follows a gradually rising route around the toe of a mountain above the left bank of the Berg River. The pipeline connects the Dasbos pump station with the Dasbos tunnel and adit, which links up with the Riviersonderend Tunnel System. The latter conveys raw water from Theewaterskloof Dam via Kleinplaas Dam, situated in the Jonkershoek valley above Stellenbosch, to the Faure and Blackheath Water Treatment plants. This tunnel system was constructed at the same time as the Theewaterskloof Dam, in the mid 1970s.

Just before entering the Dasbos tunnel the pipeline passes through a chamber, in which an isolating valve is installed. At the chamber exit a sweep tee turns the pipeline into the tunnel. In view of a possible future connection to the Muldersvlei WTW a Y-branch has been installed just beyond the sweep tee, with a second sweep tee back towards the chamber, all with isolation valve and blank flange for later connection to the proposed Muldersvlei pipeline.

The Dasbos pipeline has a cross connection to the Drakenstein pipeline just north of Dasbos pump station to:

- divert water from the Theewaterskloof Dam via the Dasbos tunnel and Drakenstein pipeline to the Wemmershoek Irrigation Release Works during the summer months
- gravitate water from the Berg River Dam past the Dasbos pump station to the future Muldersvlei Water Treatment Works

Dasbos tunnel and adit

The pipeline connects to the Riviersonderend Tunnel System (RTS) about 200 m into the adit.

Inside the Dasbos adit and up to a domed bulkhead the pipeline is mounted on concrete pedestals, offset to the right with a sufficient clearance between the pipe pedestals and the left tunnel wall to allow vehicular access down the adit and through the dome (when opened) into the tunnel.

The connection to the concrete lined tunnel is by means of DN2500 3CR12 strake fully concrete and grouted into the tunnel with a hinged dome on the end to allow vehicular access to the tunnel. From this strake a bifurcation and DN1500 valve connects to the Dasbos pipeline. For safety reasons a further isolating valve has been installed inside the tunnel in close proximity of the access dome. The design of the connection to the RTS took into account minimal downtime and disruption of water supply from Cape Town's main water source, the Theewaterskloof Dam. The dewatering of the Riviersonderend Tunnel System and connection to the existing bulkhead was achieved in nine days – the physical connection / tie-in taking just two days.

Drakenstein System

The Drakenstein System's primary function is to abstract surplus water from the Berg River during the winter months and pump it to the Berg River Dam to supplement the yield of the dam.

During the summer months the Drakenstein pipeline will be utilised in reverse mode to convey irrigation water from Theewaterskloof Dam (via the Dasbos pipeline) or Berg River Dam to the Wemmershoek Irrigation Release Works, situated on the Wemmershoek River, immediately upstream of the confluence with the Berg River.

The Drakenstein System of the Supplement Scheme consists of the following elements:

- Drakenstein abstraction works on the Berg River consisting of:
  - Diversion weir with canoe chute and fish ladder
  - Diversion works including boulder, gravel and sand traps and associated stop logs, gates and sluices
  - Diversion canal to the balancing dam with inlet control gate
  - Balancing dam
- Drakenstein pump station
- Drakenstein pipeline from Drakenstein pump station to the Berg River Dam

Drakenstein abstraction works

The diversion weir has an ogee crest and roller bucket energy dissipater to prevent downstream erosion. This type of weir has the advantage that it effectively reduces erosion downstream by creating an opposite flow direction at bottom level. The structure is positioned perpendicular to the anticipated flow direction during high floods and has an overflow length of 65,25 m. The total width of the weir, in the direction of flow, inclusive of the roller bucket, is 12,53 m. The weir has a flat bottom, and is supported in the cobble/boulder strata, about 4 m below natural river bed level. Its underside is linked to an engineered cut-off through the cobble/boulder strata down to a low-strength base rock. The cut-off consists of a pressure-grouted 1,5 m wide strip and is intended to prevent piping and essentially reduce seepage below the weir to a minimum. The river bed downstream of the weir is protected against erosion by means of rip-rap, with a D50 size of 1,1 m sourced some 60 km from site and almost delivered one by one to site! The rip-rap was placed on a filter layer of smaller size rip-rap.

The left-hand non-overflow section of the weir has a flank wall rising to level above the calculated level of a 1:100 year flood at this point.

On the right-hand side of the weir a canoe chute and fish ladder have been incorporated in the weir/ diversion structure. Water flows uncontrolled firstly through the fish ladder and then through the canoe chute fulfilling the river instream flow requirements (IFR) of up to 1,5 m^3/s during the drier summer months. The adopted average minimum and maximum monthly IFRs in winter vary between 1,5 m^3/s and 2,86 m^3/s.

At full supply level (FSL) the combined flow through canoe chute and fish ladder would be about 1,5 m^3/s. At higher IFRs the boulder trap gate will be opened to provide additional capacity.

Of the various fish ladder designs available the one chosen is considered the most suitable for fish found in the Berg River. It is provided with vertical slots in the baffle walls, placed in one line near one side, thereby creating sheltered small pools at each step for the migrating fish.

Downstream of the canoe chute a pool has been created, which basically consists of a deepening of the rip-rap protection. In addition, the rip-rap has been grouted in this location for the protection of canoeists and canoes.

Embankments protected by rip-rap have been constructed on the left and right banks to contain the river during floods of up to a 1:50 year event and to prevent the river scouring a new channel and thus bypassing the diversion works during 1:100 year flood conditions. The left hand embankment extends upstream to the confluence of the Dwars River. It is provided with a drainage system alongside the toe of the embankment on the landward side in order to control the ground water level in an adjacent vineyard and for releasing storm water to a point downstream of the diversion weir. It also functions as a draining devise after flooding. The embankment connects onto the non-overflow section of the weir on the left bank.

The right-hand embankment extends for a similar distance upstream of the diversion works, but excludes a draining system along the landward side. The right-hand embankment butts up against the extended wall of the gravel/boulder traps and has been built to generally the same levels as the left-hand embankment.

The diversion works are situated on the right bank and bend of the Berg River following investigations into the course of the

5 Drakenstein abstraction works
6 Drakenstein diversion works – sediment removal structures
7 Fish ladder; canoe chute; boulder, gravel and sand traps
8 Pipe installations at Dasbos Pump Station

river over 60 years. The works are designed to divert water from the river into the works, remove sediment down to a particle size of 0,4 mm and divert the water to the balancing dam via an underground diversion canal. The diversion works, diversion canal, balancing dam and pump station are all located in the 1:200 year flood plain of the Berg River, which is 300 mm higher than the 1:50 year flood level, and was the subject of a model study at the University of Stellenbosch to ensure minimal river flow obstruction in the floodplain.

The sediment removal structures consist of boulder, gravel and sand traps and have been configured on the basis of model studies of the whole diversion works complex. These structures are designed to divert a maximum of 6 m^3/s of river water. The boulder, gravel and sand traps remove sediment down to 40 mm, 2 mm and 0,4 mm in size respectively. A key emphasis in the design was to make the structure self-cleaning, using gravity flow washing sediment back into the river. This maintains the sediment load and river ecology and negates the necessity for costly removal of sediment from sediment traps.

Boulder scour (radial) and gravel scour (radial) gates, situated in the flushing channels downstream of the boulder and gravel traps, are used in the periodic controlled discharge of river water to flush out the boulder and gravel accumulations. The sand traps, of which four have been provided, can be flushed individually by means of sliding (sluice) gates. Trash racks are installed on the trailing wall upstream of the sand traps.

A sand scour (radial) gate positioned downstream of the sand traps is opened during flushing of one of the sand traps, allowing the flow plus sediment to be diverted back to the river downstream of the weir.

A 4,0 m wide by 2,5 m high roofed concrete diversion canal discharges the cleared water from the diversion works into the balancing dam. The flow through the diversion canal is regulated by means of an automated diversion (sluice) gate, which is controlled via a combination of signals from instruments placed in three locations. A level monitor in the river, upstream of the weir, triggers the opening or closing of the diversion (sluice) and boulder and gravel (radial) gate by comparing actual river level with the level at IFR and diverted flow. An ultrasonic flow meter, working in conjunction with a parshall flume inside the diversion canal, as well as a level monitor in the balancing dam, provides further control signals.

Abstraction starts when the IFR is exceeded, by opening the diversion (sluice) gate, which will allow water to enter the diversion canal up to a maximum of 6 m^3/s. Above IFR + 6 m^3/s the boulder scour gate opens further, followed by the opening of the gravel scour gate. These two gates will close in reverse sequence when the flow subsides again. The purpose of these operations is to maintain the FSL upstream of the weir as long as possible to maximise river abstraction. Overflow of the weir will thus only occur when river flow exceeds IFR + 6 m^3/s + capacity of boulder and gravel trap (radial) gates.

The diversion canal discharges the flow through six 1,0 m wide by 0,6 m high openings, placed at the invert of the canal, into the balancing dam. These six openings are strategically spaced to obtain even flow into the balancing dam.

The balancing dam optimises water storage for pumping purposes and to allow settlement of fine sediment up to 0,2 mm in size. Its crest level dimensions are approximately 360 m x 123 m. Embankments with rip-rap protect the balancing dam from floods up to a 1:200 year event. Generally the sides below FSL and

10 m rim of the bottom of the dam are lined with Armourflex to keep the shape of the dam. As the FSL of the dam is below the natural groundwater level, loss of water is not a concern.

Plant access into the diversion canal and the balancing dam itself for clean-out purposes is obtained by means of a ramp at the northeast side of the balancing dam. Clean-out operations could take place during the summer months once the sediment reaches a predetermined level immediately upstream of the pump station pump intakes.

Drakenstein pump station

This pump station pumps water from the balancing dam through the Drakenstein pipeline to the Berg River Dam.
The pump station structure consists of a substructure of four separate concrete sumps and a superstructure of reinforced concrete columns and beams, with plastered and painted brick infill panels. The electrical motors, screens loading bay, storage area, operators' facilities, switch room and transformer bays are situated at ground floor level above the 1:200 year flood level.

Flow into the sumps passes through trash racks. These are cleaned by manual intervention. The sumps of the pump station, inclusive of the secondary concrete, guide vanes and inlet configuration below the pump intakes were analysed with CFD (Computerised Fluid Dynamics) software to ensure proper operation in order to prevent vortex formation, pre-rotation and swirling.

Four Sulzer BK 850 3-stage vertical spindle turbine pumps driven by 2,67 MW ALSTOM motors and capable of delivering 4 m^3/s at 145 m head are installed (three in operation, one standby). Soft starters, transformers and switchgear were manufactured by Allan Bradley, ABB and ALSTOM respectively.

An external delivery manifold with isolating valve joins onto the Drakenstein pipeline.

Drakenstein pipeline

The pipeline from the Drakenstein pump station to the Berg River Dam (the Drakenstein pipeline) follows a route generally parallel to the Berg River but outside the 1:100 year flood line at varying distances of up to 600 m from it. The pipeline crosses several services, such as the Wemmershoek potable water pipeline to Cape Town, irrigation pipes in the agricultural areas, and the R45. It also crosses the Wemmershoek and Berg rivers. This presented various construction challenges to the contractors as the Berg River pipeline crossing immediately upstream of the R45 bridge crossing is 6 m below natural riverbed level.

The selection of the route was a lengthy procedure and determined on the basis of topographical surveys, the 1:100 year flood lines, and land owner input. Geological investigations were undertaken and the results used in the final stages of the selection process.

The vertical alignment of the pipeline has a minimum slope of 0,35% for drainage purposes. A maximum negative slope of 21% has been adopted for the effective removal/transportation of air (that is, pressure increasing in the direction of flow with pumping).

The R45 is crossed inside a 1 800 mm diameter concrete jacked sleeve pipe. The annulus between sleeve and pipe is grouted up. Small diameter sleeves for cathodic protection cabling and possible future use were installed in the annulus before grouting.

PIPE DESIGN

Whilst the consultants' original preference was a 10,3 mm wall thickness DN1500 mild steel, epoxy lined pipe, a 30 mm thickness cement lining (the preferred lining by the City of Cape Town) and maximum allowable velocity in the pipeline of 4 m^3/s were adopted. The thickness of the cement mortar lining was derived after extensive laboratory investigations and is the result of the aggressive and low pH levels (down to 2,9) of the water to be conveyed and high flow velocity adopted over the design life of the pipeline.

Pipes encased in concrete, generally below the river crossings, specials and valve chambers, and in Dasbos tunnel and adit are manufactured from 3CR12. The section of pipe inside the sleeve at the R45 crossing is of mild steel with a wall thickness of 20 mm to provide for additional safety in a position difficult to access. The individual pipes have been factory hydraulic tested. After installation and completion of the pipeline a further in-situ hydraulic test has been carried out. All pipes are continuously welded and joined by means of welding.

The selected corrosion protection system for the standard pipes consists of a factory applied 3,4 mm Sintakote (polyethylene) coating and a 30 mm cement mortar lining (CML) applied in two layers followed by a bituminous (Ravenol) coat which were applied in situ.

At the welds the pipe is wrapped with a shrink-on band. This is a double-layered bitumen/polyethylene band which is heat-applied on the prepared steel surface while overlapping the Sintakote coating on both sides. Pipes encased in concrete are coated with an epoxy paint.

The minimum cover on all pipes is 1,3 m. A cathodic protection system is also in place.

WEMMERSHOEK RIVER IRRIGATION RELEASE WORKS

The Wemmershoek Irrigation Release Works are positioned on the Wemmershoek River immediately upstream of the confluence with the Berg River and can release flows of up to 6,7 m^3/s through two DN600 sleeve valves. This facility enables irrigation releases to be made from either the Theewaterskloof or Berg River dams via the Dasbos and Drakenstein pipeline system into the Berg River. It consists of two DN600 sleeve valves housed in a concrete substructure discharging water with a head of up to 110 m into two chutes and stilling well. A building housing electrical and control equipment is erected on top of the chamber and above the 1:100 year flood level. For aesthetic purposes, and in order to blend into a future high-cost housing development, the outside of the building is clad with gabion baskets filled with small diameter river boulders.

GENERAL

The Supplement Scheme was constructed under three separate contracts. All pump stations, civil, tunnel and hydro mechanical installation works were undertaken by the Department of Water Affairs and Forestry Construction Division. All mechanical and electrical installations were undertaken by SULZER Pumps (SA). The construction of the Dasbos and Drakenstein pipelines was undertaken by Cycad Pipelines. Costs for the construction of the whole of the Supplement Scheme are approximately R450 million.

We wish to express our gratitude and thanks towards TCTA for permission to publish this article

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CRBs facilitate building on steep slopes

LIFTING SWIMMING POOLS TO NEW LEVELS

How many homeowners choose the site for their new home because of the view? Probably millions of people do. The problem is that if you have chosen to build on a sloping plot with a stunning view, you might end up losing ground – quite literally. You can erect buildings on sloping ground using many different methods, but what if you want a swimming pool? The answer, of course, is to build a retaining wall to contain the ground around the pool.

If this is at all possible, you probably think that you'll need an engineer, and it's going to be expensive. A Cape Town-based company has proved that anything is possible with concrete retaining blocks (CRBs) – and you don't have to rob a bank to do it!

The CRB system was pioneered in South Africa more than 25 years ago by local and international concrete block licensee Terraforce. It has since become well established in the marketplace, featuring qualities such as the ability to create retaining walls that are easily formed into complex curved shapes or walls in which the upper and lower profiles are continuously changing.

Because the blocks are reversible, the system offers a choice between round face (plant supportive) and flush face (smooth or split version) to suit specific site requirements. When installed, the blocks present a closed vertical surface structure that provides maximum amount of soil mass within the wall and prevents backfill spillage, while at the same time offering uninhibited permeability. Being hollow, yet strong, they require less concrete to do the job as compared to solid block systems.

A good example of a CRB system flexible enough to handle the challenges of a demanding site in an attractive and creative way is a pool and retaining wall that was built in Llandudno, in the Western Cape. The pool construction was done by Suburban Pools, and the wall was completed by Decorton, a specialist contractor for segmental retaining wall installations.

The installation of the supporting structure for the pool situated high up on solid granite rock outcrops required constructing a level foundation on the sloping and uneven granite rocks. This involved some core drilling and epoxy grouting of Y16 starter bars. Next, a reinforced concrete foundation was cast with steps at intervals to match Terraforce L12 block heights. The retaining wall was built to 3 m height using a concrete-filled double skin with steel reinforcing in the inner skin. The following 2 to 3 m were built with a concrete-filled single skin.

As work progressed, reinforcing geogrids were locked into the blocks, embedded in 4% cement-stabilised backfill, and tied again to sand bags filled with a specified cement-sand mix. These sandbags were used to provide the shape of the pool.

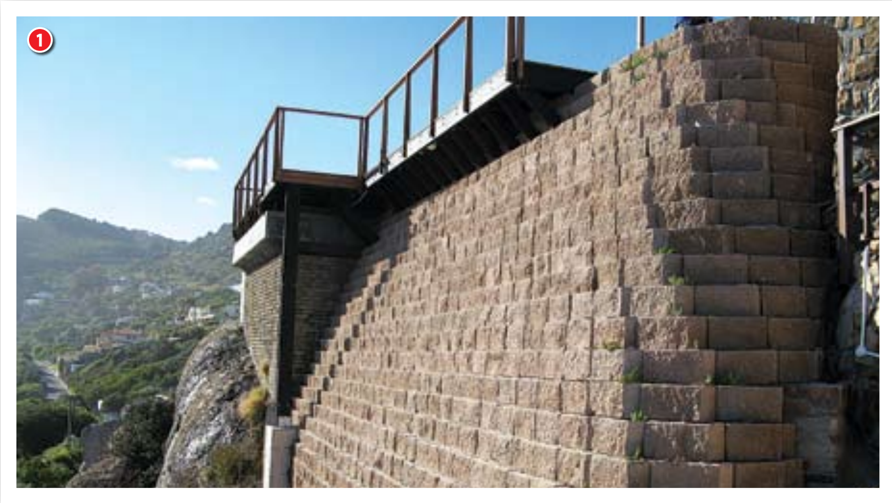
The CRB system is often used to create additional backyard space for a pool where it would otherwise have been difficult to do so. By using Terraforce L11 rockface blocks, builders provided a level, spacious platform about 3 m above road level, which surrounds the house built on a steeply sloping property. To soften the walls that support the fill for this platform, flower beds and steps were added. The 4 m wall at the back (the cut section) of the property was constructed in such a way as to provide a large backyard area where a swimming pool could be installed. The wall behind the swimming pool exhibits an artificial rock waterfall, along with more plantable space to soften the hardness of the high rock-face wall.

And yes, an engineer was involved, as this kind of installation requires a more demanding level of professional supervision than is required for standard retaining walls.

PUSHING BEYOND CONVENTIONAL BOUNDARIES

In the past, it was common knowledge that retaining walls had to be poured, reinforced concrete. Even though CRBs have been on the market for decades, there are still some who think blocks (especially hollow-core units) cannot do the same job as poured concrete, especially for structures higher than 4 m. That is simply not the case.

As an engineered structure, concrete block retaining walls offer extensive flexibility at a range of heights and in varied soil conditions when designed by experts in this complex field. The question about how high these structures can grow is



1 By building the pool up from the granite rocks below, a stunning view out across the ocean was made possible

2 Terraforce blocks have been used to create a level platform for this impressive pool with a view

relatively governed by design engineers with the expertise to push beyond conventional boundaries.

Simon Knutton, a professional engineer and consultant with over a quarter century of local and international experience in this field, authored the first design guidelines for gravity walls in South Africa.

Commenting on the benefits of the Terraforce system, Knutton says: "The closed face of the Terraforce minimises the risk of erosion-induced failure, and the contact area from block to block is better on Terraforce than any other similar product." Another advantage is that the wall angle is easily changed from near vertical to flatter slopes, and features such as stairs are comfortably incorporated.

Although composite Terraforce walls have been built to a height of 11 m with a single skin facing, it is important to note that there are certain limitations, and as a rule of thumb, any wall (with or without extra reinforcing) exceeding 8 m and with a wall angle of more than 65° will require either a double layer or concrete-filled blocks at the base to increase crushing strength, thus avoiding potential pressure cracks. Knutton also warns that terracing a wall can seem like a tempting solution – he remembers successfully reaching heights of up to 25 m in this way – as terraces effectively reduce the slope angle that the wall is resisting, but the temptation to use them can make a situation worse rather than better, since the foundation load from the upper wall can surcharge the lower one.

This does not mean terracing can never be considered for achieving greater wall height. Silvio Ferraris, a professional civil engineering technician from ReMaCon Products cc, a Gauteng-based concrete retaining block manufacturer, feels that it can be a good option, especially when space allows for it. As a basic guideline, the lower terrace must be approximately one third of the total wall height and the distance between terraces depends on overall wall height and overall horizontal space available. Generally, geofabric-reinforced lower terraces will offer greater overall wall stability. Most important, says Ferraris, the overall slope angle must be considered at the design stage.

When building composite walls of any significant height, it is of crucial importance to consult with an experienced engineer. Ferraris stresses that the law is very strict on these matters: "The NHBRC requirement is that one can build a wall to a height of 1,2 m without consulting an engineer, but as a general rule, 1,5 m for walls no steeper than 70° is also possible. Steeper and especially load-carrying walls must be designed by a qualified engineer, even if only 1,2 m high."

There are a variety of methods of building high, composite retaining walls using hollow-core, interlocking blocks and each of these has to be carefully evaluated to establish suitability for any given situation:

Double skin

Double skin effectively doubles the gravity mass of the wall and increases the lever arm for overturning moments. The wall mass can be further increased by spacing the front and back skins using a stabilised fill and a geotextile or grid to hold the two faces in juxtaposition. It is not always necessary to take the second skin to the full height of the wall.

Geofabric

The use of horizontal, tensile layers increases the maximum height of the Terraforce wall significantly. The basis here is to determine the force of the 'active' soil, then place enough fabric to counter this force and to intersect the slip plane with sufficient depth to resist 'pull-out' when forces in the soils are activated. The choice of fabric is important and is determined by the nature of the fill material, that is, coarse-free draining or high-fines content, possibly high PI with clays. The last row of geofabric, usually three rows from the top, is mainly a 'needle-punched' fabric placed to carry and distribute 'line' loads close to the top of the wall and to limit storm water damage. Whilst the design is sometimes complex, the application is straightforward enough. BS8006 is considered the 'Bible' when it comes to geosynthetic slopes and there has been a move away from geotex-

1 This CRB retaining wall at Montecasino in Fourways, Johannesburg, was completed within four months

tiles in favour of higher tenacity products such as grids.

Concrete infill

Concrete fill has a similar effect to double skin in as much as the mass of the wall is increased per square meter. The concrete also improves shear resistance from block to block and boosts crushing strength. It is also possible to reinforce the concrete infill with steel or to incorporate vertical RC pillars or horizontal RC beams into the blocks.

Steel reinforcement

When considering the use of steel reinforcement in a concrete-filled wall, the block effectively is considered to be a combination of a shutter and a spacer. The use of reinforcement would require structural input to assess the efficacy of the whole system.

Interlocking keys

Concrete keys would only have value where there are higher than usual shear forces in a wall. They can either be plain coarse gravel infill, cement-stabilised soil infill or concrete keys. The soil inside the blocks should be tamped leaving a 50 mm gap. Once the next row of blocks is placed, the soil is tamped through into the 50 mm recess, effectively keying in the blocks.

Regardless of the methods described above, there are a few basic guidelines that need to be adhered to during the construction of a very high CRB-Terraforce wall, and Ferraris is very clear on how he would proceed. "A level foundation and an accurate first row is just the first step in many to ensure a safe and stable wall. Angled profiles need to be set up so that the wall angle will keep to the design slope. Compaction must be 93% mod AASHTO or more, and if possible, use soil material with less than 15% passing a 0,075 mm sieve. If that is not possible, intermediate soil blanket drains and/or water transmissive geotextiles with adequate strength, as well as drains both at the base of the wall against the cut face and at intermediate heights, need to be considered. Drains should be placed against cut faces using either continuous sheets, if circumstances require, or 'wick' drains placed at between 1 m to 2,5 m centres and at 45° against the slope face."

Ferraris adds that in all cases, although this is difficult, all soils should be tested by a soils laboratory to determine the internal shear strength of soils, their cohesion, the percentage of fines and the plasticity index of both backfill soils and retained soils.

Nevertheless, each situation can call for a different solution and over the years many interesting and challenging Terraforce projects have been completed in South Africa and abroad. One such extensive retaining wall, completed within four months at Montecasino in Fourways, Johannesburg, boasts a face area of 2 700 m^2 and an average height of 9 metres. In this case Terraforce L13 blocks were placed on a 25 mpa concrete foundation and built to full height in chainages of about 60 metres.

The bottom 12 rows of blocks were filled with a cement-stabilised load-bearing mix, while the fabric-reinforced backfill was made up of 5% cement-stabilised soil (mixed with a TLB and placed with a telescopic loader) and compacted to 93% mod AASHTO. Light and heavy grades of woven geofabric were specified depending on their position within the wall. In situ concrete shear keys were installed on every row and every other block, including rows with fabric layers. All geotextiles were pre-tensioned in warp direction before placement of backfill material took place.

Often a steep property calls for steep measures, especially when vehicle access proves difficult. In the following case the client purchased two properties, a vacant stand and an existing house, in an exclusive real estate area. The house was demolished and extensive earth works carried out to prepare the site for the new house and build a driveway up to the level of the new garage. To achieve this, the engineers designed reinforced concrete retaining walls on both sides of the driveway. Above that level, Terraforce L11 retaining walls were used to a height of 9 m.

These were constructed on reinforced concrete foundations that were in turn held in position with anchors through the foundation. At predetermined positions, vertical reinforced concrete columns were incorporated into the blocks. These were in turn linked to another, horizontal reinforced concrete beam approximately halfway up the wall height, which was tied back with soil nails up to 7 m long into the benched embankment behind the walls.

Due to poor access to the site and to reduce the cost of removing and importing suitable fill material, it was decided to use the excavated decomposed granite material as backfill. To make this problematic fill work, it had to be reinforced with horizontal layers of restrain 50 geofabric placed at various levels in the backfill and locked into the L11 block-facing layer. To improve service access, various terraces were specified between walls, with stairways connecting them. Hardy creepers and ground covers were planted, and an irrigation system installed to ensure an even, green cover in a short space of time. ◻

Massive retaining wall project at FNB-Wesbank development

THE NEWLY COMPLETED FNB-Wesbank administrative centre in Fairland, Johannesburg, is a development which has generated considerable interest among construction professionals and members of the public alike, owing primarily to some highly innovative architecture used in its design by Kim Fairbairn of Continuum Architects (Pty) Ltd.

Having been built on a site with a marked and varied slope, it is a development which required extensive retaining wall support.

A total of eight retaining walls were built, some of which reached heights of 7,5 metres. These cover an area of some 3 000 m^2 and used close on 30 000 concrete retaining blocks (CRBs) in their construction. CRB walls are more cost-effective than conventional reinforced concrete walls and are considerably more attractive, facilitating as they do varying shapes and contours, as well as the growth of plants in the soil-filled blocks.

All the walls were built by Kalode Construction using INFRASET's Terrace Block retaining system, the one exception being an internal wall in the Basement 3, which was built using Concor Technicrete's Envirowall block system. This wall comprised a geogrid-reinforced fill structure built at 85° – the Envirowall block is best suited to this type of application.

The walls were built in two phases. Phase 1, which comprised the Basement 3 wall and the fire escape structured fill wall on the northern side of the project, was designed by John Joubert of Foundation and Slope Stability Engineering, and Phase 2, which consisted of the remainder of the walls, was designed by Herman Pietersen of Herman Pietersen and Associates.

Anyone visiting the site for the first time will immediately be confronted by a retaining wall at the Wilson Street entrance. Although not part of the FNB-Wesbank development per se, it was also constructed by Kalode Construction on behalf of Brian Wescott Construction. Completed in 2006, the wall was built on the southern slope of the feeder road which serves both the FNB-Wesbank development and Worldwear Shopping Centre adjacent to the FNB development. A pure gravity structure, the wall is 60 metres end-to-end and reaches three metres at its highest point.

Further evidence that retaining walls play a crucial role at this site becomes apparent at the gatehouse where 5 000 CRBs were used to create an attractive 80 metre wall. Once plants and flowers are established on this section of wall it will form an extremely attractive feature. The wall itself entailed a standard

design and installation. It rests on a concrete strip footing 200 mm deep by 600 mm wide, tops 4,5 metres at its apex, and for the most part, slopes at an angle of 70°. Blasting was necessary on parts of this section and the exposed rock face was covered with CRB blocks.

One of the more challenging CRB projects at the FNB site was a wall built to support a fire escape on the north-western side of the development. Seventy metres long and seven metres high, it was built at an angle of 70°. The fill in this wall is well compacted and reinforced with high strength polyester geogrids supplied by Kaytech . The fire escape sits directly on the structural fills and applies loadings on these fills of 150 kPa.

The wall built with Concor's Envirowall blocks is a vertical structure situated in the basement, which houses the building's fire fighting equipment. Approximately 14 000 blocks were used on this wall and Kalode were responsible for all the fills and the stabilising.

This wall was offered as an alternative to the originally proposed retaining wall as it was much more cost effective, by approximately 40%. Just on 100 metres long and reaching a height of 6,8 metres, the top half of the structure was reinforced with tensioned polyester geogrids which extend into the backfill. The bottom 2,5 metre section of the wall is constructed with a 5% cement-stabilised fill reinforced with tensioned polyester grids.

Kalode Construction managing director, Jan Pienaar, says Envirowall blocks were used on this wall as they are ideal for vertical structures that are heavily loaded. The bottom two metre section of the wall is cement-stabilised and soil-reinforced with stretched geogrids supplied by Kaytech. The top 4,5 metres is a conventional stretched soil reinforced structure with the blocks acting more as a facing than a structural element.

On the south-eastern and south-western section of the building a sunken wall 6,5 metres high and 93 metres long was built at a slope of 70°. A composite wall, it was constructed with a double skin up to a height of four metres and a standard geogrid reinforced fill was used above that to maintain the weight.

Another wall section, the south-western pod, was built around a staircase. It is also a composite structure in which cement-stabilised soils and geogrids, as well as plain geogrid-reinforced fills and terraced stepbacks were used to accommodate the staircase landings and to break the stark lines of a high CRB wall situated in confined surroundings. It is 125 metres long, varies between three and eight metres in height, and has a 70° slope.

All structures were built with adequate subsoil drainage consisting of clean stone wrapped in horizontally-laid Kaytape A2. Wick drains 250 mm wide were laid on the face of the exposed embankment and these act as sub-soil cut-off and collector drains.

INFO

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1 This 70 m x 7 m high retaining wall, built with INFRASET Terrace Blocks, supports a fire escape and is situated on the northern side of the FNB-Wesbank development in Fairland, Johannesburg

2 A 140 m x 7,5 m retaining wall built with INFRASET Terrace Blocks on the southern side of the FNB-Wesbank development in Fairland, Johannesburg

MASDAR INITIATIVE IN ABU DHABI FOCUSES ON ALTERNATIVE ENERGY SOURCES

A COMBINATION OF circumstances is leading to less reliance on petroleum products as the primary source of energy for the world: environmental concerns over global warming caused by greenhouse gas emissions, increased costs of oil, and the eventual depletion of the oil reserves. These driving forces have stimulated efforts at developing alternative energy sources – solar, wind, biomass, etc.

Oil rich countries have been slow to recognize that the demand and supply of their petroleum reserves is changing. At least one of the richest oil producing countries, sitting on some 10% of the proven reserves in the world, has recognized the impending developments and has chosen a strategic path forward. The emirate of Abu Dhabi in the United Arab Emirates (UAE) has taken action to invest a significant portion of its current oil revenues in developing alternative energy sources for the future.

The Masdar Initiative in Abu Dhabi is focused on developing alternative energy sources as an economic base for the future of the country. It includes the Abu Dhabi Future Energy Company, which is investing in exploiting current alternative energy technologies and the Masdar Institute of Science and Technology, which is developing graduate education and research programs to build human capacity for the future.

The Masdar Institute of Science and Technology is developing masters and doctoral programs, and research activities, relevant to alternative energy. It is to be housed in a green-zone new demonstration city which is designed for zero carbon emissions.

The Government of Abu Dhabi has established the Masdar Institute of Science and Technology to meet the exceptional and progressive goal of transforming its economy from one based on petroleum to one focused on sustainable technology and renewable energy. This new, private graduate Institute positions Abu Dhabi to make an historic transformation and to become a knowledge hub for global innovation.

Developed with the support and cooperation of the Massachusetts Institute of Technology (MIT), the Masdar Institute of Science and Technology (MIST) is an independent, not-for-profit, research-driven institution focused on science and technology. MIST will educate a workforce that will be prepared to compete in global markets and participate in research and development with an emphasis on alliances with global corporations and entrepreneurial opportunities.

MIT is assisting the Masdar Institute of Science and Technology in four integral areas: (1) joint collaborative research; (2) development of degree programs; (3) outreach that encourages industrial participation in research and development activities of MIST; and (4) support for capacity-building at MIST in terms of its organization and administrative structure, as well as scholarly assessment of potential faculty candidates for the Institute.

INFO

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HOT DIP GALVANIZING INDUSTRY ACKNOWLEDGED AT AFRICA ENERGY AWARDS 2008

THE HOT DIP Galvanizers Association Southern Africa (HDGASA) received

1 *Derek Watts, TV personality, and Emma Sayers, GM of Terrapin, hand Bob Wilmot of HDGASA the Africa Energy Award for the Best Environmental Rehabilitation Project*

the Award for the Best Environmental Rehabilitation Project at the Africa Energy Awards held on 16 April 2008.

The finalists in this particular category were the Vanilla Development Foundation in Kenya and the HDGASA, who submitted an entry on behalf of the hot dip galvanizing industry.

The hot dip galvanizing industry has for more than 50 years been a major supplier to the Southern African power distribution industry. It has been at the forefront of supplying the primary corrosion control requirements that are used to provide long-term service life and sustainability of a wide range of steel structures used in this sector. Power transmission lines, sub-station steelwork and numerous other ancillary steel installations throughout the Southern African region have been hot dip galvanized as the primary means of protecting steel structures that are subjected to the destructive corrosive elements present in a wide range of differing environmental conditions.

To win this award the entrant has to meet the category criteria, i.e. enhancing environmental benefits and meeting the government requirements of environmental rehabilitation. On receiving the award, Robert Wilmot, Executive Director of the HDGASA, said that zinc, used in the hot dip galvanizing process, is regarded as one of man's friendly metals as it is essential for all forms of growth, does not contaminate or harm the environment, and has the ability to provide long-term corrosion protection of steel structures at extremely economical life cycle rates.

INFO

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WORLD RIVERS DAY SET FOR 28 SEPTEMBER

WITH MANY OF the world's rivers facing severe and mounting threats associated with climate change, pollution, and industrial development, the British Columbia Institute of Technology (BCIT) and the Canadian branch of the United Nations (UN) Water for Life initiative are encouraging countries and conservation groups around the world to participate in this year's fourth annual World Rivers Day (WRD) on 28 September.

"Rivers are the arteries of our planet and yet many waterways continue to suffer from inadequate protection and inappropriate practices," says Mark Angelo, WRD founder and program head of the Fish, Wildlife and Recreation program at BCIT.

Angelo, a member of the Order of Canada and an inaugural recipient of a UN Award for Science, Education, and Conservation, initially founded the Rivers Day event in British Columbia before successfully lobbying numerous organisations and agencies of the UN to recognise WRD in 2005. Marking a global response to the need to better manage and conserve river ecosystems, WRD celebrates the many values of the world's waterways while encouraging appropriate action to better protect rivers and streams. The event is also intended to compliment the UN's worldwide Water for Life initiative.

Endorsed in its inaugural year by UN agencies such as the United Nations University and the International Network of Water, Environment, and Health, WRD events can and will include river clean-ups, fish enhancement projects, stream restoration initiatives, workshops, educational programs, and community riverside festivals. Last year events took place in countries ranging from Canada to England, Poland to the United States, Taiwan to the Congo, and from Togo in West Africa to the island of Dominica.

Founded by Angelo in 1980, British Columbia Rivers Day has since become a template for WRD with close to 100 000 people participating in British Columbia alone. WRD fosters an increased awareness of water-related issues and promotes core values associated with sustainability, conservation, and river stewardship.

All countries are encouraged to participate. For further information or to register an event, visit http://www.worldriversday.bcit.ca.

NEW FACET TO SA'S FAST-GROWING RECYCLING INDUSTRY

RECYCLING OF MATERIALS for reuse in South Africa is a fast-growing industry. Now a new facet has been added to the business – the recycling of slag.

The latest move comes from National Scrap Metals at Kuilsrivier, Cape Town, a company that is serious about protecting the environment and South Africa's natural resources. National Scrap Metals currently holds two international ratings, the ISO 14001 and the ISO 9001, and is working towards an ISO 18000 that may be awarded by the end of the year.

Major shareholders in National Scrap Metals are Murray and Roberts and the New Reclamation Group.

According to Adri Vosloo, general manager of National Scrap Metals, Cape Town, the company had recently purchased sophisticated equipment from Pilot Crushtec – a Finlay 663 Supertrak, which is a mobile track-mounted diesel-driven screening plant, and a Modular MJ1252 skid-mounted electric granulator jaw crusher, manufactured by Pilot Crushtec. He added that the facility is seen to be a 'pilot' operation that is expected to develop nationwide as investigations into possible uses of crushed slag continue.

The Kuilsrivier plant is currently processing 3 500 t/m of slag from the Murray and Roberts-owned Cape Town Iron and Steel, while additional material from a stockpile is also being fed into the system. Crushed slag is currently going to the construction industry to be used as filler and for road manufacture, as well as to manufacturers of specialised bricks. Interest in the product is growing, and sales are increasing.

National Scrap Metals had purchased modular crushing and screening equipment from Pilot Crushtec in 2003 as a trial with the purpose of extracting metal from an existing waste dump while crushing slag. The decision to upgrade was taken recently when growth in demand for crushed slag started to develop. Currently the new jaw crusher is being used to enhance the production of the modular plant that, together with the Finlay 663 Supertrak, is delivering products from very small to 50 mm. Vosloo says that production is flexible and different sizes of material can be provided to meet customer needs.

Nicolan Govender, national sales manager for Pilot Crushtec, confirms that the recycling industry is growing fast, especially in the Western Cape and Gauteng.

"We see more recycling taking place on site for material to be reused, to avoid increasing transport costs and the increased costs of dumping at waste sites. Strong growth is seen particularly in the construction industry, though mining in Southern Africa is now also focusing more on recycling."

According to Govender the Pilot Crushtec Modular MJ1252 skid-mounted electric granulator jaw crusher is a new model in the Modular range and two are already being used in the mining industry. More than 20 Finlay

1 *The Finlay 663 Supertrak delivers different sizes of crushed slag material to meet customer needs*

Supertrak models have already been sold into the recycling industry in South Africa.

INFO

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NEW WATERPROOFER TO THE AID OF SEAL PUPS

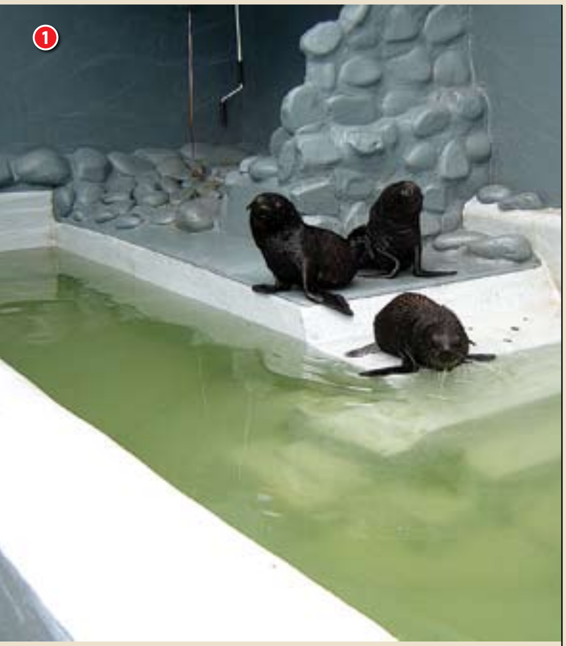
a.b.e. Construction Chemicals was recently approached by Seal Alert in Hout Bay for technical advice on an effective way of waterproofing the holding tanks in which seal pups, who had been washed ashore, are housed before being released to the sea.

Seal Alert rescues these day-old pups from the beaches after exceptionally high seas or culling had orphaned them. Once the seals have grown to a size where they are able to fend for themselves, they are released into the sea at Hout Bay where a few rafts are moored specifically for this purpose.

Dave Papayanni, Technical Sales Representative of a.b.e. Construction Chemicals in the Western Cape, says Seal Alert's one holding tank had already been waterproofed with a.b.e.'s Super Laykold waterproofing product. "But, although the product provided extremely effective waterproofing, the 'black' sealing system proved a problem. The depth perception of seal pups is poor, and the black colour aggravated this, resulting in them falling off the upper landing of the tank, injuring themselves."

a.b.e. donated a few cans of its new Fibrated Super Laycryl seamless waterproofer, which is produced in eight colours, to apply in a grey version to avoid the black appearance of the bottom of the tanks. Fibrated Super Laycryl is not designed for continuous immersion in water, but in the short term it has served the purpose of preventing injury to the pups.

"In fact," Papayanni added, "six months later, despite its total immersion in water,



1 *Some of the orphaned seals in their a.b.e. waterproofed holding tank at Hout Bay*

Fibrated Super Laycryl is still providing excellent waterproofing and the first batch of seal pups have now been successfully released into the ocean off Hout Bay."

a.b.e.'s Fibrated Super Laycryl is a water-based, fibre-reinforced acrylic, seamless waterproofer. It is suitable for waterproofing stable flashings, parapet walls, flat roofs, re-waterproofing over existing waterproofing systems, and the sealing of joints, laps and roofing screws.

INFO

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www.abe.co.za

THE SIMBITHI ECO-ESTATE PROJECT

THE 430-HECTARE Eco-Estate lies in the heart of KwaZulu-Natal's northern coastline. This natural coastal paradise has dense, indigenous riverine vegetation, lush valley wetlands, undulating hills and breathtaking vistas. But it was the intricate design which involved the maintenance of a 30 m buffer zone from the wetland area for conservation that made this project memorable. Louise Le Cordier from Makanyane Consulting Engineers describes the project:

"The first phase of the project was completed by Kwezi V3 Engineers and comprised approximately 1 000 units, made up of single residential and medium density residential sites linked by a network of internal roads. Makanyane Consulting received the green light for phases 2, 3, and 4, which comprised a further 434 units designed around an 18-hole executive short course. Although this project was extremely demanding, it was one of the most exciting projects to work on."

The dream team of this dynamic company consists of Louise, as senior partner, and her two fellow partners, Akram Khan and Gary Visser. Each member of the Makanyane team brings a unique set of skills which has created an unmistakable synergy and has led to the procurement of high-level contracts in short succession. The Simbithi Eco-Estate was one of the first projects that the company was awarded when it first opened its doors in 2004.

Every possible precaution was taken to minimize environmental impact during the completion of the Simbithi project. Various initiatives included geology and soil assessments, water resource and drainage appraisals, land use and vegetation studies, as well as aesthetic, historical and cultural appraisals to ensure that the development would be perfectly in tune with its natural surroundings.

According to Louise, the intricate project design was detailed with the help of infrastructure software design packages Civil Designer and AllyCAD. "We tested the software to the full during the extension of the Simbithi Eco-Estate on 60,63 ha, which accommodated 288 residential units, with a new service entrance and administrative centre for the estate. There was also the design of a new arterial road reserve that ran parallel to the N2, the relocation of all the existing overhead power lines to underground cables and the installation of the server mains to link to the existing bulk reticulation."

One of the biggest environmental challenges during the execution of the project was that a 30 m buffer zone from the wetland had to be maintained for conservation purposes. This placed considerable limitations on the design team, but was necessary to ensure that a strict code of compliance in the Environmental Management Plan was adhered to. According to Louise, a buffer surrounding the wetland served several functions: "A buffer would reduce the level to which pollutants and sediments directly enter the wetland, as some of these elements would be trapped before entering the wetland. It would also provide some adjacent natural habitat, which reduces the isolation (from other natural areas) to which many wetlands in urban areas are subjected."

Other advantages provided by a buffer include the fact that the value of a wetland for supporting biodiversity is derived not only from the quality of habitat contained within the wetlands, but also from the linkages it has with other natural areas, because many wetland-dependent species move between wetland and non-wetland habitats. Without a buffer, it becomes increasingly difficult to carry out necessary management practices in the wetland, and it also reduces the proximity of human presence which directly disturbs wildlife.

The Environmental Management Plan, which had to be approved prior to construction, made provision for strict requirements. The Plan made allowance for the downstream maintenance of the ecological reserve, and in addition, the water quality could not be adversely impacted during the construction of the proposed dam walls, which had to be designed to include a diversity of habitats for fish and wading birds. Also, soil erosion on site had to be prevented, or where applicable, controlled at all times. Other considerations included the replacement of the existing gum plantation with indigenous vegetation during the execution of the project.

A high level of community interaction amidst the numerous environmental restrictions added further complexity to the project. Louise mentions that provision was made for public participation at an early stage already. This involved numerous public meetings to discuss and address concerns by members of the community. One of the concerns raised had to do with the valleys and wetlands which had previously been planted with sugar cane. In these cases the grasslands and coastal forest were rehabilitated and indigenous game

1 *Louise le Cordier – senior partner, Makanyane Consulting Engineers*

species reintroduced. Louise notes that, since the planting of indigenous vegetation to rehabilitate the site, the entire area has been enhanced.

Long-term strategies had also been included in the program. "Rather than exclusively planting indigenous trees and excluding fire in all the wetland areas, thereby encouraging the wholesale extension of swamp forest, the Environmental Management Plan prescribed that herbaceous areas should be maintained on the site. In order to do so, a burning program, as well as a controlled grazing program, was drawn up for these areas to contribute to the promotion of habitat heterogeneity within the herbaceous wetland areas."

Despite the many challenges on the project, the well-known Simbithi Eco-Estate will continue to set the footprint that other eco-estates are likely to follow, making it a landmark project.

INFO

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SA BUILDERS TO MEET AMIDST SEVERE CHALLENGES

THE MASTER BUILDERS South Africa (MBSA) 2008 annual congress in Port Elizabeth in September will be held against a backdrop of one of the most critical stages in the history of the South African building industry.

Eunice Forbes, president of the MBSA, says the upsurge in activity in the building sector over the last two years has substantially challenged the industry and highlighted the crippling shortage of skilled artisans. She feels that the industry has to drastically improve its training programs to cope with the demands not only of the 2010 Soccer World Cup, but also the more general growth projects which should continue long beyond 2010.

"MBSA also strongly feels that the necessary exit clauses for imported labour should be put in place to ensure that South Africans are not excluded from jobs after the Soccer World Cup. The potentially devastating effect of AIDS on our already precarious workforce also needs urgent attention," she stresses.

Pierre Fourie, CEO of MBSA, says the building industry is now under unprecedented pressure to preserve environmental resources and lessen its negative impact on the planet. "The restrictions and conditions of the 'Green Building' wave sweeping the world have already reached South Africa, where the building industry still has much to do in this regard. The building industry also has the power supply crisis to contend with. The opportunities for national networking and decision-making toward unified solutions offered by this congress come at a vital time for our sector."

The MBSA 2008 congress will be held at the Boardwalk Conference Centre in Port Elizabeth from 21 to 23 September. Guest speakers already secured include Thoko Didiza, the Minister of Public Works; Neil Cloete, MD of Grinaker-LTA; Pepi Silinga, Chief Executive of Coega IDZ; Samuel Isaacs of the South African Qualifications Authority; Aubrey Matshiqi of the Centre for Policy Studies; Daniel Silke, futurist; Claire Deacon of Occumed; and André Fourie of the National Business Initiative.

The annual MBSA National Safety

1 *Port Elizabeth's The Boardwalk Conference Centre will be the venue for the 2008 MBSA Congress*

Competition awards will be made after the congress which will also feature a display of building material, and suppliers' products and services.

INFO

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DEMAND FOR C&CI TRAINING SOARS IN MIDST OF BUILDING BOOM

THE CEMENT & CONCRETE Institute's School of Concrete Technology is experiencing unprecedented demand for its services as the South African construction sector tries to cope with a shortage of skills in the midst of a building boom.

According to Bruce Raath, C&CI Education and Training Manager, the School of Concrete Technology exceeded the projected student numbers and income for the first four months of this year. Raath says that not only are all planned courses well-attended – and in many cases over-subscribed – but the demand for unscheduled courses has also increased, stretching the availability of venues and lecturers to capacity.

The projected number of student days for the first four months of 2008 had been around 800 whereas the actual days reached almost 1 200.

1 *Training in progress at the C&CI School of Concrete Technology. The School is experiencing exceptionally strong demand for training*

Raath ascribes this upswing in training (which has been noticeable for the past 18 months) to the urgent need for skills, the extremely busy construction sector and, in the case of professional staff, the need to accumulate Continuing Professional Development (CPD) points.

C&CI has also announced that it will step up its involvement in tertiary education in South Africa to ensure the future of the engineering profession and to increase awareness of concrete as building material. For the remainder of 2008, C&CI will concentrate on universities and, from 2009, universities of technology will also be included.

An educational program of lectures, laboratory work and site visits is already under way for 165 second year Construction Management students at the University of the Witwatersrand, with a program aimed at second year Wits Civil Engineering students also in place. Similar educational packages are planned for around 100 second year civil engineering students from the University of KwaZulu Natal during the second half of this year.

INFO

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ARCUS GIBB ACQUIRES AFRICAN CONSULTING ENGINEERS

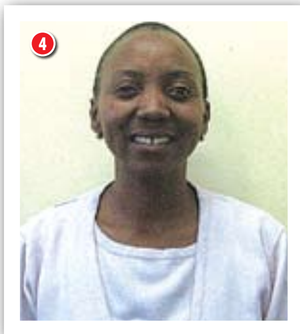
ARCUS GIBB Holdings have purchased African Consulting Engineers, trading as GIBB Botswana and GIBB Swaziland. This purchase gives ARCUS GIBB Holdings the licensing rights to the GIBB trademark exclusively in a number of African countries. It also brings together all the GIBB operations in the SADC region under a single owner, i.e. the ARCUS GIBB Staff Trusts representing ARCUS GIBB employees.

The acquisition is in line with ARCUS GIBB's strategy to grow the company into the rest of the continent, whilst using their well established GIBB brand. Botswana's state of business is very healthy and ARCUS GIBB will be able to run successful projects there for several years. Operations in South Africa will also continue to benefit from projects in these countries, as some members of staff are involved with projects like the Thune Dam, the Gaborone Sewers, and road upgrades. Vernon Joubert will continue in his role as Managing Director of the Botswana Operations, reporting directly to CEO Richard Vries.

ARCUS GIBB CEO Richard Vries says, "We want to take the opportunity to welcome the Botswana and Swaziland staff as they now become fully integrated into the GIBB Group. We also hope that, through this acquisition, we have created more opportunities for all our staff members to work on exciting projects throughout the region."

1 *Richard Vries (CEO ARCUS GIBB) concludes the purchase transaction with Richard Gordon of African Consulting Engineers*

People



1 Arthur Taute
2 Dr Tom Marshall
3 Cecil Rose
4 Lintle Maliehe
5 Gillian Wayman

Top management changes at Vela VKE

Arthur Taute has stepped down as CEO of Vela VKE to take up his new role as Managing Director of VKE International and head of the IT Division. In his place Dr Tom Marshall, who has been with Vela VKE for 26 years, has been appointed CEO. He was previously head of the Development Division and Chief Operating Officer, and is on the Board of Directors.

Arthur Taute became CEO of VKE in 1998. Under his leadership VKE experienced substantial growth and economic success, and was transformed to an employee-owned firm with more than 150 shareholders. Black management in the firm was enhanced dramatically and black ownership increased to 31%. As a symbol of the transformed nature of the firm, the name was changed to Vela VKE and a new logo was adopted. During Arthur's tenure VKE ventured into the USA where an office was opened in Atlanta, later moving to Portland. Arthur is enthusiastic about the future of Africa and believes that the continent has the human capacity to become an economic force to be reckoned with.

Cecil Rose appointed to CIDB

Cecil Rose, who had served as president of the South African Association of Consulting Engineers in 2006-2007, and who is also a member of SAICE's Western Cape Branch, was recently appointed by the Minister of Public Works as Deputy Chairperson of the Construction Industry Development Board (CIDB). This appointment comes at a time when CIDB activities are beginning to impact more on the professional sector. The CIDB is currently developing a register of Professional Service Providers which would include architects, consulting engineers and quantity surveyors who wish to do work for the state or any of its entities. With this appointment Cecil joins a number of prominent SAICE members who have been, or still are, active within the CIDB leadership. Of particular note in this regard are four previous presidents of SAICE, namely Brian Bruce, Rodney Milford, Trueman Goba and Sam Amod.

Spending time in Nigeria

ARCUS GIBB has been appointed by the Rivers State Government to prepare a Development Plan for the redevelopment of Port Harcourt, Nigeria, as well as the design of the first phase of a new city providing up to 20 000 housing opportunities.

Lintle Maliehe and Gillian Wayman were accepted as Local Resident Project Coordinator and Coordinator's Assistant respectively, and will remain in Nigeria until February 2009. Together the two women, who have been in Nigeria since 1 May of this year, are responsible for the smooth running of the Port Harcourt project. Lintle joined ARCUS GIBB in May 2007, while Gillian Wayman has been with ARCUS GIBB for over 15 years. □

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NSTF Awards' tenth birthday – and a present for SAICE

DURING AN ILLUSTRIOUS gala dinner, which marked the tenth birthday of the National Science and Technology Forum (NSTF) Awards, various individuals and groups were honoured for their outstanding contributions towards scientific, engineering and technological (SET) development during 2007. The Minister of Science and Technology, Mr Mosibudi Mangena, who is also the patron of the NSTF, presented the awards. Winners were selected from more than 70 nominations. The event is unique in that it affords an opportunity for recognition to all practising scientists, engineers and technologists across the spectrum of innovation, including, for example, teachers and students in mathematics, science and technology.

Denis Hunt, the chief adjudicator explained the theme, *Today's research – Tomorrow's innovation*, and emphasised the contribution that dedicated individuals, either working by themselves or as part of an organisation, can make towards improving the quality of life for current and future generations. It is clear that South African SET is on a par with global standards. It is also important to take note that great innovation is only really achievable through people. South Africa can be proud of the NSTF Awards winners and nominees.

1 Minister of Science and Technology Mosibudi Mangena, Allyson Lawless, Lulu Khumalo (BHP Billiton)

2 Minister of Science and Technology Mosibudi Mangena, Prof Fred Hugo (University of Stellenbosch), Debbey Cromhout (Executive Director TRAC), Ephraim Baloyi (Dept Trade and Industry)

ALLYSON LAWLESS

It was with great joy that we witnessed SAICE's Allyson Lawless winning in the category for 'Activities other than research and its outputs over the last five years or less'.

During her year as the first lady president of SAICE in 2000, Allyson became acutely aware of the skills shortage in the civil engineering profession and undertook a project across the country, which covered interviews, questionnaires and

continued on page 79

SAICE at work in Parliament

THE PARLIAMENTARY PORTFOLIO Committee on Water Affairs and Forestry called for submissions on "water quality and pollution challenges facing South Africa". Hearings were held over two days at Parliament in Cape Town. Presentations were made by a number of bodies – such as the CSIR and Eskom, DWAF, a number of municipalities, and activist groupings. Dr Kevin Wall, president of SAICE in 2001, made a presentation on behalf of SAICE.

He started the presentation by describing the water cycle, the water services delivery process, and the integrated nature of this process. Hence, he said, the delivery results would only be as strong as the weakest links in that process. Drawing on the findings of SAICE (such as in the infrastructure report card) and of other organisations (in particular of the CSIR), he sought to show that the weakest link was more often than not in respect of skills, followed, some distance behind, by both finance (budget constraints in particular) and the management and leadership of the water services institution.

He outlined the main water-related legislation and strategies, saying that these were good, but that the problem lay in implementation.

As befits a learned society, SAICE had put a lot of effort into understanding the issue of skills. He presented the results of surveys, undertaken in particular by Allyson Lawless, and ran through a number of matters of concern, including the need to rebuild civil engineering capacity, and to outsource, both of which require capacity in the water services institutions.

Kevin concluded by outlining the various programs of SAICE, in particular ENERGYS, and by pleading that elected representatives treasure their engineering personnel, and listen to their advice! And if there was one thing outside the water sector, and hence outside the purview of the Portfolio Committee, that the committee members could nonetheless, as MPs, try to influence, it should be to do what they can to improve the primary and secondary education system.

The presentation was followed by discussion and questions from the committee members. The chairperson, Ms Connie September, concluded by sayng that she would welcome further submissions, and a continuation of the "ongoing relationship that she enjoyed with SAICE." ◻

▶ Kevin Wall presenting Ms Connie September (MP and Chairperson of the Portfolio Committee on Water Affairs and Forestry) with a SAICE Outreach pack. Looking on is Lemias Mashile (MP and SAICE Council member).

We welcome a new editor!

TEN YEARS AGO Verelene de Koker joined SAICE's staff as the SAICE frontline contact - the voice on the switchboard. Prior to that she had been administering SAICE's SPEBS bursary scheme from home for a number of years. She continued administering the scheme as part of her regular office duties until 2005 when the administration of the scheme was outsourced.

At the beginning of 2001 Verelene moved to the Communications Department where her main task was serving as secretariat for the SAICE magazine and journal. In this position she honed her already formidable writing skills and gained extensive experience in the general management of the magazine and journal. In the process she also built up an effective network of SAICE contacts.

Verelene's appointment to the position of editor brings the magazine back in-house, after a spell of close on forty years, during which time SAICE's editor had always been a contractor based outside the National Office structure. This move, incidentally, brings to fruition an idea that had been mooted more than eight years ago, namely that SAICE should strengthen its editorial position by fostering closer links with its constituents.

Welcome to the editor's chair Verelene!

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News snippets on Loading Code

REVISED "LOADING CODE" TO BE RELEASED FOR COMMENT BY PROFESSION

The SAICE Working Group will complete final revisions to the new SANS 10160: *Basis of structural design and actions for buildings and industrial structures* by the end of July. It is intended that the revised code should be available for comment by the profession in October 2008.

The code, commonly referred to as the "loading code", has been substantially updated since the last revision of its predecessor SABS 0160 in 1993. These updates bring the code in line with ISO reliability standards and achieve substantial compatibility with the Eurocodes. The sections on basis of design, wind actions, crane induced actions and seismic actions have been extensively revised and a new section on the basis of geotechnical design has been added.

Following approval of the Committee Draft by STANSA sub-committee SC5120.61M, the draft standard will be posted on the SABS web site where it will be open for review and comment by the profession for a period of 60 days. After consideration of the comments received and necessary amendments to the draft, the final document will be issued as a South African Standard early in 2009.

A series of seminars are to be held throughout the country during which the revised code will be presented to the profession. The intention of these seminars is to highlight the changes made to the code and the background to these changes. Provisional dates and venues for these seminars are as follows:

7th October 2008 Port Elizabeth
Summerstrand Hotel
9th October 2008 Cape Town
Belmont Conference Centre
14th October 2008 Durban
KZN Master Builders Association
16th October 2008 Gauteng
Eskom Conference Centre

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GEOTECHNICAL DIVISION'S POSITION ON A SA GEOTECHNICAL DESIGN CODE

On 22 May 2008, geotechnical designers from around the country met at SAICE's offices in Midrand to discuss the way ahead for the implementation of a South African geotechnical design code. The discussions were prompted by the provisions made in the revised SANS 10160: *Basis of structural design and actions for buildings and industrial structures* for geotechnical design and the compatibility of this code with the Eurocodes.

Three possible courses of action were debated at the meeting. These were:

1. Adopting EN1997-1 (Geotechnical Design – General Rules) as a South African design code. This will entail writing what amounts to a South African National Annex to the code.
2. Writing a South African design code based on SANS 10160 and EN1997. This code would contain only those aspects of the Eurocode relevant to South African conditions.
3. The *laissez-faire* approach. This is effectively the current situation where, in the absence of a geotechnical design code, designers use whatever design method is best suited to the problem at hand.

Option 3 above was seen as the easy way out but does not hold any benefits for the profession.

The meeting acknowledged that drafting a South African design code would be beneficial. The new code would be a practical design code, relevant to South African conditions, written by engineers for engineers. The main drawbacks are the amount of time required to write such a code and that it would be difficult to write a code of this nature before the profession has more experience in the use of limit states design in geotechnical engineering.

The meeting agreed that geotechnical designers should be encouraged to use EN1997-1 in conjunction with SANS 10160 over the next few years. Thereafter, a more informed decision can be taken whether to adopt or adapt EN1997-1 or another international design code. This agreement was ratified by the Geotechnical Division Committee during their meeting later on the same day.

Anyone interested in participating in such a programme of trial implementation of EN1997-1 is welcome to contact the Geotechnical Division for further information.

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SAICE Student Chapter UCT

Committee members of the SAICE Student Chapter at the University of Cape Town From left to right: Bruno Salvoldi (treasurer), Maksotsene Makgalemele (outreach), Lydia Holze (deputy chair), Michael Vice (chair), Charles MacRobert (secretary), Cheri Hobson (events manager)

THE SAICE STUDENT Chapter located at the University of Cape Town caters for the needs of all civil engineering students who would like to extend their interest in their chosen profession. The student chapter committee endeavours to facilitate talks and discussions with men and women representing different environments within the civil engineering profession, as well as with professionals from related fields who have an influence on the engineering profession in and around Cape Town.

A previous talk on "What to expect on your first day of work, as a civil engineer" gave students an idea of the day to day operations in a civil engineering design office and on the contractor's playground. Students were briefed on this topic by Jeffares & Green executive associate, Chris Wise, who is also a UCT civil engineering alumnus.

Talks planned for the future include a briefing by Highveld PFS on graduate recruitment, financial consulting, tax information, and financial benefits analysis. These talks would give students a perspective on aspects of their chosen profession that are not taught in the more 'science based' class environment. Through these talks students are exposed to the working world and the realities of financial benefits and work packages. A 2010 soccer world cup presentation has also been planned for the near future, which promises to attract many eager students.

The Civil Engineering Department at UCT caters for some 350 undergraduate and postgraduate students of whom 240 are currently SAICE student members. Students have responded positively to this fairly new initiative, which is encouraging, given that the chapter is only in its second year of operation. Students may also participate in the monthly presentations of the SAICE Western Cape Branch. These are often very educational and encourage deeper learning. □

BKS-SAICE 'Take a girl-child on site'-day

IN 2007 SAICE and BKS took the liberty to change Cell C's 'Take a girl-child to work' day to 'Take a girl-child on site' day in support of the Cell C initiative. Earlier this year, 30 girls from the Umqhele Comprehensive School in Ivory Park, Midrand, were taken to the BKS construction site at UNISA to show them what civil engineering is all about. In the photo structural engineer Kim McKenzie from BKS briefs the girls. Earlier in the day the girls attended presentations on civil engineering projects, where they also learnt what infrastructure is, why it should be maintained, and why the country needs civil engineering professionals. SAICE and BKS hope that this initiative will be adopted country-wide as a way to expose learners to the civil engineering profession and inspire them to consider the profession as a career. □

CPUT student receives SAICE award

THE DEPARTMENT OF Civil Engineering and Surveying at the Cape Town campus of the Cape Peninsula University of Technology held its annual award ceremony earlier this year where prizes were handed to deserving students for their achievements during 2007. Here Taryn Jones receives the SAICE award for best third year student from Alan Proctor, course head in Civil Engineering. Taryn also received the trophy for the best student in all three years of the National Diploma in Civil Engineering. □

continued from page 75

workshops for and with students, graduates and other sources of input. This culminated in the publication of 'Numbers and Needs: Addressing Imbalances in the Civil Engineering Profession' and a second, similar analysis of the local government situation. These have changed perceptions regarding scarce skills in South Africa where for the first time the extent of the engineering skills shortage has been measured and published. The work is frequently quoted when the topic is addressed at the highest level. The interventions suggested in the books are being very successfully implemented, e.g. through the ENERGYS project for which purpose SAICE established a section 21 company. UNESCO has proposed that the work should serve as a model for studies in other African countries, as well as in certain first world countries.

TRAC

We were equally delighted when another civil engineering-connected winner was announced, this time in the category for 'Innovation developed through an NGO/Not-for-Profit Organisation (NPO) or Community Based Organisation (CBO)'. The award went to the Technology Research Activity Centre (TRAC) Programme of SET Education Support of the Department of Civil Engineering at the University of Stellenbosch.

TRAC South Africa is a national, non-profit programme, the objective of which is to support physical science, mathematics, and technology education in South African secondary schools. The TRAC Programme seeks to enable and encourage learners to enter into careers in science, engineering, and technology. TRAC is also involved in education intervention programmes, where the main aim is to uplift the standard of physical science education in South Africa. This is done with educator training programmes, vocational guidance assistance, as well as classroom intervention in schools where the resources are limited or lacking. The TRAC emblem has become a familiar hallmark in the endeavour to improve

TRAC South Africa is a national, non-profit programme, the objective of which is to support physical science, mathematics, and technology education in South African secondary schools

what is being done to enhance science and mathematics amongst school learners, especially in the rural areas. In 2006, in excess of 68 000 learners were exposed to the TRAC programme, while during 2007, 109 000 learners were exposed to the programme and 2 831 teachers were trained by TRAC.

Prof Fred Hugo, who served as SAICE president in 1993 and who is the 'father' of TRAC, received the award together with TRAC Executive Director, Debbey Cromhout.

To Allyson and the TRAC team – please accept our heartiest congratulations! ◻

Date	Event and CPD validation number	Presenters/venue	Contact details
06–13 September Bedfordview 08–14 November Bedfordview 06–12 December Bedfordview	The Application of Finite Element Method in Pratice *SAICEstr06/00018/08*	Roland Prukl	Dawn Hermanus dhermanus@saice.org.za
17–19 September TBA 6–8 October Midrand 4–6 November Heidelberg 2–4 December TBA	Engineering & Construction Contract *SAICEcon07/00201/09*	Chris Wentzel	Cindy cindy@tcq.co.za
26–27 August Polokwane	Technical Report Writing *SAICEbus06/00014/08*	Les Wiggill	Sharon Mugeri cpd.sharon@saice.org.za
27–29 August IIR House Rosebank	Practical Masterclass in Engineering Procurement & Construction Management *ProvSAICEot08/00316/08*	Various presenters www.iir.co.za	Carmen Spence cspence@iir.co.za
8–9 September TBA	Engineering and Construction Short Contract *SAICEcon08/00311/11*	Chris Wentzel	Cindy cindy@tcq.co.za
23 September Howick, KwaZulu-Natal	Bulk Transport Optimisation symposium	Various presenters	Prof. Carel Bezuidenhout bezuidenhout@ukza.ac.za 033 260 5703
24–26 September Langebaan	SAICE Transportation Division Quadrennial	Various presenters	Carla de Jager info@carlamani.co.za
06–07 October Polokwane 13–14 October Port Elizabeth 11–12 November Gauteng 24–25 November Gauteng	Business Finances for Built Environmental Professionals *SAICEfin06/00004/08*	Wolf Weidemann	Dawn Hermanus dhermanus@saice.org.za
08–09 October Polokwane 15–16 October Port Elizabeth 06–07 November Gauteng	Handling Projects in a Consulting Engineer's Practice *SAICEproj06/00003/08*	Wolf Weidemann	Dawn Hermanus dhermanus@saice.org.za
22–24 October Gauteng 29–31 October Durban 12–14 November East London 19–21 November Cape Town	Annual Workshop on the newest version of USEPA SWMM5 and PCSWMM.NET *SAICEwat06/00090/09*	Professor William James & Chris Brooker	Kathy Holland admin@computationalhydraulics.com
27–31 October Gauteng	Tailings Course 2008 *SAICEot07/00232/10*	Beric Robinson	bericr@fraseralexander.co.za
24–26 November Cape Town	2nd International Conference on Concrete Repair, Rehabilitation and Retrofitting	www.civil.uct.ac.za/iccrrr	iccrrr@eng.uct.ac.za +27 21 689 7471

For more information on courses, venues and course outlines please visit **http://www.civils.org.za/courses.html** or contact **cpd.sharon@saice.org.za**

Chapter 3
Background on the Eastern Basin and the Blesbokspruit

Abstract This chapter provides background on the eastern basin with special focus on the significance of the Blesbokspruit. It describes the East Rand in the Gauteng Province. The intricate nature of the Blesbokspruit is presented and how dependent various stakeholders who reside or work in the eastern basin are on this watercourse. The Blesbokspruit wetland was named a Ramsar site in 1986 and it underwent extensive transformation due to industrial development over the years and the resultant ecological damage, which led to it being placed on the Montreux Record. The chapter then sets out the non-statutory bodies contributing to the governance of the Blesbokspruit by explaining the role of the Blesbokspruit Forum and Blesbokspruit Trust, which include members of various spheres of government that are responsible for managing the Blesbokspruit. A brief section on the research methodology is included.

Keywords East Rand · Eastern basin · Blesbokspruit wetland

3.1 Introduction

This chapter provides background on the eastern basin with a special focus on the significance of the Blesbokspruit. It begins by describing the East Rand in the Gauteng Province. The East Rand was known for its abundance of mineral resources and had become highly lucrative since the 1940s, which brought many people to the area. However, the many profitable years of mining had a detrimental role on the environment of the eastern basin and specifically the Blesbokspruit. The intricate nature of the Blesbokspruit is presented as well as how dependent various stakeholders who reside or work in the eastern basin are on this watercourse. The Blesbokspruit wetland was named Ramsar site in 1986, and it underwent an extensive transformation due to industrial development over the years and the resultant ecological damage, which led to it being placed on the Montreux Record (explained in Sect. 3.4). The chapter then sets out the non-statutory bodies contributing to the governance of the Blesbokspruit by explaining the role of the Blesbokspruit Forum

S. Naidoo, *Social Constructions of Water Quality in South Africa*,
https://doi.org/10.1007/978-3-030-98237-9_3

and Blesbokspruit Trust, which include members of various spheres of government that are responsible for managing the Blesbokspruit. A brief section on the research methodology is included.

3.2 The East Rand

The wider Witwatersrand, of which the East Rand forms part, is the most densely populated region in South Africa. This area has a Highveld summer rainfall that occurs between November and April, with the average annual rainfall varying between 650 mm and 950 mm (Hawley and Desmet 2020, p. 10). The East Rand is prone to extremely low temperatures during the winter season but has hot summers. The East Rand (Fig. 3.1) includes the towns of Boksburg, Brakpan, Benoni, Springs and Nigel, which all fall within the jurisdiction of the City of Ekurhuleni (CoE) in the Gauteng Province (Digby Wells Environmental 2015, p. ii). This book is mostly centred on Springs, where the eastern basin acid mine drainage (AMD) treatment plant is situated. The CoE covers an area of approximately 1975 km^2 (Hawley and Desmet 2020, p. 1), and the surface water in the CoE is made up of several dams (e.g. Cowles and Nigel dams) and streams, which include the Blesbokspruit.

Many of the towns on the East Rand, such as Springs, came into existence through mining activities. Some of the black townships in the CoE, such as Daveyton, Kwa-Thema, Duduza and Tsakane, were established to create a residence for the mineworkers (Labuschagne 2015, p. 11). The increased number of people residing in the area is due to the employment opportunities that mining created. However, this also led to social risks such as the insufficient supply of clean drinking water and safe sanitation. It sounds contradictory that Ekurhuleni, translated as a 'Place of Peace',[1] has environmental problems that mostly stemmed from people's excessive need for, and use of, water.

The East Rand is home to numerous important agricultural areas scattered across the region, and agriculture is known as the sector that requires the largest volumes of water (Environomics 2014, p. 18). The largest use of land (Fig. 3.2) is in the built-up urban group, accounting for 37%, cultivation agriculture covering 14% of the CoE, and mining accounts for 3% of land use (Hawley and Desmet 2020, pp. 20–21). Owing to growing business, the East Rand is described as a sanctuary for agricultural and mining activities and is proven to be unequivocal in the development and economic growth of South Africa. The East Rand is largely modified by urban, mining and agricultural development, and the CoE still supports threatened biodiversity and important ecological infrastructure within the grassland biome, which offers a variety of ecosystem services (Hawley and Desmet 2020, p. 1). Historical mining activity created a few lakes on the East Rand – such as Benoni, Boksburg and Germiston – which were used to supply the mines with water, before the Vaal Dam

[1] The Tsonga word 'Ekurhuleni' means 'Place of Peace' (South African Cities Network 2019).

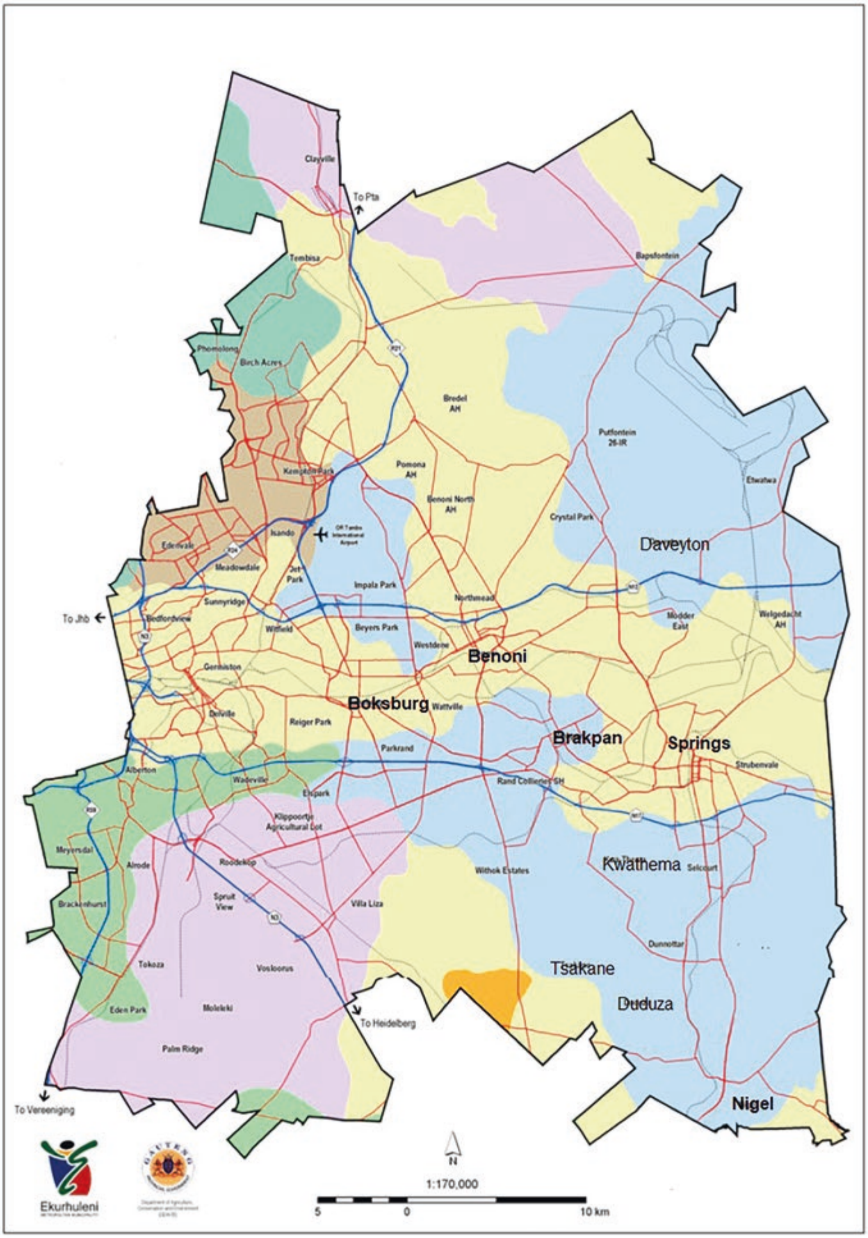

Fig. 3.1 Map of the East Rand. (EMM 2007b, p. 7)

was developed, and these lakes now serve recreational purposes (Labuschagne 2015, p. 1). These surface water areas act as sanctuaries to a substantial amount of South Africa's biodiversity and are threatened by grassland biomes (Labuschagne

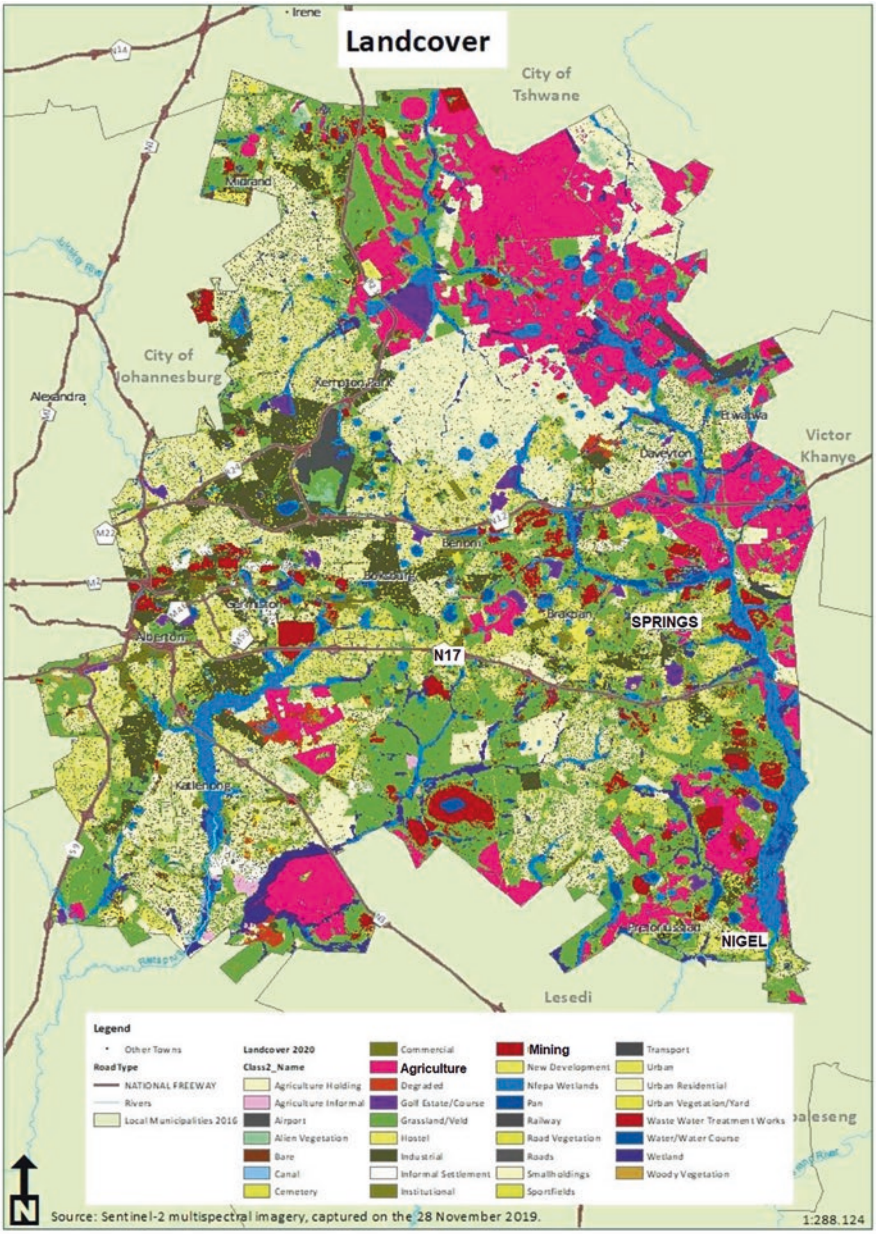

Fig. 3.2 Land use on the East Rand. (Hawley and Desmet 2020, p. 22)

2015, p. 1). However, because of the substantial degree of alteration of the natural landscape, most of the remaining ecosystems on the East Rand are threatened. These threats arise from the fact that the various uses of water for human purposes, such as agriculture, industry or for urban use, exceed the amount of renewable water available (Molle et al. 2007, p. 585). Molle et al. (2007, p. 585) suggest that this leads to over-commitment of the water resource due to users not accounting for environmental water requirements, lack of hydrological knowledge, uncertain water rights or poor governance, resulting in more water being used than the system (environment) can allow.

Labuschagne (2015, p. 1) notes that South Africa is known as a treasure house due to its valuable minerals. Its comparative advantage in terms of mineral endowment has not translated into an economic competitive advantage due to numerous challenges facing the mining industry. The industry is continually working on addressing these challenges to maintain and reserve its space in the global market, while addressing national and community needs (Neingo and Tholana 2016, p. 283). However, as illustrated in Fig. 3.2, there is little available land around the Blesbokspruit system to accommodate new economic development, especially since there are a few areas that have little or no impact already on the East Rand. There is a “significant challenge to densify and redevelop existing built-up areas, as well as old mining and other land that is no longer used optimally” (EMM 2007a, p. 5).

For the sake of clarity, it is important to explain the terminology used in this book, and therefore to distinguish between the East Rand, the eastern basin, the Blesbokspruit Wetland and the Blesbokspruit catchment. The East Rand is a group of towns, which fall under the CoE’s jurisdiction. The East Rand can be differentiated from the eastern basin (see Fig. 3.3); a *basin* refers specifically to a river

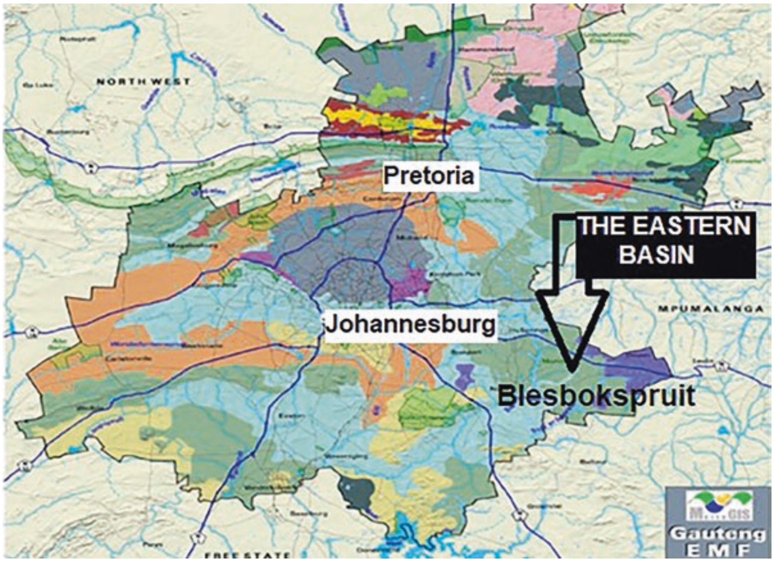

Fig. 3.3 Location of the Blesbokspruit and the eastern basin in the Gauteng Province. (Environomics 2014, p. 11)

drainage system, an area of land drained by a river or its tributaries (Milwaukee Riverkeeper 2015). Mining resources were found in this basin. Thus, mining overlaps with the geographical area, indicating that there can be residential areas situated where mining activity is taking place, as in the case of the eastern basin.

The Blesbokspruit catchment forms part of the eastern basin, which is on the East Rand, within the Upper Vaal Water Management Area, which is one of the water management areas that have been identified in the National Water Resource Strategy of South Africa (du Plessis et al. 2014, p. 2950). The Blesbokspruit catchment (see Fig. 3.4) drains an area of almost 1000 km^2 and functions within the Vaal

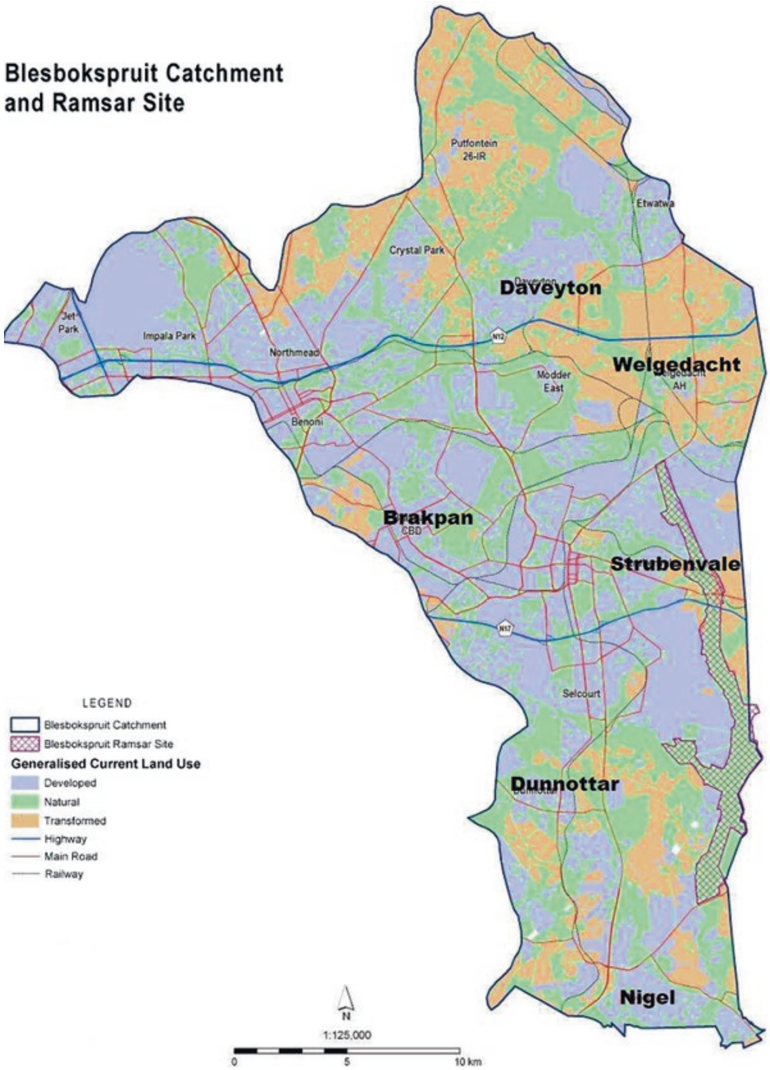

Fig. 3.4 Blesbokspruit catchment. (EMM 2007b, p. 18)

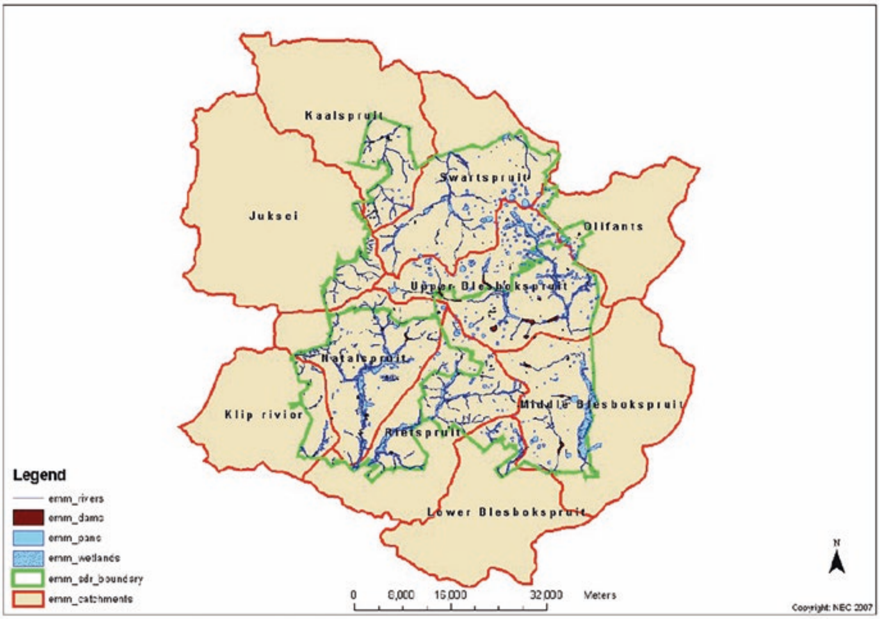

Fig. 3.5 Catchment management areas in the City of Ekurhuleni. (EMM 2007b, p.14)

Barrage and Vaal Dam catchments of the Upper Vaal Water Management Area. The Blesbokspruit (see Fig. 3.5) is managed by a catchment management agency, which aims to achieve effective communication with all stakeholders in the water management area to formulate and implement a catchment management strategy. Catchment management is achieved through the Blesbokspruit Forum (discussed in Sect. 3.5.1) (Blesbokspruit Forum Charter 2003, p. 2; RSA 1998). The Blesbokspruit is the watercourse that is the focus of this book. For the purpose of the book, the eastern basin is referred to because of the relevance of mining and its impact on the water quality of the Blesbokspruit. Depending on the context, the term Blesbokspruit catchment is used when referring to the management of the water, and the term Blesbokspruit wetland or river is used when referring to the uses of the water.

3.3 The Eastern Basin

The *eastern basin* – also referred to as the East Rand basin (see Fig. 3.6) – refers to the mining-related areas to the east of Johannesburg, and the term is used in the context of dealing with AMD on the Witwatersrand. This terminology is based on the three underground mining basins, namely (1) eastern, (2) western and (3) central established on the Witwatersrand after the discovery of gold in 1886 (Adler et al. 2007, p. 34). The discovery of gold is attributed to George Walker and George

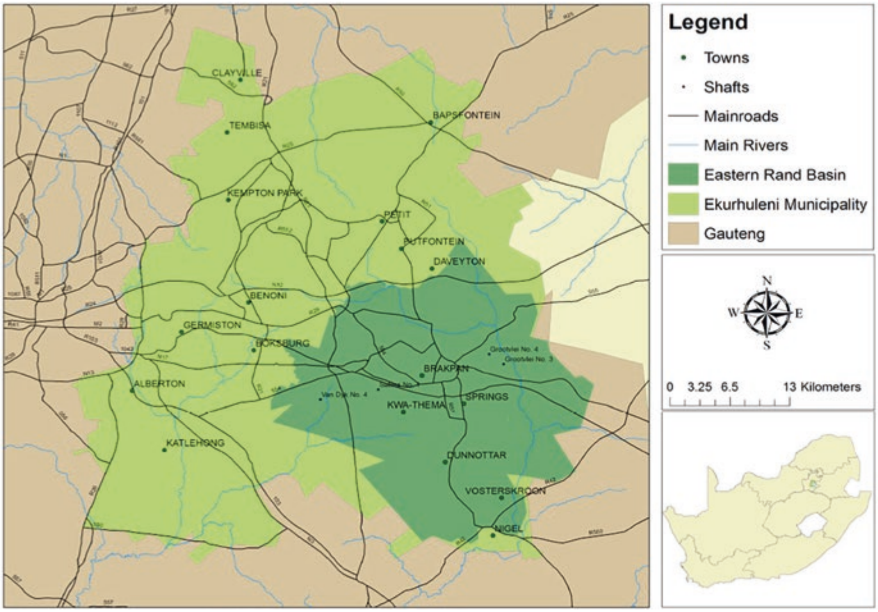

Fig. 3.6 The eastern basin in the Gauteng Province. (Labuschagne 2015, p. 2)

Harrison. They identified "surface outcrops of gold-rich conglomerate on old farmland", called *Langlaagte*, near the centre of Johannesburg (Kirk et al. 2004, p. 534). After this discovery, the "outcrop of the Main Reef Group, which hosts the most important gold-bearing conglomerate reefs of the Witwatersrand, was soon traced along the Central Rand for some 40 kilometers (km), from the Durban Roodepoort Deep mine in the west to the East Rand Proprietary Mines in the east" (Tucker et al. 2016, p. 106). This is how gold in the west, east and central basins were discovered. The Witwatersrand basin is known as the largest goldfield in the world, having produced half of the gold ever mined (Kirk et al. 2004, p. 534); in total over 52,000 t of gold, with approximately 30,000 t still available to mine (Tucker et al. 2016, p. 106; Hartnady 2009, p. 328). Partly owing to gold-mining activities on the Witwatersrand, including the East Rand, in 2009 South Africa dominated the world as the number 1 gold producer, indicating the extent of mining that took place. South Africa is currently the fifth largest producer of gold, with China, Australia, Russia and the United States having overtaken the country's position (Neingo and Tholana 2016, p. 283).

The eastern basin is about 30 km long and 20 km wide and has a mine lease area that extends for 768 km^2 (Fig. 3.7) (Labuschagne 2015, p. 1). Gold mining has occurred in the eastern basin since the discovery of gold in 1886 and reached its peak in the 1940s and 1950s. In 1955, there were 24 gold mines and 90 shafts existed, but due to the fixed gold price and high working costs, there were several mine closures between 1950 and 1960, with mines being made inactive, waiting for closure certificates or completely abandoned (Labuschagne 2015, p. 12; Scott 1995, p. 19). Extensive coal mining in the eastern basin also took place. Coal mines began

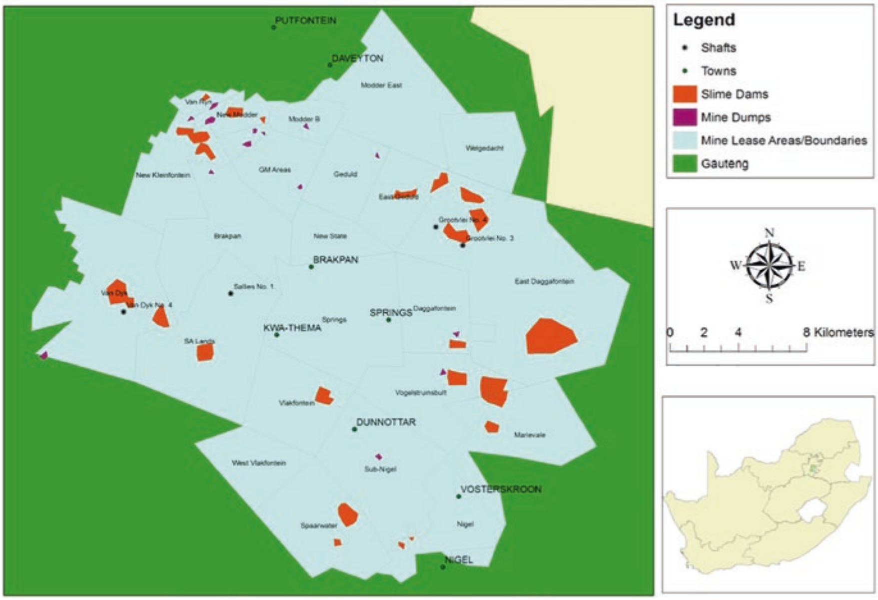

Fig. 3.7 Eastern basin mine lease areas**.** (Labuschagne 2015)

operating from the early 1890s and ended in the late 1940s. However, the economic resource potential still existed in the area, which led to active mining for many more years. As a result, even though most gold mining in this basin had already reached its lifespan and began to decline, during its peak it had 28 mines and produced about 10,000 tons of gold (Labuschagne 2015, p. 2). Thousands of people earned their living off mining during its predominant years, implying that "the mines of the Witwatersrand have shaped the economy of this country" (Scott 1995, p. 6) (see Fig. 3.8 for how widespread mines are across the Gauteng Province). However, by 2011 most of the mines were already closed, and damage caused began to surface increasingly (Ambani 2013, p. 88). The damage was due to "depth, geological complications and their primitive, poorly planned, beginnings" (Scott 1995, p.1). The mining industry had underestimated the potential life of the gold mines of the Witwatersrand (Tempelhoff et al. 2007, p. 107). Figure 3.9 illustrates the rate at which mining excelled and then declined in the eastern basin, as well as how many leading mining companies operated at a time.

Owing to the fact that mineral recovery is not a renewable process, once a mine reaches the end of viable economic production, the mine needs to be closed (Milaras et al. 2014, p. 1). Sustainable mine closure must be in place not to negatively impact the area that was mined so that the land can be used in future. This requires thorough and efficient management of mine closure, which creates "significant management problems" for governments, communities and mining companies (Milaras et al. 2014, p. 2). This implies that mining has a stark effect on the natural environment, making it impossible to measure the benefits versus the obstacles. Mining began

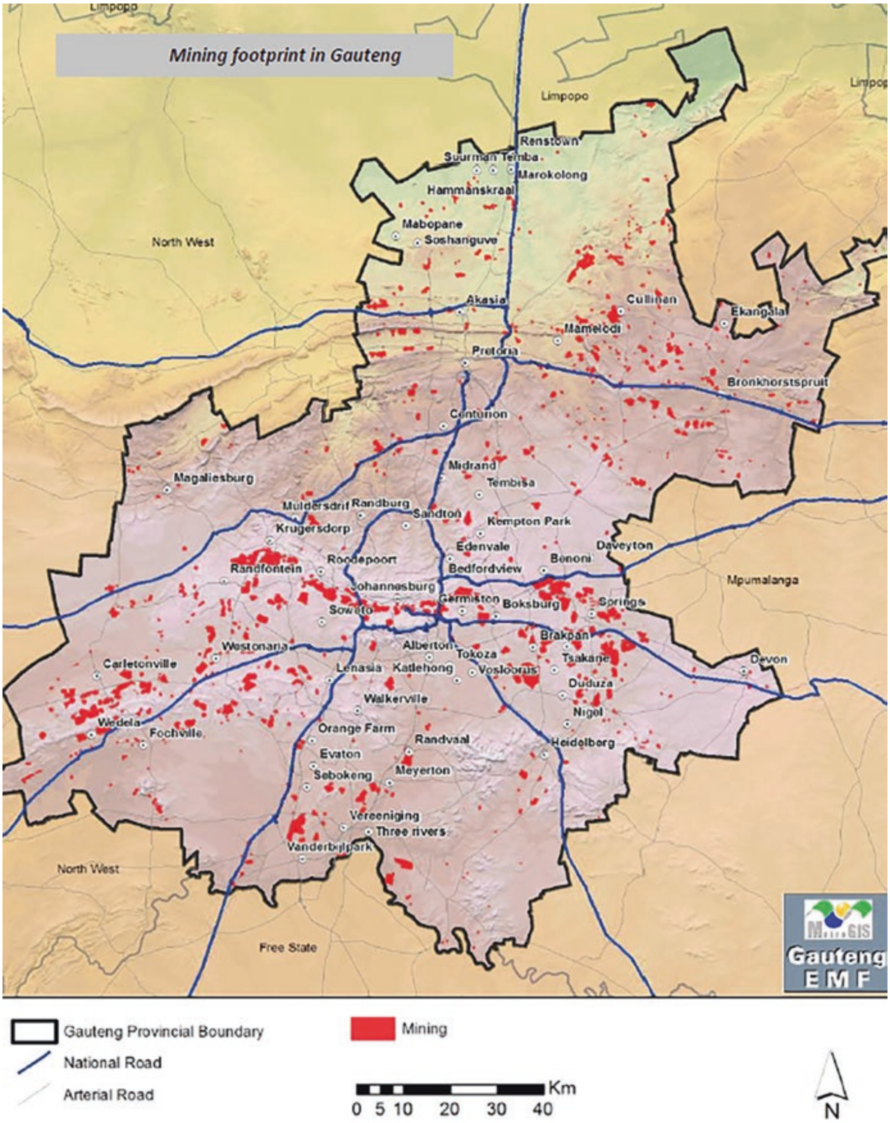

Fig. 3.8 Mining in Gauteng Province**.** (Environomics 2014, p. 50)

over a century ago, and its ongoing detrimental impact on the environment was possibly never anticipated when gold was discovered. Similarly, when gold was discovered, the process of extracting the resource had to be learnt, and during this process the impact it could pose to the environment was yet to be revealed. Therefore, ways to address the impact also had to be tried and tested. Consequently, the commencement of mining led to the discovery of mining's destruction of the environment.

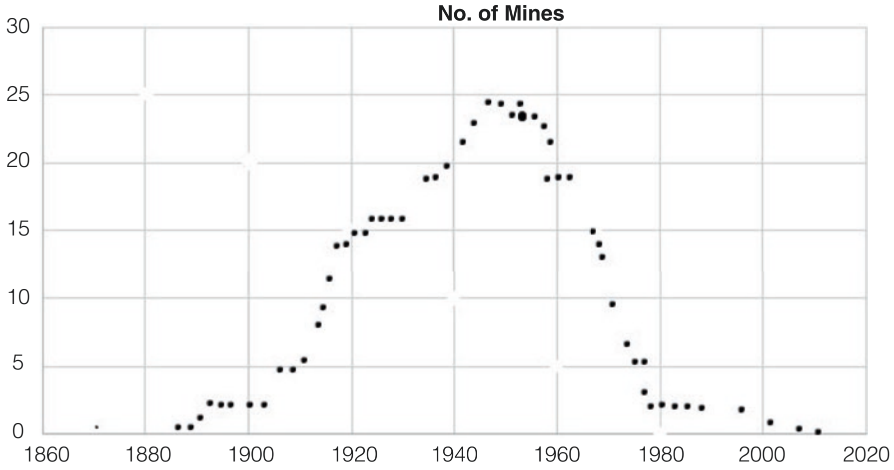

Fig. 3.9 Mining companies in the eastern basin since the late 1880s. (Adapted from Scott 1995, p. 27; Ambani 2013, pp. 87–88)

As gold mining developed on the East Rand, the underground operations became interlinked and fewer mines used dewatering (to remove excess water). Underground mining results in the collapse of the overlying rock strata, and when mining terminates, the voids in the fractured rock become filled with water and decanting occurs from the lowest opening. Further, opencast coal mining involves blasting and removal of the rocks overlying the coal layer, which is removed completely. Opencast coal mining is known to destroy the natural groundwater systems and severely alter the nature of groundwater and surface water interactions because decanting takes place almost a decade or more after mining ceases (Environomics 2014, p. 28).

Environmental problems stemmed from ongoing groundwater control, water resource contamination by acid mine drainage and other factors of pollution caused by illegal underground mining by Zama Zamas[2], "the glory days of South African gold mining appear to have arrived finally at a shameful end" (Hartnady 2009, p. 329). The commencement of environmental degradation associated with the formerly booming industry now posed a severe threat and is costing far more than the value of some of the gold ever mined (Hartnady 2009, p. 329). Further, coal is increasingly becoming available in the eastern basin and extensive coal mining operations occur (De Jager, personal interview, 2018; Madden, personal interview, 2018; Pillay, personal interview, 2018; Storey, personal interview and site visit, 2018; Van der Merwe, personal interview, 2018).

Coal mining is vital because through the process resources are obtained that cannot be produced through farming or cannot be made in a factory, such as electricity, which is imperative considering South Africa's struggle with ongoing power cuts

[2] This is a term used in South Africa for an illegal miner.

due to demands for electricity (Creamer 2019a). Until alternative more sustainable energy sources can replace the need for coal mining, the coal industry is crucial for human sustainability, and vital for economic growth and social upliftment (Environomics 2014, p. 54). While this remains the case, enormous cost implications and damage to the environment occur. Coal mining activities include the creation of slimes dams, quarries, mine dumps and disturbed land (Labuschagne 2015, p. 10), and the continuous pumping to remove inflow water.

The aforementioned make it critical for new technology to be experimented with globally as part of an initiative to ensure mining is safer and more efficient. New initiatives for safer mining are jointly funded by the private and public sectors. Representatives are utilised to “provide longevity to the declining South African mining industry” (Creamer 2019b). The main aim is “to mark the end of mining’s fragmented past” and therefore to advance in safer, healthier and more efficient mining to take mining to a level for the benefit of the South African people (Creamer 2019b).

The Blesbokspruit experienced declining water quality over the years in which mining took place and more so when mining ceased in 2011, which implied that pumping of water had come to an end (discussed in Sect. 4.3). In addition, as the population grows, increasing volumes of water from wastewater treatment plants are discharged into the Blesbokspruit, further exacerbating an already sensitive system.

3.4 The Blesbokspruit and Its Wetland

The Blesbokspruit area of study includes Springs (see Figs. 3.10 and 3.11), where the AMD treatment plant is situated. Springs[3] includes several residential areas, such as Strubenvale, Casseldale, Grootvaly Agricultural Holdings, Bakerton, Welgedacht and Aston Lake. The town of Nigel is downstream of the Blesbokspruit and community members from this town were also interviewed for this book.

There are 75,300 individuals and 23,700 households that fall within the Blesbokspruit area (Digby Wells Environmental 2015, p. 82). The potential economically active percentage of the population is 72%, and 6% are of retirement age. Of the households, 9% reside in rural areas, including farms and smallholdings, and 92% access water through municipal means or other water service providers. The majority of the area is considered established as most houses have been in existence for over 20 years (Digby Wells Environmental 2015, p. 83). The economic development in the area was discussed in Sect. 3.2.

The book identified stakeholders and key individuals who interact with the Blesbokspruit to explore how various social constructions of the water quality are formed, and why they differ. Stakeholders who interact with the Blesbokspruit

[3] This study refers to the Springs community unless otherwise stated.

Fig. 3.10 The Blesbokspruit. (Photographs by researcher)

include environmental activists, communities (mainly residential property owners from Springs and Nigel), researchers, government (local, provincial and national), industry (mining and wastewater treatment works), tourism (Marievale Bird Sanctuary, and wedding and conference venues) and commercial agriculture (including feedlots). The satellite image in Fig. 3.12 indicates where these stakeholders are situated in proximity to the Blesbokspruit and, therefore, users of the water. Residential areas are situated alongside the river and irrigation points are visible. Recreational activities along the Blesbokspruit happen at places such as the Stable Inn Lodge and Conference Venue, and the Riverside Country Estate wedding venue. Marievale Bird Sanctuary, the Suikerbosrand Nature Reserve and the Karan Beef Feedlot are situated further downstream. The eastern basin AMD treatment plant is situated upstream, on the Grootvlei Mine site. The AMD treatment plant discharges from 80 $M\ell$ up to 110 $M\ell$ of water per day into the Blesbokspruit. This created increased volumes of water flowing into the Blesbokspruit, which led to the flooding of the banks of property situated alongside the river.

The Blesbokspruit originates to the north of Benoni and Daveyton and flows southwards through Springs, Heidelberg and Nigel towards the Vaal River (EMM 2007a, p. 10; Springs Advertiser 2014a). Most of the Blesbokspruit catchment though falls within Nigel. Half of the Blesbokspruit wetland is protected by the Marievale Bird Sanctuary, and the other half is owned by the Anglo-American Group, due to being situated on land they own (Thorius 2004, p. 18). For clarity, the Grootvaly Wetland Reserve lies off Welgedacht Road and is a high-altitude wetland

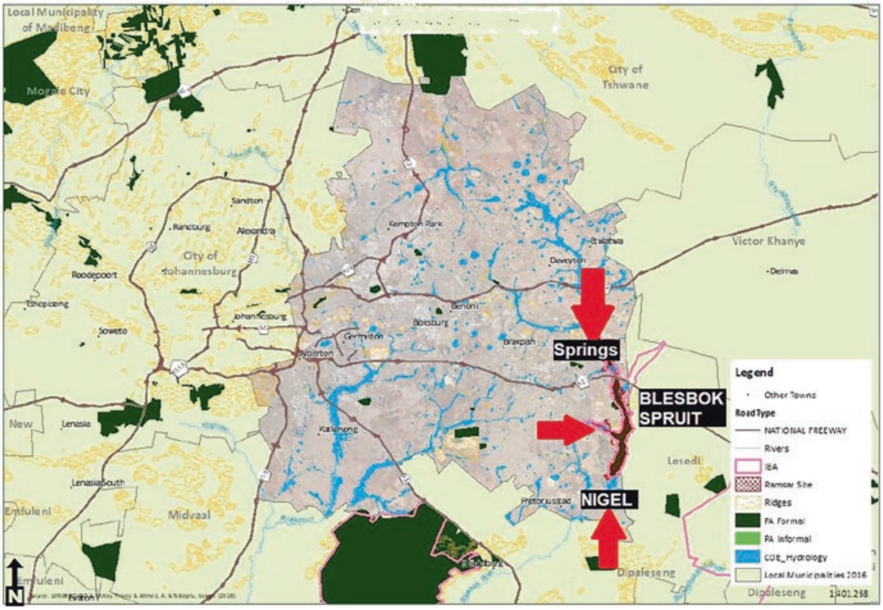

Fig. 3.11 Location of the research area. (Hawley and Desmet 2020, p. 24)

that runs along the Blesbokspruit River. The Grootvaly wetland lies to the north of the Blesbokspruit and at the southern end is the Marievale Bird Sanctuary; and these two form the Blesbokspruit Wetland Reserve (Ambani 2013, p. 63; South Africa Venues 2019). In this book, I refer to this as the Blesbokspruit wetland.

The Blesbokspruit wetland is one of the largest wetlands on the Highveld and was declared a Ramsar site in December 1986 (see Fig. 3.13), meaning it gained the status of international significance due to its unique ecosystem (Krige 2018; Madden, personal interview 2018). The Ramsar Convention[4] on Wetlands of International Importance was agreed to in Iran as one of the first international environmental treaties to monitor wetland degradation, and therefore to protect these ecosystems as habitats for wildlife and birds (Ambani 2013, p. 17). Wetlands that are classified on this list are those requiring special attention due to their significant value.

The Blesbokspruit (see Fig. 3.14) is one of the most important river systems in Gauteng and forms part of the Vaal River Catchment, along with the Klip River and the Natal Spruit. The Blesbokspruit flows into the Suikerbos River where it then joins the Klip River (Labuschagne 2015, p. 8). The Blesbokspruit, covering an area of 1427 km^2, is one of two main streams in the East Rand, the Rietspruit (which is

[4] South Africa was one of the first signatories to the Ramsar Convention in 1975 (Ramsar website 2017).

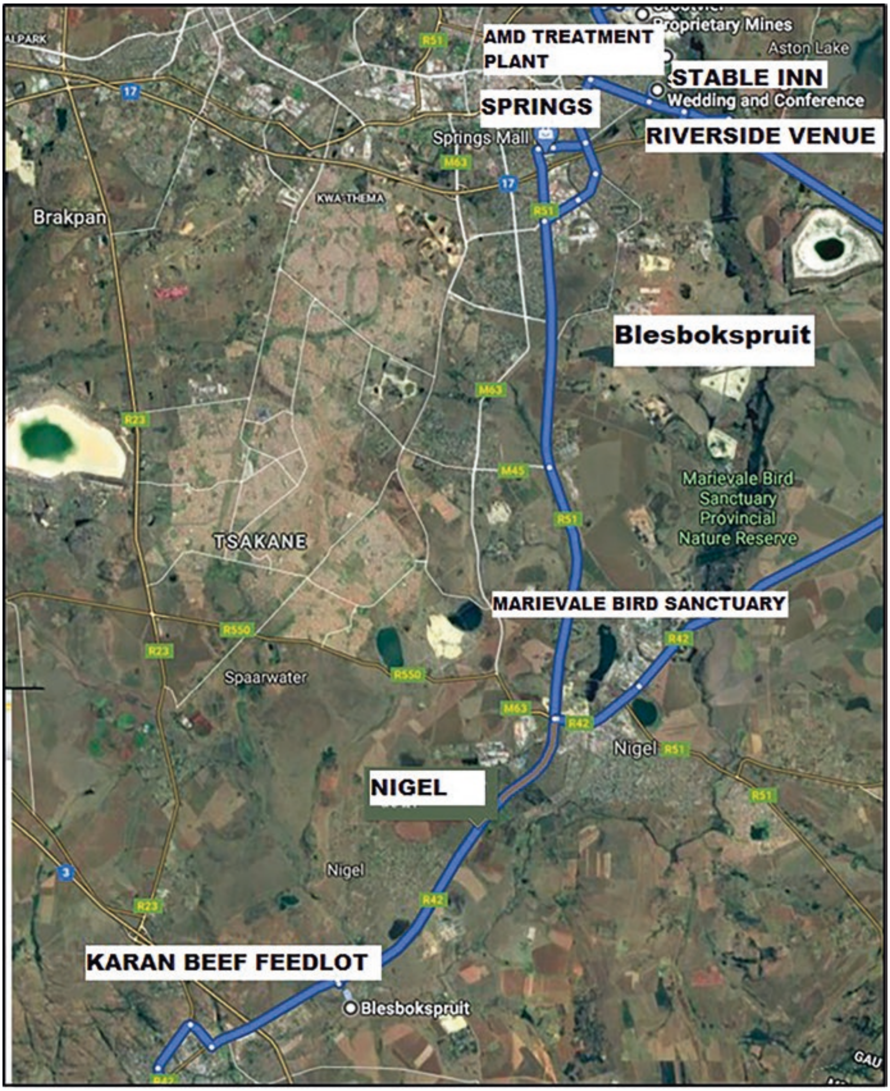

Fig. 3.12 Stakeholders who interact with the Blesbokspruit. (Google Maps 2020)

820 km²) being the other (Scott 1995, p. 16). It extends over 22 km between the R22 and R555 road routes and is about 7 kilometres wide (Springs Advertiser 2014a).

The Marievale Bird Sanctuary is situated within the upper reaches of the river. It is known as one of the most popular attractions in Gauteng and covers over 1000 ha of the Ramsar site (Gauteng Tourism Authority 2020; Madden, personal interview, 2018). According to Hawley and Desmet (2020, p. 19), its ecosystem provides protection for over 450 bird species, including water birds (Gauteng Tourism Authority 2020). Approximately 18 species are of conservation concern and are reliant on the

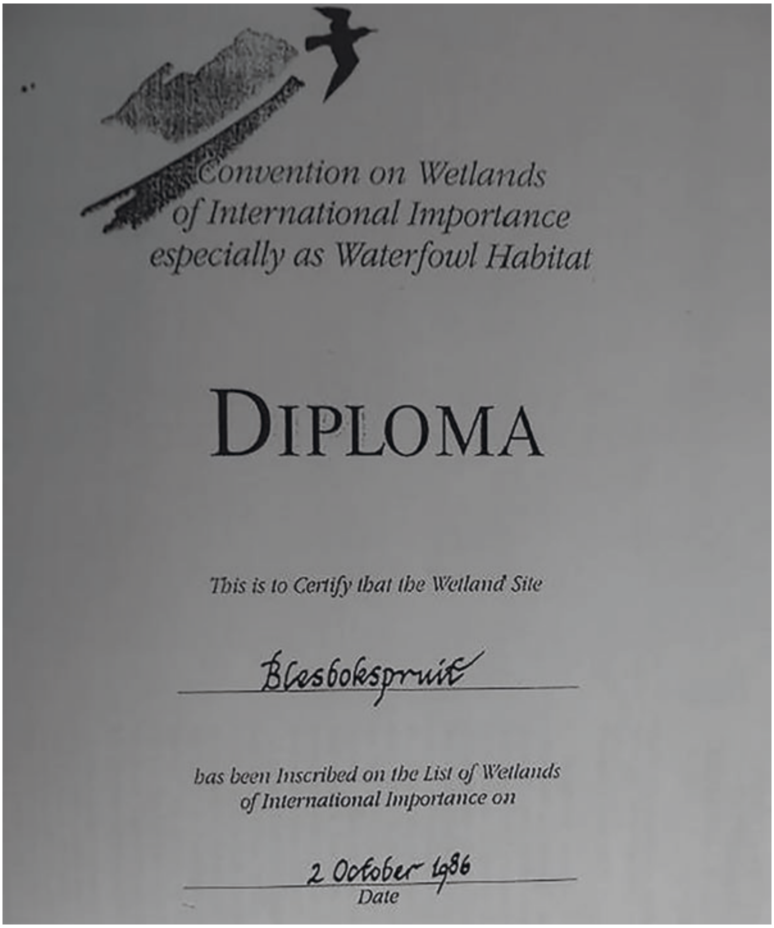

Fig. 3.13 Certificate indicating the recognition of the Blesbokspruit wetland as a Ramsar site. (Photograph by Stan Madden)

habitat in the CoE, 2 of these species are endangered, 9 are vulnerable as they are reliant on wetland habitats, and 7 are threatened (Hawley and Desmet 2020, p. 19). In 2016, 3082 birds were counted, according to the Coordinated Wetland Aquatic Count (Krige 2018). To the east of the wetland there are extensive natural wetlands, and the area to the west is highly developed by agriculture and human settlements, mines, waste disposal sites and wastewater treatment works, all impacting negatively on the quality of the water of the Blesbokspruit (EMM 2007a, p. 10). Further, most of the Blesbokspruit is filled with reeds, proven to be necessary for the system, as it absorbs chemicals and other substances from the water into their roots, and this cleans the water (Van der Merwe in Krige 2018). However, if not managed, reeds can halt the flow of water in certain parts of the river, causing excessive flooding.

Fig. 3.14 The Blesbokspruit wetland. (Photograph by Stan Madden)

Based on these human-induced changes, the Blesbokspruit is described as an artificial wetland that was created through mining (Blesbokspruit Trust representatives, personal communication, 2018; Govender, personal interview, 2018; Madden, personal interview, 2018). It developed into a permanent wetland because of the discharge of large quantities of water from underground gold mines in the early 1990s (Ambani 2013, p. 19). This means that the quantity of water in the Blesbokspruit is no longer dependent on the season but has water all-year-round. The Blesbokspruit has therefore been partially modified due to the impacts on the river and serves as a buffer for the water entering the Vaal River, the main source of water for Gauteng's socio-economic activities (Ambani and Annegarn 2015, p. 48). The Blesbokspruit wetland acts as a purifier of mining, industrial and wastewater treatment works discharges. The challenge is now for water management, especially in agriculture due to the importance of the sector for food security. Much stricter inspections by decision-makers and civil society of new infrastructure development in relatively open river basins are needed to avoid over-commitment of already limited water resources (Molle et al. 2007, p. 585). Water resources in the Blesbokspruit are fully committed to a variety of human uses. This implies that water quality is degraded, river-dependent ecosystems are endangered and increasing demand for water is leading to strong competition between users (Molle et al. 2007, p. 587).

Owing to the over-exertion on the system and its deteriorated state, in 1996 the Blesbokspruit wetland was placed on the Montreux Record. This is equivalent to a person being blacklisted for having unpaid debt (Ambani and Annegarn 2015, p. 1; *Spring Advertiser* 2014b). Environmental sites of international importance that experience serious ecological problems both for humans and wildlife are placed on this record. It is "a register of wetland sites on the List of Wetlands of International Importance where changes in ecological conditions have occurred, are occurring, or are likely to occur as a result of technological developments, pollution or other human interference" (Ramsar website 2017). Despite numerous attempts to better the Blesbokspruit wetland, it remained on the Montreux Record throughout the duration of the research conducted for this book. Mashau (in Blesbokspruit Forum 2018d), a representative of the Gauteng Department of Agriculture and Rural Development (GDARD), explained that in order for the Blesbokspruit to be removed from the Montreux Record, it has to regain its Ramsar status and meet specific water quality guidelines. Mashau (in Blesbokspruit Forum 2019a, d) further reported that the paperwork to remove the Blesbokspruit from the record was complete and had been submitted to the Department of Environmental Affairs (DEA), who is responsible for submitting the paperwork to the National Ramsar Convention on behalf of GDARD. This was a positive attempt from the GDARD. However, by the end of the research period the DEA had still not submitted the documents to Ramsar.

3.5 Non-statutory Bodies Contributing to the Governance of the Blesbokspruit

This section introduces two non-statutory bodies in the management of the Blesbokspruit catchment. It is important to note that this section does not explain the direct roles of the various departments that are involved in managing the Blesbokspruit; this is explained in Chap. 7 (Sect. 7.3.1) to provide a detailed background on the roles and responsibilities of the various spheres of government with regard to the management of the Blesbokspruit, before delving into the issues of power relations between governing bodies and other stakeholders (which is the purpose of Chap. 7). This section specifically refers to the role of the Blesbokspruit Forum, which is attended by government departments that manage the Blesbokspruit catchment. They meet with interested parties, sectors and businesses that interact with the Blesbokspruit through their discharge of water or the abstraction of water. This forum is significant to the book because all stakeholders who interact with the Blesbokspruit are meant to attend this forum to report back to create an awareness of what takes place in the catchment, therefore, to enhance communication pertaining to the Blesbokspruit catchment. It is a public forum and is open to the community. The Blesbokspruit Trust is a non-governmental organisation (NGO); their contributing role to the catchment is explained below.

Members of the Blesbokspruit Wetland Forum, the Gauteng Wetland Forum and Blesbokspruit Trust served as significant sources of information for the research. The Blesbokspruit Forum (discussed further in Sect. 3.5.1) is a catchment forum where representatives of government departments present their water quality results according to a set of In-Stream Water Quality Guidelines, and organisations have to report on their water usage (Reservoir website 2020; Blesbokspruit Forum Charter

2003). A Department of Water and Sanitation (DWS) representative records the information and distributes the minutes of the meetings to the forum representatives. Meetings take place in Springs at the Grootvaly Educational Centre (Blesbokspruit Forum 2018a, b, c, d)[5]. The Gauteng Wetland Forum is a platform where relevant representatives of the various catchment forums in Gauteng meet to provide feedback on each catchment. The vision of the Gauteng Wetland Forum is to "effectively conserve and manage wetland ecosystems in the Gauteng Province" (Wetlands Portal of South Africa 2016). Meetings take place at the Endangered Wildlife Trust venue in Modderfontein (Gauteng Wetland Forum 2018a, b, c). These meetings allowed for sound interaction with various individuals among the stakeholders (Fig. 3.15). The Blesbokspruit Trust (discussed further in Sect. 3.5.2) consists of several members who are residents in the area. They have a vested interest in protecting the Blesbokspruit Ramsar site because they reside in the area. The Trust consists of 10–12 members (five of whom were interviewed) who meet on a monthly basis to discuss the welfare of the area and address issues pertaining to the Blesbokspruit. For instance, the excessive reeds and hyacinth growth halt the flow

Fig. 3.15 Members of the Gauteng Wetland Forum during a tour of Marievale Bird Sanctuary led by Stan Madden. (Photographs by researcher)

[5] During the Covid-19 global pandemic, all forum meetings took place online via Zoom.

of the Blesbokspruit; therefore, maintenance of the reeds needs to take place (Naidoo, personal interview, 2018).

3.5.1 The Blesbokspruit Forum

The following information is taken from the Blesbokspruit Forum Charter (2003, p. 2). The Blesbokspruit Forum was established in 1996, and since the adoption of the National Water Act (NWA) in 1998, its intention was to promote the aims of the NWA. The Forum's mission is "to provide a platform to assist in the development of an integrated environmental management strategy for the Blesbokspruit catchment through stakeholder participation". The Blesbokspruit Forum is a body that meets on a quarterly basis, providing an opportunity for all role-players to participate on a platform that is transparent to discuss the issues within the Blesbokspruit catchment. Therefore, "the participation of all people in the protection, use, development, conservation, management and control of the water resources of the Blesbokspruit catchment" is promoted through this forum (Blesbokspruit Forum Charter 2003, p. 2–3). It serves as the biggest communication link between the spheres of government related to the Blesbokspruit (Maurizi, personal interview, 2018). Water use licences, environmental authorisations and mining rights are presented and discussed in the forum. The aim is for all information pertaining to the management of the catchment to be made available to stakeholders. It is therefore a body that "has the capacity to make recommendations to the authorities and other forum management structures [such as the Gauteng Wetland Forum] on behalf of the broader body of Forum members". However, this Forum, according to its charter, cannot be considered a pressure group, an activist body or one that can dictate actions to participants (Blesbokspruit Forum Charter 2003, p. 2–3). The Forum consists of government departments concerned (i.e. national, local and provincial), mines, industries, farmers, local authorities, NGOs, water service providers and the general public. Considering that this forum brings together stakeholders that contribute and have a role in managing the Blesbokspruit catchment, this is a platform where communication is transferred; therefore, the information about the Blesbokspruit and the water quality is presented on this platform. If a stakeholder or public individual is not aware of why a water use licence, for instance, was issued, they could question the relevant authority at a forum meeting or through the e-mailing group.

Through observation and attendance of forum meetings since 2018, it was found that the Blesbokspruit Forum is chaired[6] by the DWS and is made up of representatives of 18 organisations, including mining companies, industry and the agricultural sector, and government units. Local government includes the CoE and Lesedi Local Municipality, provincial government includes GDARD and national government

[6] Rand Water assisted in chairing forum meetings since 2020, once they were held virtually.

includes the Department of Mineral Resources (DMR) and the DWS. Five units within or under the DWS are represented, which are the Trans-Caledon Tunnel Authority (TCTA), Compliance Monitoring and Enforcement (CME), Catchment Management Agencies, Water Services Regulation and Water Use Licences. Lastly, two NGO representatives of the Gauteng Wetland Forum and the Blesbokspruit Trust are also typically present (Blesbokspruit Forum 2018a, b, c, d, 2019a, b, c, d). Six water quality reports are normally presented at forum meetings by the DWS, the CoE, the Ekurhuleni Water Care Company (ERWAT), Lesedi Local Municipality, Rand Water[7] and the TCTA. The forum is open to public attendance, and influential members of the community attend to raise issues on behalf of the community. From a government point of view, this is considered part of the public participation process for environmental conservation. As of 2020 points were allocated to those who participate in the forum, by the South Africa National Accreditation System, each representative is able to obtain two points a year (half a point allocated for attending the four meetings per year). This is significant to those who are involved in managing the Blesbokspruit to indicate their attendance and contribution to the forum. Further, those representatives who do not usually attend forum meetings might be more inclined to attend as a result.

Numerous presentations typically take place in the forum, such as new environmental authorisation processes, new mining applications, water use licence status in the catchment, environmental conservation and wetland protection. Further, pollution incidents are a permanent agenda item for raising current or new incidents. Details of the Blesbokspruit Forum, such as the minutes and water quality reports, are placed on the Reservoir website, which is administered by Rand Water on behalf of the DWS (Blesbokspruit Forum 2018a). At the beginning of 2019, a Google e-mailing group was created to ensure that the transfer of information outside forum meetings reached all stakeholders involved in the Blesbokspruit catchment. This platform allows stakeholders to raise issues before and after meetings (Blesbokspruit Forum 2018d).

This forum was therefore crucial to the research because it served as the most important platform where communication between stakeholders took place. Those who attended forum meetings were also able to share the information with other stakeholders and therefore contributed significantly as a factor (the transfer of information and communication) that influenced key individuals' and stakeholders' social constructions of the water quality of the Blesbokspruit (discussed in Chap. 6).

3.5.2 The Blesbokspruit Trust

Members who live in Springs (see Fig. 3.16) and who were interested in environmental conservation formed the Trust as a registered NGO in 1998 (Madden, personal interview, 2018). At the time that this research was conducted, Charl van der Merwe served as the chairperson of the Trust (Blesbokspruit Forum 2019a). The

[7] Rand Water is the bulk water provider in the Gauteng Province and surrounding provinces.

Fig. 3.16 Blesbokspruit Trust members (from left to right: Ewald Meyer, Charl van der Merwe and Stan Madden). (Photograph by researcher)

main aim of the Trust is for its voluntary members to contribute to reducing pollution impacts on the Blesbokspruit by reporting these incidents to the appropriate government department. Often, residential property owners contact the Trust regarding pollution incidents and they contact the municipality to ensure that the problem is attended to (Van der Merwe, personal interview, 2018). Members of the Trust live in residential areas adjacent to the Blesbokspruit, and they have a vested interest in issues pertaining to the river. The Trust assists with reviewing environmental impact assessments (EIA) and attending stakeholder meetings regarding new mining applications, as well as being part of the Blesbokspruit Forum and Gauteng Wetland Forum.

Members of the Trust meet monthly, and they function similarly to an NGO. Initially, the Trust was made up of residential property owners some of whom were also representatives of corporate companies, such as the SAPPI Enstra Mill, Impala Platinum, Grootvlei Mine and Zincor Operation, and government officials. Residential property owners who are members of the Trust got their respective companies involved because this contributed to their livelihood and benefitted these companies by conserving the environment. Some of these corporate companies sponsored the Trust (such as Zincor) via monthly financial contributions over a period of 10 years (Van der Merwe, personal interview, 2018). The Trust relies on sponsors and donations to operate, which has declined over the years (Naidoo, personal interview, 2018). The Trust was financially sound when it began but is currently struggling to maintain its sponsors. Anglo American is one of the companies that no longer sponsors the Trust, and by 2018 there were severe financial constraints (Naidoo, personal interview, 2018). While Carnival City[8] is the biggest funder and Impala Platinum also continues to fund the trust (Naidoo, personal interview, 2018), it is a struggle to secure sufficient finances. Many members are leaving the Trust due to the closure of mines, which places financial strain on companies. The corporate companies that still serve as members are not in a financial position to provide ongoing financial assistance (De Jager, personal interview, 2018). According to Pravin Naidoo, who is a member of the Trust and a Springs resident and manager at Impala Platinum, Impala is an ongoing sponsor of the Trust. All the sponsored money goes towards environmental conservation.

An environmental education centre, called the *Grootvaly Educational Centre*, was built through the CoE, with the assistance of many sponsors, such as Impala Platinum[9]. The Trust runs this centre, built to train children, especially the underprivileged, in environmental conservation (Naidoo, personal interview, 2018). Busloads of schoolchildren were taught at the centre once a week, through funds made available by Anglo American (Madden, personal interview, 2018). In 2017, it educated 1411 children, but owing to the high transport costs involved in bringing children to the centre, the number of children has reduced over the years (Van der Merwe, personal interview, 2018). The Trust also consistently tries to make many people aware of what they do (De Jager, personal interview, 2018; Naidoo, personal interview, 2018).

3.6 Research Methodology

The Blesbokspruit was used as the case study for the research conducted for this book. A case study was used to explore the views of various key individuals and other stakeholders who interacted with the Blesbokspruit due to their need for water and based on their need for water, how they socially constructed the quality of the water. A case study was the most suitable approach for this research to identify stakeholders' perceptions of AMD treatment in the eastern basin, and how and why various social constructions of the water quality of the Blesbokspruit were formed due to vested interests, which resulted from power relations.

Owing to the in-depth nature of the research, a qualitative research design was used to obtain both primary and secondary data. The book therefore uses a qualitative research design to explain how water quality in the Blesbokspruit is socially constructed in the context of AMD and its treatment.

[8] Carnival City is a hotel and casino situated in the East Rand.

[9] According to Naidoo (personal interview, 2018), Impala is passionate about the environment and spent close to a billion rand over the last 20 years to assist with environmental conservation in the area.

3.6.1 Data Collection

The data collection included a combination of primary and secondary data. Data were collected in two phases during the research which stretched from January 2018 to August 2020. The first phase involved identifying the various stakeholders who interact with the Blesbokspruit and the key individuals within stakeholders who were linked to AMD treatment. The second phase involved conducting in-depth interviews, attending the Blesbokspruit Forum and the Gauteng Wetland Forum, and site visits.

Primary data included scoping interviews, face-to-face in-depth interviews with key individuals, attendance of Blesbokspruit Forum meetings (since 2018), attendance of Gauteng Wetland Forum meetings (since 2018), attendance of the Blesbokspruit Trust meeting, attendance of the 2017 launch of the eastern basin AMD treatment plant. Many site visits to the East Rand were conducted, which included the Blesbokspruit wetland, Springs and Nigel communities, mining areas and farms, a tour of the AMD treatment plant, visits to the Stable Inn Conference Venue and the Riverside Conference and Wedding Venue, and the Marievale Bird Sanctuary with the Gauteng Wetland Forum. Personal and follow-up communication with key individuals and other stakeholders took place via telephone and e-mail, before or after forum meetings and after site visits. Telephone communications with Springs and Nigel community members (who formed part of the EIA process in 2014) were conducted on their post-views of the AMD STT. Observations of key individuals' interactions with the Blesbokspruit took place during site visits and observations of stakeholders during the forum meetings.

The purpose of conducting follow-up communication with community members who formed part of the EIA process was to identify whether they held the same views after the STT treatment began, as they did during the EIA process[10]. Some of the key individuals that were interviewed served as key informants, providing information on public meetings, new mining activities or communication between government officials regarding pollution incidents and providing links to other participants for the research. All participants used for the research were adults over the age of 18 years. Attendance of the Blesbokspruit Forum and Gauteng Wetland Forum, and site visits to the AMD treatment plant, the Blesbokspruit, agricultural areas, surrounding residential areas and tourist attractions formed a significant part of the research.

Secondary data included a combination of published literature (books, journal articles) on the Blesbokspruit, media reports, official government documents (including the EIA for the sludge disposals site and TCTA reports), national legislation, acts and policies pertaining to water, mining and the environment. Key

[10] The prominent community members interviewed for this study are part of the key interviews conducted because they are influential in the community; they attend the catchment forums, form part of the Blesbokspruit Trust and often referred to in media reports. The community members who were telephonically interviewed were chosen based on the comments they provided during the EIA process because they are property owners.

interviewees provided published and supposed publicly available documents that were not easily accessible, which assisted with the research. Such documents were useful in cases where some people did not want to be interviewed because they did not have permission from their department heads, for example.

In 2016, five scoping interviews were conducted with stakeholders. This included an environmental activist, Ms Mariette Liefferink, Chief Executive Officer (CEO) of the Federation for a Sustainable Environment, and four stakeholders within the agricultural sector, namely, Mr Bennie van Zyl from the Transvaal Agricultural Union, a farmer on the West Rand (at this stage the research area was still to be confirmed), Dr Piet Nell from the Agricultural Research Council (ARC) and an agricultural consultant on the East Rand. From these scoping interviews and reading newspaper articles, it was clear that the major topic of discussion with regard to the Blesbokspruit was on AMD treatment and its potential implications (or not) for the Blesbokspruit. The AMD STT in the eastern basin was launched in February 2017, and exploring and understanding the perceptions regarding the water quality of the Blesbokspruit in the context of the AMD STT proved relevant to various stakeholders. The scoping interviews assisted in formulating the research objectives. In addition, extensively reviewing the EIA documents compiled by Digby Wells Environmental early in the research process was essential to form a better understanding of the views of the various stakeholders on the proposed AMD STT and its anticipated impacts on the quality of water of the Blesbokspruit. Numerous stakeholders felt that their views were not being heard and that the EIA process was merely a tickbox exercise. The EIA documents indicated who the key individuals were among stakeholders and which areas were likely to be most affected by the establishment of the AMD treatment plant.

The section that follows provides a brief explanation of how the participants were selected, how the in-depth interviews were conducted and how observations took place. It is important to note that based on the variety of data collection methods used in this book the findings of the book represent the view of key individuals and stakeholders in general that are linked to the Blesbokspruit.

3.6.2 Selection of Participants, In-Depth Interviews and Observations

Purposive sampling and snowball sampling were used in this research to identify key individuals. *Key* is explained as those individuals among stakeholders who have expert knowledge on water quality and AMD treatment; those involved in the management of the Blesbokspruit catchment; those using the water of the Blesbokspruit; and those who live in the surrounding areas. This book does not claim that the individuals interviewed are a representative sample of a particular stakeholder group (e.g. tourism, agriculture, industry, community) or sphere of government or particular government department. The intention was not to identify a representative sample, but rather to conduct interviews with key individuals. Even though key individuals were interviewed, it is not entirely an individualised process. It is possible that these individuals' thinking about the Blesbokspruit, and the treatment of AMD, is linked to, and influenced by, their stakeholder grouping.

Through reviewing media reports and official government documents and policies, further relevant individuals were identified. The scoping interviews also assisted in identifying additional individuals who were beneficial sources of information. Attendance of the catchment forums made it possible to identify other appropriate individuals for the research, that is, those who attended the meetings, what role they played and whether they would be beneficial to the research.

Even though purposive sampling was used, part of the sample was determined as the research progressed. For one, snowball sampling was used to find further relevant individuals. Snowballing worked well where an interview was requested with a specific individual, but the person was hesitant due to his or her organisational affiliation. In such cases, they provided useful suggestions to alternative people. After becoming familiar with who was directly involved in the AMD STT project team and who key individuals in the Springs community were, they too were approached for interviews. Other helpful community members were identified through the EIA documents reviewed for the research. Those members who frequently commented during the EIA public participation process and made comments that were valid for this research were contacted.

Each interview was structured based on the individuals' professional stance and affiliation to the Blesbokspruit catchment, and what role they played with regard to AMD STT and the management of the Blesbokspruit. It is important to note that some of the interviewees play more than one role in the Blesbokspruit due to various interests; for instance, they may live and work in the area. Some key individuals are associated with more than one stakeholder; for instance, those who are both residents and working for a stakeholder, such as the City of Ekurhuleni [CoE; formerly Ekurhuleni Metropolitan Municipality (EMM)]. Others owned property and had businesses in the tourism sector. Most of the prominent community members interviewed also played an environmental activist role. The information collected from each individual was based on these roles, and each response was used based on these roles to identify how social constructions are formed.

Observations were made during the catchment forums; at the launch of the AMD treatment plant; during site visits to the Blesbokspruit and surrounding mining and agricultural land, tourist attractions, including the Marievale Bird Sanctuary, and residential areas; and during a tour of the AMD treatment plant.

3.7 Conclusion

This chapter provided a background on the East Rand, the eastern basin, and the Blesbokspruit and its wetland. The relevance of this chapter was to place the Blesbokspruit in the context of mining on the East Rand and to showcase the importance of the Blesbokspruit based on the various uses of the water. The known water uses can be grouped into five categories, namely (1) agriculture, (2) mining, (3) industry, (4) tourism and (5) domestic use. The next chapter explains how AMD became an issue in South Africa and, more specifically, the eastern basin, requiring AMD treatment to reduce its impact on the Blesbokspruit and its users of the water.

References

Adler, R., Claasen, M., Godfrey, L. & Turton, A. 2007. Water, mining and waste: An historical and economic perspective on conflict management in South Africa. *The Economics of Peace and Security Journal*, 2(2):33–41.

Ambani, AE. 2013. *Long-term assessment of the surface water quality in the Blesbokspruit Ramsar wetland*. Unpublished MSc dissertation. Johannesburg: University of Johannesburg. Available at: https://ujcontent.uj.ac.za/vital/access/manager/Repository/uj:11619. Accessed on: 21 June 2019.

Ambani, AE. & Annesgarn, H. 2015. A reduction in mining and industrial effluents in the Blesbokspruit Ramsar wetland, South Africa: Has the quality of the surface water in the wetland improved? *Water SA*, 41(5):648–659. Available at: https://journals.co.za/content/waters/41/5/EJC179283. Accessed on: 22 February 2017.

Blesbokspruit Forum. 2018a. Minutes of Blesbokspruit Forum meeting and personal attendance, 8 February 2018.

Blesbokspruit Forum. 2018b. Minutes of Blesbokspruit Forum meeting and personal attendance, 11 May 2018.

Blesbokspruit Forum. 2018c. Minutes of Blesbokspruit forum meeting and personal attendance, 8 August 2018.

Blesbokspruit Forum. 2018d. Minutes of Blesbokspruit Forum meeting and personal attendance, 8 November 2018.

Blesbokspruit Forum. 2019a. Minutes of Blesbokspruit Forum meeting and personal attendance, 7 February 2019.

Blesbokspruit Forum. 2019b. Minutes of Blesbokspruit Forum meeting, 9 May 2019.

Blesbokspruit Forum. 2019c. Minutes of Blesbokspruit Forum meeting, 8 August 2019.

Blesbokspruit Forum. 2019d. Minutes of Blesbokspruit Forum meeting and personal attendance, 7 November 2019.

Blesbokspruit Forum Charter. 2003. Terms of reference for the Blesbokspruit Forum October 2003. Available at: http://www.reservoir.co.za/forums/vaalbarrage/blesbok_forum/blesbok_documents/BF_TOR_Oct2003.pdf. Accessed on: 1 July 2018.

Blesbokspruit Trust Representatives (Meyer, E., Madden, S. & Van der Merwe, C). 2018. Blesbokspruit Trustee Members. Personal communication, 8 February. Springs, South Africa.

Creamer, M. 2019a. Menar's Canyon offers Eskom cheaper coal on open-book basis. *Mining Weekly,* 19 March. Available at: http://www.miningweekly.com/article/menars-canyon-offers-eskom-cheaper-coal-on-open-book-basis-2019-03-19. Accessed on: 4 April 2019.

Creamer, M. 2019b. Researchers at Mandela Mining Precinct deserve strong support. *Mining Weekly,* 29 May. Available at: https://www.miningweekly.com/article/research-development-and-innovation-activists-at-mandela-mining-precinct-deserve-strong-support-2019-05-29/rep_id:3650 Accessed on: 30 May 2019.

De Jager, P. 2018. Lawyer and Springs resident. Personal interview, 25 January. Springs, South Africa.

Digby Wells Environmental. 2015. *Construction and operation of the proposed sludge disposal facility and pipelines associated with the treatment of acid mine drainage in the eastern basin of the Witwatersrand, Gauteng: Final environmental impact assessment report*. Johannesburg: Digby Wells and Associates.

du Plessis. A., Harmse, T. & Ahmed, F. 2014. Quantifying and predicting the water quality associated with land cover change: A case study of the Blesbok Spruit catchment. *South Africa Water*, 6(10):2976–2968. Available at: https://www.mdpi.com/2073-4441/6/10/2946/htm. Accessed on: 14 August 2020.

Ekurhuleni Metropolitan Municipality (EMM). 2007a. *Environmental management framework for Ekurhuleni*. Ekurhuleni: EMM. Available at: https://www.ekurhuleni.gov.za/yourservices/environmental-health/environmental-policies-plans-and-strategies/469-environmental-managment-framework-2008/file.html. Accessed on: 15 October 2018.

Ekurhuleni Metropolitan Municipality (EMM). 2007b. *Wetland inventory report: Identification, classification, assessment & delineation of wetlands within the Ekurhuleni Metropolitan Municipality*. Ekurhuleni: EMM. Available at: https://www.ekurhuleni.gov.za/473-env-wetland-inventory-report-2007/file. Accessed on: 15 October 2018.

Environomics. 2014. *Gauteng environmental management framework report*. Johannesburg: Gauteng Province, Agriculture and Rural Development. Available at: http://www.gauteng.gov.za/government/departments/agriculture-and-rural-development/Documents/Gauteng%20Provincial%20Environmental%20Management%20Framework/2014%20GPEMF%20Section%20A%20Introduction%20and%20Status%20Quo.pdf. Accessed on: 20 June 2019.

Gauteng Tourism Authority. 2020. Blesbokspruit Gauteng Tourism Authority. Available at: https://www.gauteng.net/attractions/blesbokspruit. Accessed on: 5 March 2020.

Gauteng Wetland Forum. 2018a. Minutes of Gauteng Wetland Forum meeting and personal attendance, 23 February 2018.

Gauteng Wetland Forum. 2018b. Minutes of Gauteng Wetland Forum meeting and personal attendance, 25 May 2018.

Gauteng Wetland Forum. 2018c. Minutes of Gauteng Wetland Forum meeting and personal attendance, 31 August 2018.

Google Maps. 2020. Map of the stakeholders who interact with the Blesbokspruit. Available at: https://www.google.com/maps/dir/Acid+Mine+Drainage+Plant+-+Eastern+Basin. Accessed on: 30 September 2019.

Govender, B. 2018. Chief directorate Mine water management unit: Department of Water and Sanitation. Personal interview, 1 March. Pretoria, South Africa.

Hartnady, CJH. 2009. South Africa's gold production and reserves. *South African Journal of Science*, 105. Available at: archive.sajs.co.za/index.php/SAJS/article/view/101/82. Accessed on: 11 June 2019.

Hawley, G. & Desmet, P. 2020. *Review of the City of Ekurhuleni Bioregional Plan 2020*. Draft for public comment, July 2020.

Kirk, J., Ruiz, J., Chelsey, J. & Titley, S. 2004. The origin of gold in South Africa. *American Scientist*, 91. Available at: https://www.researchgate.net/publication/240968643. Accessed on: 11 June 2019.

Krige, I. 2018. Walk and talk at the Blesbokspruit. *Springs Advertiser,* 9 July. Available at: https://springsadvertiser.co.za/192898/walk-and-talk-at-the-blesbokspruit/. Accessed on: 10 August 2018.

Labuschagne, DC. 2015. *A 3D geological model for the East Rand Basin, South Africa*. MSc dissertation. Potchefstroom: North West University. Available at: https://dspace.nwu.ac.za/bitstream/handle/10394/15351/Labuschagne_DC.pdf?sequence=1&isAllowed=y. Accessed on: 4 October 2018.

Madden, S. 2018. Environmentalist and Springs resident. Personal interview, 8 February. Springs, South Africa.

Milaras, M., Ahmed, F. & McKay, TJM. 2014. *Mine closure in South Africa: A survey of current profession thinking and practice*. Johannesburg: University of the Witwatersrand. Available at: https://www.researchgate.net/publication/278035528. Accessed on: 7 May 2020.

Milwaukee Riverkeeper. 2015. What's a river basin? What's a watershed? Available at: https://www.milwaukeeriverkeeper.org/whats-a-river-basin-whats-a-watershed/. Accessed on: 5 September 2019.

Molle, F., Wester, P, Hirsch, P., Jensen, JR., Murray-Rust, H., Paranjpye, V., Pollard, S & Van der Zaag, P. 2007. River basin development and management. In *Water for life: A comprehensive assessment of water management in agriculture.* Edited by Molden, D. London; Earthscan: 585-624. Available at: https://www.researchgate.net/publication/40794254_River_basin_development_and_management. Accessed on: 5 September 2019.

Naidoo, P. 2018. Manager Platinum and Metals: Impala Platinum. Personal interview, 7 March. Springs, South Africa.

Neingo, PN. & Tholana, T. 2016. Trends in productivity in the South African gold mining industry. *The Journal of the Southern African Institute of Mining and Metallurgy*, 116. Available at: http://www.scielo.org.za/pdf/jsaimm/v116n3/14.pdf. Accessed on: 11 June 2019.

Pillay, M. 2018. Business Development Executive: Digby Wells Environmental. Personal interview, 16 January. Bryanston, South Africa.

Ramsar. 2017. *The Ramsar Convention on Wetlands: The Montreux Record*. Available at: http://archive.ramsar.org/cda/en/ramsar-documents-montreux/main/ramsar/1-31-118_4000_0__. Accessed on: 10 January 2018.

Republic of South Africa (RSA). 1998. *National Water Act, no 36 of 1998*. Pretoria: Government Printer. Available at: http://www.dwaf.gov.za/Documents/Legislature/nw_act/NWA.pdf. Accessed on: 14 April 2013.

Reservoir website. 2020. About the Reservoir website. Available at: http://www.reservoir.co.za/about.htm. Accessed on: 13 August 2020.

Scott, R. 1995. *Flooding of the Central and East Rand gold mines: An investigation into controls over the inflow rate, water quality and predicted impacts of flooded mines* (Water Research Report No. 486/1/95). Pretoria: Water Research Commission. Available at: http://www.wrc.org.za/wp-content/uploads/mdocs/486-1-95.pdf. Accessed on: 11 June 2019.

South African Cities Network. 2019. City of Ekurhuleni. Available at: http://www.sacities.net/member-cities/ekurhuleni. Accessed on: 4 September 2019.

South Africa Venues. 2019. Grootvaly Wetland Reserve. Available at: https://www.sa-venues.com/game-reserves/grootvaly-wetland-reserve.php. Accessed on 4 September 2019.

Springs Advertiser. 2014a. Blesbokspruit gets too much water: The nutrient-rich water caused the reeds to overgrown the spruit. *Springs Advertiser*, 13 April. Available at: http://springsadvertiser.co.za/89328/blesbokspruit-gets-too-much-water/. Accessed on: 22 February 2017.

Springs Advertiser. 2014b. Springs says no to opencast mining: Residents oppose these-zoning of the land. *Springs Advertiser*, 23 April. Available at: https://springsadvertiser.co.za/90116/springs-says-opencast-mining/. Accessed on: 22 February 2017.

Storey, A. 2018. Nigel resident. Personal interview and site visit, 26 January. Nigel, South Africa.

Tempelhoff, J., Munnik, V. & Viljoen, M. 2007. The Vaal Barrage, South Africa's hardest working water way: An historical contemplation. *The Journal for Transdisciplinary Research in Southern Africa*, 3(1):107–133.

Thorius, T. 2004. *The effect of Grootvlei mine water on the Blesbokspruit*. MSc dissertation on Environmental Management. Johannesburg: University of Johannesburg. Available at: https://ujcontent.uj.ac.za/vital/access/manager/Repository/uj:14868. Accessed on: 8 July 2019.

Tucker, RF., Viljoen, R. & Viljoen, MJ. 2016. A review of the Witwatersrand Basin: The world's greatest goldfield. *Episodes*, 39(2):105–133. Available at: https://www.researchgate.net/publication/305924249_A_Review_of_the_Witwatersrand_Basin_-_The_Worlds_Greatest_Goldfield. Accessed on: 11 June 2019.

Van der Merwe, C. 2018. Chairman: Blesbokspruit Trust. Personal interview, 21 February. Springs, South Africa.

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The influence of urbanization on pans on the East Rand (Johannesburg, South Africa)

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Abstract

Pans are naturally occurring depressions or closed basins. Thousands of pans characterize the southern African landscape. Many pans form an integral part of the natural and cultivated landscape and some are found in the urbanized East Rand to the east of the metropolis of Johannesburg. Little research has been conducted on how humans have influenced the pans occurring in this urban environment, how these pans are frequently misused and mismanaged, and to what extent they may form an asset by complementing the open areas in urban environments. The aims of this research were to investigate the negative influences that aspects of urbanization have had on pans of the East Rand, and to supply some recommendations as to how these pans could be properly utilized for the benefit of the urban environment.

Textural analyses of the pan floor sediments revealed that the sand fraction varies between 15.6% and 43.1%. For lower values, the pan water is hydrologically isolated from the underlying groundwater table; higher values pose a real threat to groundwater pollution from contaminated pan water percolating downwards. Chemical analyses of the pan water showed that the pH range from 6.0 to 9.0 (as compared with pH 6.8 under 'natural' conditions), and that nitrate and ammonia concentrations vary from 1 ppm for slightly polluted to 17 ppm for severely polluted pans. These values clearly indicate the positive or negative influence of humans on the pan.

It is recommended that every pan should be considered as a natural feature of the landscape within the urban environment. Residents should get involved in preserving the pan, and the establishment of residential areas next to the pan should be avoided.

Introduction

Thousands of naturally occurring depressions or closed basins, normally called 'pans' (Goudie and Thomas, 1985) characterize the southern African landscape (King, 1953). ('Panne' is a synonym for pan; the term 'playa' is frequently used elsewhere for the same feature, though a pan is usually much smaller in area than a playa, and the former is found in both temperate and semi-arid or arid climates.) Saline pans are mostly found in semi-arid and arid areas to the west of the subcontinent and freshwater pans in the moderate and subtropical eastern rainfall belt. Pans occur more frequently on the interior plateau than on the coastal lowlands. Most pans are found on horizontal Mesozoic Karoo strata (South African Committee for Stratigraphy, 1980), and very few on the older, underlying Precambrian granitic or metamorphosed basement rocks. For this reason, pans are found on the East Rand but not on the Central and West Rand (Fig. 1). Pans form an important feature of the natural (Fig. 2(a)), and, on the East Rand, of the cultivated and urban (Fig. 2(b)) landscape.

Pans may vary significantly in their appearance. They may be perennial or seasonally filled with water, be flooded from time to time only, or be totally dry. Pan sediments may consist of coarse to fine grained sand, or silt and clay, or

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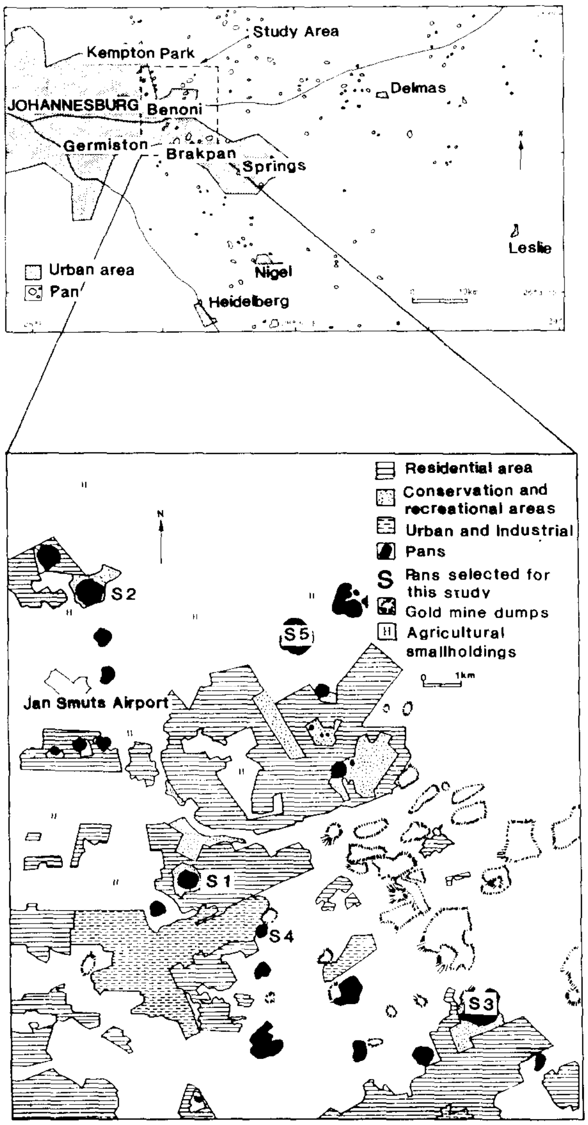

Fig. 1. East Rand pans and those selected for investigation (S1 to S5).

clay only, or a varying mixture of these. Some pans in the arid areas are heavily enriched by evaporites or brines from which salt can be mined economically, while others have infillings of organic rich turf soil (Harmse, 1992). Grasses that grow on these turf soils are grazed by livestock (Verhagen, 1990). Pans with loamy soils may be cultivated. There is general consensus that clay filled pans are hydrologically isolated from the underlying groundwater regime, but that an active interchange occurs between water contained in a sand-filled pan, and the underlying groundwater table (Verhagen, 1990). Freshwater springs empty into many pans (Scott and Brink, 1992) where hundreds of artefacts of past civilizations may be found (Deacon, 1983), whereas many others are totally avoided by humans as a result of their barren and inhospitable appearance. All pans show typical centripetal natural drainage.

Some pans have a surface area of tens of square kilometres, while others are less than 100 m^2 in size (Neal, 1975). In most instances, pans have been viewed as unwanted by farmers as well as urban dwellers, except where they may be used to their benefit (e.g. salt lick for livestock, irrigation and sewerage reservoirs, municipal dumping sites).

For more than a century southern African pans have been studied by scientists from various disciplines (e.g. De Bruiyn, 1971; Le Roux, 1978; Beaumont et al., 1984). The scientific literature on southern African pans has been widely published, nationally as well as internationally (Harmse et al., 1990). One focus of interest has been the debate on the origin of these features (Geyser, 1950; Goudie and Thomas, 1985; Marshall, 1987; Marshall and Harmse, 1992). However, little research has been conducted on how humans influence the pans that are found in urban environments (Le Grange, 1992), how these pans are frequently misused and mismanaged, how pan water is polluted by urban runoff, and to what extent these pans may be an asset in complementing the open areas ('breathing spaces') of urban environments.

The aims of this paper are: (1) to investigate the effect of the summer rainfall and winter dry season on the quality of the suburban water that centripetally drains to the pans on the East Rand, which lie to the east of the metropolis of Johannesburg; (2) to determine the negative influences that some selected aspects of urbanization have had on various pans in the area; (3) to determine the possible ex-

(a)

(b)

Fig. 2. (a) Pristine pan in a rural environment near Delmas with an abandoned farmstead in the background. (b) Industrialized area encroaching on Pan 4.

change of pan water and groundwater; (4) to put forward some recommendations as to how these pans should be properly utilized to the benefit of humans in their urban environment.

The study area

The pans on the East Rand are part of the Eastern Highveld freshwater pan series (Allan, 1987), which are found in a temperate climatic zone (Schulze, 1965) on the southern African plateau between 28° 10′ and 30° 00′ east longitude, at 26° 15′ south latitude. East Rand pans themselves are situated between 28° 13– east and 28° 30– east (Fig. 1), covering the area in and around various municipal areas from Benoni in the west to Springs in the east. In these urban areas, residential, recreational, industrial activities, and refuse dumping sites are found, either bordering on or surrounding the pans. The present study focuses in the municipal areas of Boksburg, Brakpan and Kemp-

Table 1
Urban functions of East Rand pans

Pan No.	Area (m^2)	Type of function						
		Conservation	Recreation	Residential park	Storm water reservoir	Industrial waste	Sewerage works	Refuse dump
S1	25 000	P		S	T		T	
S2	37 500	T	P	S				
S3	65 000				S		P	
S4	10 250				T	S	P	
S5	62 500					S		P

Function category: P, primary; S, secondary; T, tertiary.

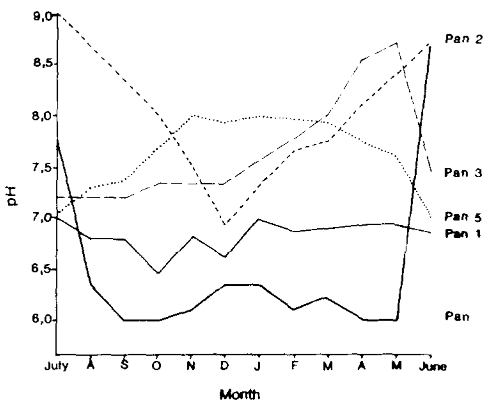

Fig. 3. Annual variation in pan water pH.

ton Park of greater Johannesburg, between 28° 13′ and 28° 22′ east. This is the only area in southern Africa where pans form part of a highly urbanized region. Owing to this unique setting, pressure from humans and their urban activities act upon the pans of the East Rand, more so than in the rural Delmas environment where numerous other pans are found. The majority of East Rand pans are perennially filled with fresh water from natural and polluted water of varying degree from urban runoff, while only a few are intermittent or permanently dry.

Data and analysis

Five pans out of a total of 57 in the urbanized area were selected for investigation (Fig. 1). They vary in area from 10 250 to 65 000 m^2 (Table 1). Selection depended on accessibility and the function it serves in the urban environment. A classification was made of the urban functions present at each pan (Table 1), which indicates that some pans in this study serve more than one urban function.

At each pan, three sediment samples were extracted by soil auger from the pan floor at a depth of 20 cm. This occurred at regular 50 m intervals, across the pan floor from south to north. The sand fraction relative to silt and clay combined, was determined for each sample and calculated as a percentage, using the settling method in a settling tube (Pettijohn et al., 1972). From this the potential seepage of water from the pan to the surrounding underlying groundwater environment was deduced.

The pH (Fig. 3), nitrates (Fig. 4), and am-

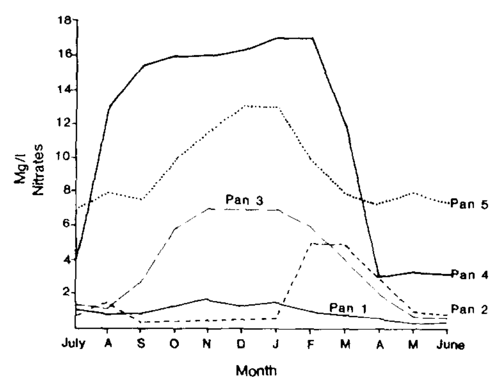

Fig. 4. Annual variation in pan water nitrates (ppm or $mg\,l^{-1}$).

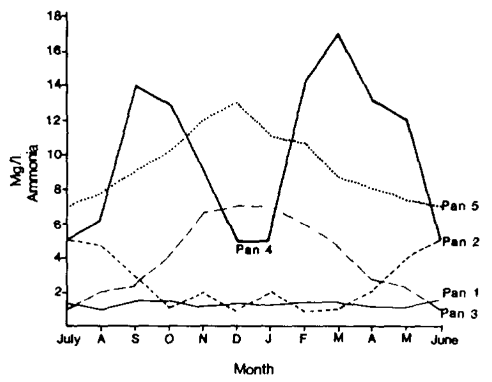

Fig. 5. Annual variation in pan water ammonia (ppm or mg l^{-1}).

monia (Fig. 5) concentrations contained in the water of these five perennial pans were monitored on a monthly basis over a period of 1 year from July to June. This time period was selected as it covered the complete dry winter (May, June, July) as well as the summer rainfall season (the latter occurs from October to March). The three monitoring variables were selected in accordance with Schmitz (1989), who proved that under similar climatic and geological, but natural conditions, the pH of pan water averaged 6.8 with a total absence of nitrates and ammonia. In urban areas, nitrates and ammonia are excellent indicators of water pollution from urban sources (Council for Scientific and Industrial Research, Watertek, personal communication, 1992).

Discussion

A government proclamation decrees that the natural habitat of the area surrounding and including Pan 1 should be conserved as a wildlife sanctuary. This area had been fenced off and contains the following game: springbuck, *Antidorcas marsupialis*; steenbuck, *Raphicerus campestris*; and blesbuck *Damaliscus dorcas phillipsi*. These animals graze on the grassland surrounding the pan; the fence allows many bird species to breed, undisturbed by humans. The percentage of sand present in the sediments of this pan floor varies between 19.4% and 23.7%, giving it a very high silt and clay content of approximately 80%. There is thus no indication that water contained in the pan itself will percolate through the silt and clay of the pan floor to supplement the surrounding groundwater table. Figs. 3–5 indicate the high quality of the water in Pan 1 (pH only slightly acidic, with low concentrations, less than 2 parts per million (ppm or mg l^{-1}) of nitrates and ammonia). On an annual basis, there is little variation between the summer (rainy) season and the winter (dry) season.

This cumulative evidence shows that the natural environment of a pan in an urban setting is only slightly disturbed by humans if the pan is protected as a wildlife sanctuary, even though the pan is situated in a densely developed residential area. It is also interesting to note that real estate in the immediate vicinity of the pan is valued at 20–30% more than that in the surrounding areas, farther away from this pan.

Pan 2 and its immediate environs have been developed as a recreational zone for urban dwellers. Provision is made for angling, canoeing, ball games, camping and picnicking. Here the sand fraction of the pan floor sediments varies between 31.8% and 43.1%. This suggests that pan water can readily percolate through the pan floor to supplement the underlying groundwater environment. Furthermore, Fig. 3 illustrates that the pH levels of the water in this pan reaches an alkaline peak of pH 9 in the dry winter months, but never drops below pH 7.0–7.5 in the humid summer months. Fig. 4 shows that high concentrations of nitrates (up to 5 ppm) are found in the pan water in the late summer, with very low values (less than 1 ppm) during the winter and early summer. Fig. 5 shows that ammonia values in the water of this pan can be as high as 5 ppm during the winter months, but rapidly decline to 1–2 ppm for the rest of the year. The generally lower values of pH, nitrates and ammonia in the summer months may be explained by the influx of rain water from the surrounding area to the pan during the rainy summer season, thus 'diluting' the above-mentioned pollutants. This pan serves as an example of how humans and their recreational activities can influence the natural pan environment.

Pan 3 is one of several where the immediate surroundings have been developed as an open park area for low level recreational purposes. Here urban dwellers can walk their pets, stroll around or have a picnic. Unfortunately this park area is severely littered, with no evidence of cleaning-up operations. The sediments on the floor of this pan contain only 15.6–18.2% sand, which implies that the water in this pan is hydrologically isolated from the underlying groundwater regime. This is caused by the high silt and clay content of the sediments (more than 80%). Fig. 3 shows that the pH of the water in the pan varies from pH 7.2 in mid winter and early summer to an alkaline level of pH 8.7 in early winter, when no rain water is added to the pan. Nitrate concentrations vary from as low as 1 ppm in the winter months to as high as 7 ppm in the summer months (Fig. 4). This value reflects the influence of the polluted pan environment on the water quality of the pan itself, probably owing to the rain water being polluted in the immediate environment of the pan before flowing into the pan. Ammonia concentrations (Fig. 5) follow very much the same trend (with the same values) as the nitrates; this reinforces the hypothesis that the pan water is being polluted in the immediate surroundings of this pan.

A highly industrialized area is encroaching on Pan 4. Heavy as well as light industries are located in this industrial complex, ranging from heavy steel industry to motor vehicle battery manufacturers. During field work it was immediately noted that this pan is devoid of any bird life.

The sand fraction of the pan floor sediments varied from 26.9% to 31.7%. These values suggest the possibility that the water contained in this pan may slowly percolate through the pan floor sediments mixing with the underlying groundwater zone. Fig. 3 shows that the pH of the pan water varies between an acidic pH 6.0 in autumn and spring to an alkaline value of pH 8.2 in early winter. The average value does not, however, deviate much from neutral (pH 7.0). Nitrate concentrations (Fig. 4) vary from an alarming high of 17 ppm in late summer and 15.5 ppm in spring, to an unexpected low of 3 ppm in early winter. On average, these values exceed 7 ppm. Fig. 5 shows that ammonia concentrations in this pan vary from a value of 5 ppm during mid winter and early to mid summer, to disturbingly high values of 14–17 ppm during early spring and late summer. These relatively high values of nitrates and ammonia may be the reason for the absence of bird life here, compared with the abundance of bird life found in Pan 1. It also illustrates the negative influence of industry on the pan environment.

A municipal authority uses Pan 5 as an urban refuse dump. Only a part of this pan contains perennial water. The traditional method of 'dump and land fill' is employed on the dry section of this pan. Here the sand fraction in the pan floor sediments varied from 17.6% to 23.1%. This implies that the pan floor is impervious to pan water percolating down to the groundwater table, and to polluted water seeping through the refuse dump to the pan and eventually the groundwater table. Chemical analysis of water contained in this pan was limited to the water-filled section. Fig. 3 indicates that the pH of the water here varies between pH 7.0 and 8.0, probably due to the water supply being replenished during the rainy season. Nitrate and ammonia values vary between 7 and 13 ppm (Figs. 4 and 5), indicating the effect of refuse dumping in the pan environment.

Recommendations

South Africa, and especially the Witwatersrand (of which the East Rand forms the eastern part), is experiencing a tremendous influx of people from rural to urban areas (Van der Merwe, 1992), which is typical of a developing country. Many of these people cannot afford solidly constructed homes serviced by sewerage and storm water runoff, so they settle as squatters in various areas, some of them on land surrounding the pans. In future, much stress will be caused by these newcomers as well as other settled urban people on the existing natural features that have partially or totally survived the development of the urban landscape, of which the pans on the East Rand form an integral part. With this as background, the following recommendations are suggested regarding the future utilization of the pans.

Natural landscape features

All pans should be considered as natural landscape features within the urban environment and managed and utilized with responsibility. Any surrounding urban development should be thoroughly planned and not executed in a haphazard manner. Exploitation and utilization of the pans should be kept to a minimum. Environmental impact assessments should be carried out before a pan is utilized for a certain function, otherwise aquatic life in the pan may be irreparably destroyed or the groundwater in the area may become polluted. Only hydrologically isolated pans (where sediments contain over 80% silt and clay) should, as a last resort, be considered for municipal and industrial waste disposal.

Involvement

The public as well as natural feature conservation organizations should become involved in the management and development of the pans as well as their immediate surroundings. Such action should prevent them from being utilized as dumping sites for either municipal or industrial wastes. Perhaps an 'Adopt a Pan' programme similar to the 'Adopt a Highway' system in the USA, where citizens or a company maintain a section of a highway in a neat condition, should be implemented.

Residential development

The establishment of residential areas on ground bordering the pans should preferably not be permitted. Nearby residential and squatter housing may result in the pollution of pan water. The pan and its immediate surroundings should be utilized to create high quality recreational areas, as formerly discussed, where residents may relieve their stresses from modern urban living conditions.

References

Alian, D., 1987. Transvaal Highveld pans. Afr. Wildl., 41: 233–235.

Beaumont, P.B., Van Zinderen Bakker, E.M. and Vogel, J.C., 1984. Environmental changes since 32 000 B.P. at Kathu pan, Northern Cape. In: J.C. Vogel (Editor), Late Cainozoic palaeoclimates of the Southern Hemisphere. Proceedings SASQUA Symposium, Swaziland. Balkema, Cape Town, pp. 329–338.

Deacon, H.J., 1983. Another look at the Pleistocene climates of South Africa. S. Afr. J. Sci., 79: 325–328.

De Bruiyn, H., 1971. Pans in the Western Orange Free State. Ann. Geol. Surv. S. Afr., 9: 121–124.

Geyser, G.W.P., 1950. Panne – hul ontstaan en die faktore wat daartoe aanleiding gegee het. S. Afr. Geogr. J., 32: 15–31.

Goudie, A.S. and Thomas, D.S.G., 1985. Pans in southern Africa with particular reference to South Africa. S. Afr. Geogr. J., 52: 93–101.

Harmse, J.T., 1992. A publication on pans. S. Afr. Geogr., 19: 5–6.

Harmse, J.T., Olivier, P.G. and Goudie, A.S., 1990. A Bibliography on Pans and Related Deposits. Rand Afrikaans University, Johannesburg, 60 pp.

King, L.C., 1953. South African Scenery. Oliver and Boyd, Edinburgh, 308 pp.

Le Grange, C.N., 1992. Die ontstaan en menslike benutting van panne aan die Oos-Rand. Unpubl. M.Sc. thesis, Rand Afrikaans University, Johannesburg, 183 pp.

Le Roux, J.S., 1978. The origin and distribution of pans in the Orange Frce State. S. Afr. Geogr., 6: 167–176.

Marshall, T.R., 1987. Morphotectonics of the Orange Free

State. Unpubl. M.Sc. thesis, University of the Witwatersrand, Johannesburg, 167 pp.

Marshall, T.R. and Harmse, J.T., 1992. On the origin and propagation of pans. S. Afr. Geogr., 19: 9–21.

Neal, J.T., 1975. Playas and Dried Lakes: Occurrence and Development. Dowden, Hutchinson and Ross, Stroudsburg, PA, 411 pp.

Pettijohn, F.J., Potter, P.E. and Siever, R.E., 1972. Sand and Sandstone. Springer-Verlag, Berlin, 327 pp.

Schmitz, P.M.U., 1989. The origin of pans in the northwestern Orange Free State. Unpublished Research Report, Rand Afrikaans University, Johannesburg, 67 pp.

Schulze, B.R., 1965. Climate of South Africa, Part 8: General Survey. Weather Bureau Publication 28. Government Printer, Pretoria, 330 pp.

Scott, L. and Brink, J., 1992. Palynological and palaeontological studies at South African pans. S. Afr. Geogr., 19: 22–34.

South African Committee for Stratigraphy (SACS), 1980. Lithostratigraphy of the republic of South Africa, South West Africa/Namibia and the republics of Boputhatswana, Transkei and Venda. Government Printer, Pretoria, SA, 690 pp.

Van der Merwe, H.J., 1992. GIS in the urban shadow: Reconciling dualistic First World–Third World planning priorities on the edge of the 'Apartheid city'. Technical Programme Abstracts, 27th International Geographical Congress, 9–14 August 1992, Washington DC, pp. 636–637.

Verhagen, B.Th., 1990. On the nature and genesis of pans. Palaeoecol. Afr., 21: 179–194.

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Public lies, private looting and the forced closure of Grootvlei Gold Mine, South Africa

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Mine closure and acid mine drainage (AMD) are major interrelated challenges facing South Africa's Witwatersrand gold mines. As a result of mining, the East, West and Central Rand compartments of the Witwatersrand Basin are interconnected, making AMD a regional problem. Consequently, the South African National Department of Mineral Resources recommends regional mine closure strategies. Unfortunately, the mismanagement of Grootvlei Gold Mine and its AMD problem resulted in premature and unplanned closure of the mine; massive job losses; pollution of a river and its Ramsar wetland site, as well as a significant setback for regional mine closure. Although directors were held civilly liable for damages to the mine, to date no one has been held liable for the water pollution, creating an impression that environmental laws can be flouted with impunity.

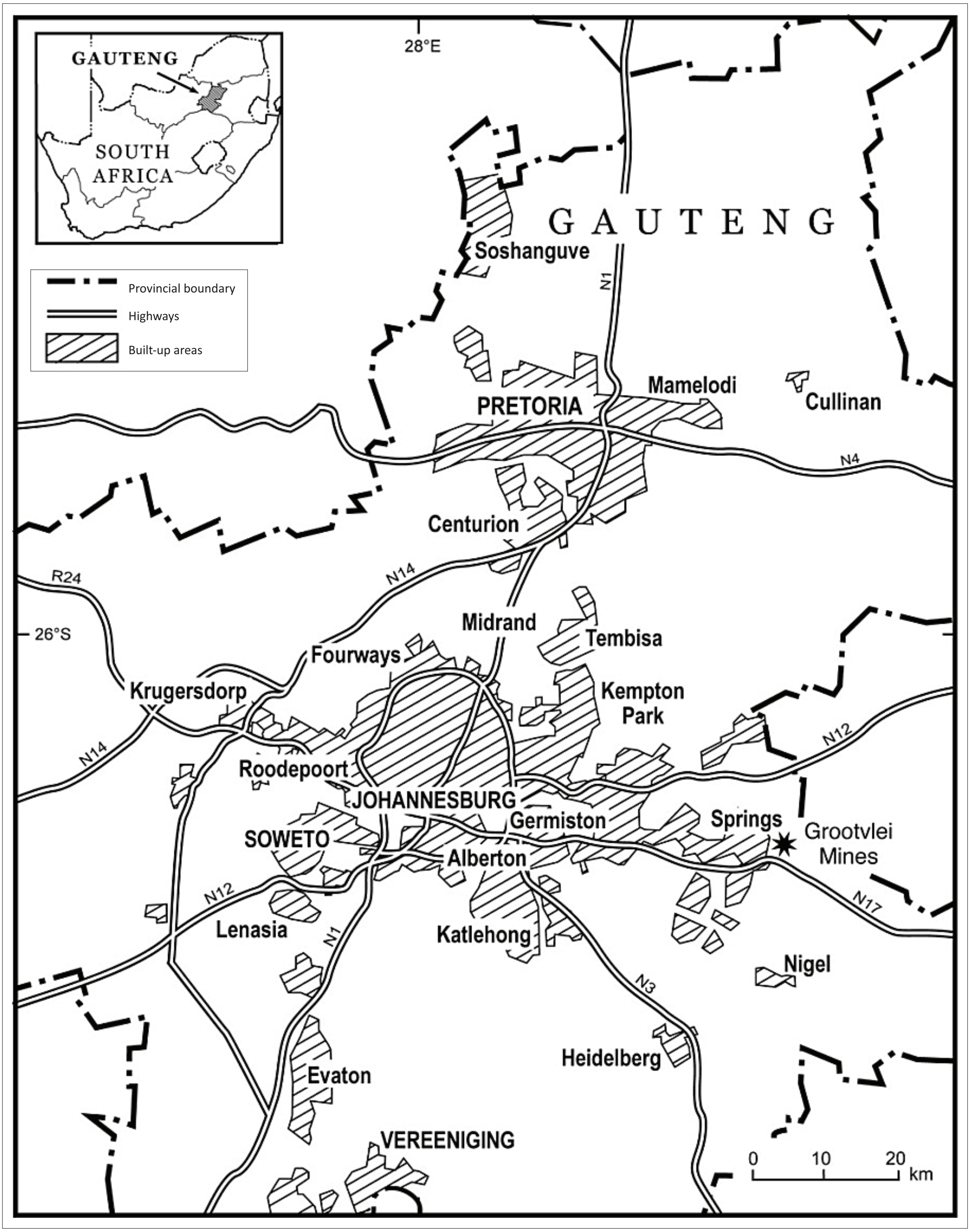
Introduction

Gold mining has been ongoing in the Witwatersrand Basin since 1886, with a cumulative impact on the region's land, water quality and ecosystems (Tutu, McCarthy & Cukrowska 2008). Rehabilitation is expensive, in part because impacts do not cease when a mine closes and the impacts are multiple. Moreover, the South African gold mining industry is in its 'sunset stage', creating major cash-flow challenges for the proper management of impacts (de Wet & Sidu 2013). One well-known and major impact is that of acid mine drainage (AMD) (Blowes et al. 2014; Bremmer 2013). The impact of AMD is a regional one, as underground workings are prone to flooding. If water is not consistently pumped out, underground tunnels become unworkable which may lead to forced mine closure. But pumping brings the AMD to the surface. As the underground tunnels of various mines are often connected, cessation of pumping (and subsequent flooding) of one mine threatens others (de Wet & Sidu 2013; McCarthy 2011). Thus, mines must pump this AMD even if the AMD is not actually a result of their own mining. AMD, however, is a threat to the freshwater systems of the Vaal Barrage sub-catchment and Vaal River, as well as the Crocodile West and Limpopo Rivers (Durand 2012). Therefore, any water pumped out by mines must also be treated to ameliorate such pollution. Consequently, the management of AMD is a major concern both for government and mining operations. In the case of financially stressed, end-of-life mines, such AMD responsibilities can become a serious financial burden in times of diminished cash flow (Milaras, Ahmed & McKay 2014).

This is a study of the Grootvlei Gold Mine (see Figure 1) situated in Springs, east of Johannesburg. Declining gold production has resulted in mine closures and the progressive cessation of AMD pumping regimes in the region, leaving Grootvlei the last operational gold mine on the East Rand Basin (McCarthy 2011). All responsibility to pump and treat AMD thus fell to Grootvlei, as the Eastern Basin's interconnected underground tunnels placed substantial water pressure on Grootvlei's operations. If the mine did not dewater, it would not be able to maintain production (Durand 2012). However, as Grootvlei was not always able to cope with both the cost of pumping and treating huge volumes of acidified water, untreated AMD was often pumped straight into the Blesbokspruit River System (Fourie 2009).

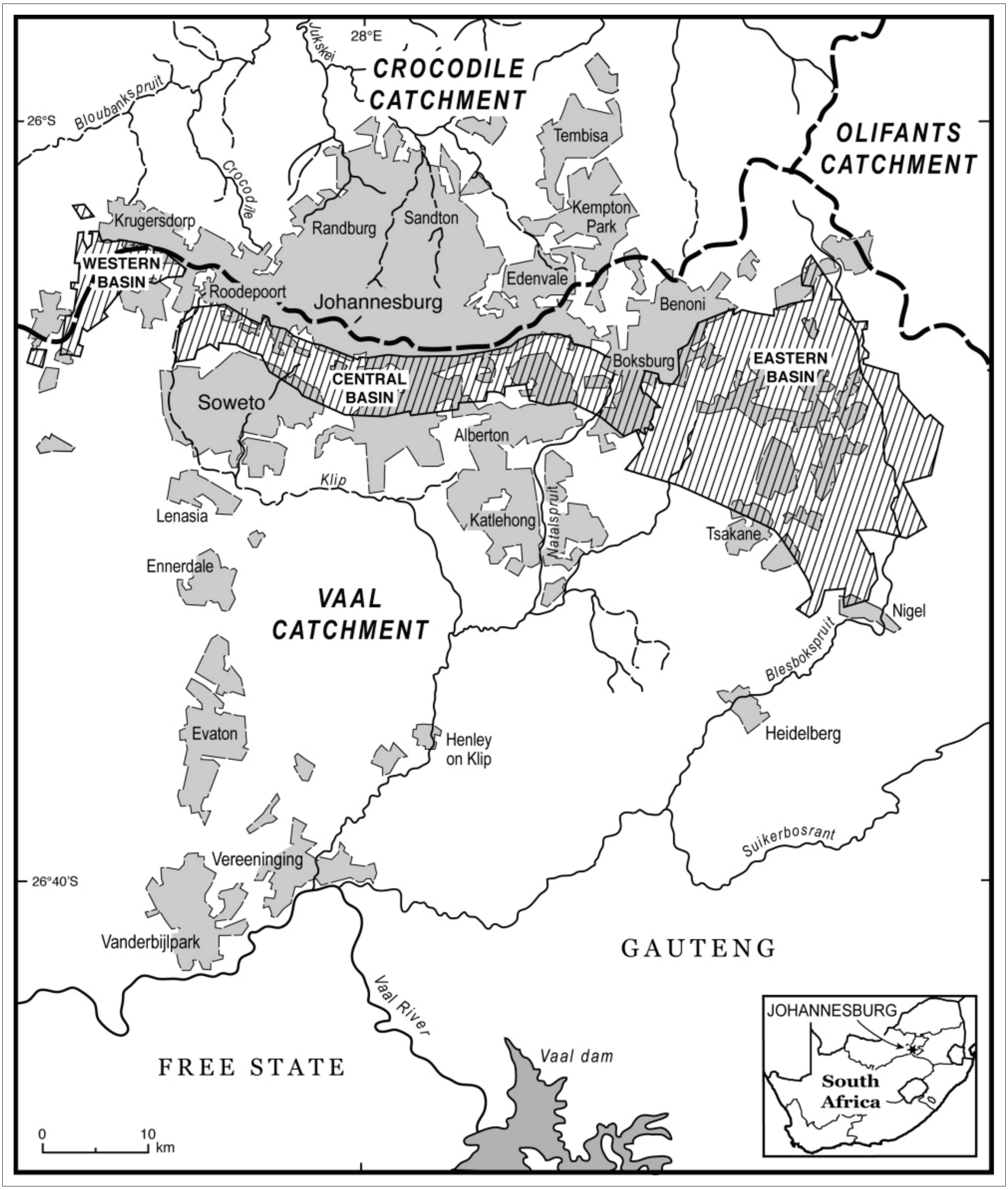
An overview of the AMD problem facing the Witwatersrand

The gold mines of the Witwatersrand region connect three sub-basins: the East Rand, West Rand and Central Rand (see Figure 2). To varying extents, all three face an AMD problem (DWA 2011). AMD forms when rocks that contain sulphide mineral pyrite (FeS_2) are exposed to oxygenated air and water. The resultant oxidisation leads to the formation of sulphuric acid and ferrous sulphate, or AMD (Blowes et al. 2014). AMD is saline, acidic, rich in mobilised heavy metals and thus highly toxic.



Source: Authors own work.

FIGURE 1: Grootvlei Gold Mine, Gauteng, South Africa.



Source: Authors own work.

FIGURE 2: The three Witwatersrand sub-basins and the associated water catchment areas of the Upper Vaal.

Management of AMD, therefore, requires (inter alia) acid neutralisation regimes. Although ideally source control techniques (preferably in the initial mine design) should be implemented, AMD on the Witwatersrand has been managed with 'reactive' control techniques (Murphy, Taylor & Leake 2012).

In 1957, the first report on the AMD problem in the Witwatersrand was released, although no action was taken to deal with it, until the severity of the AMD decant problem became apparent. Then, a treatment plan was presented to parliament in 1996. The plan was accepted in 1998, but again, little action was forthcoming. Mining and its associated underground dewatering practices first ceased on the West Rand in the 1990s, causing the old mine voids to flood (McCarthy 2010; Winde & Stoch 2010). Consequently, by August 2002, AMD began decanting to surface from an abandoned Randfontein Estates Ltd mine shaft in Mogale City into the Tweelopiespruit and Wonderfonteinspruit (Bremmer 2013; Hobbs & Cobbing 2007). It was only then the nature of the environmental risks to freshwater resources, as well as the socio-economic consequences, began to be realised (Ewart 2011). As all mining (and pumping) ceased in the Central Basin in 2008, it is expected that a similar situation will develop there. Despite this escalating situation, many mining companies appear to have little appetite for upgrading water treatment facilities or adhering to legislation designed to deal with the problem, resulting in perceptions that they are unwilling to take responsibility for the AMD problem (Hobbs, Oelofse & Rascher 2008; McCarthy 2010).

The decanting of AMD on the West Rand resulted in a massive outcry by environmentalists, NGOs and the media (Bremmer 2013). Consequently, the Minister of Water Affairs established an inter-ministerial committee (IMC) in 2010 (McCarthy 2010). This IMC was a specialised technical team tasked with investigating the problem and proposing a viable solution for the short, medium and long term. Task team members were made up of employees from the Department of Water Affairs (DWA), Department of Mineral Resources (DMR), Council for Scientific and Industrial Research (CSIR), Council for Geoscience (CGS) and Mintek and Water Research Commission (WRC). Cabinet adopted the final recommendations of the IMC report in January 2011 and, following pressure from NGOs, released it to the public in February 2011 (Ewart 2011). The task team report maintained that the AMD problem needed urgent attention and proposed solutions that drew on international (and national) best practices concerning water ingress, AMD generation and decanting, namely: (1) reduce the volume of water ingress into the shafts, (2) undertake to install flood and decanting management solutions so as to reduce the need to pump, (3) accurately predict when and where decant will occur once pumping ceases, (4) undertake to monitor the impact of underground mine flooding, (5) undertake an analysis of the impact of AMD on the environment and human health risks, and (6) ensure that uncontrolled decanting of AMD is avoided. Funds for the rehabilitation of abandoned mines and the financing of AMD have proven to be highly controversial and problematic, as has prosecution of the accountable mining companies (de Wet & Sidu 2013). The delays in taking action have been prolonged by both the government and mine owners, each claiming that the other is ultimately responsible and, thus, should pay for AMD treatment (Milaras et al. 2014).

Environmental rights, environmental legislation and acid mine drainage

South Africa has a strong legal regime promoting environmentally responsible mineral extraction and mine closure. Legislation includes the following: (1) the MPRDA or *Mineral and Petroleum Resources Development Act* No. 28 of 2002, enforced by the Department of Mineral Resources (DME), (2) the NEMA or *National Environmental Management Act*[1] No. 107 of 1998, enforced by the Department of Environmental Affairs (DEAT 1998) and (3) the NWA or *National Water Act* No. 36 of 1998,[2] enforced by the Department of Water and Sanitation (DWAF 1998). Both NEMA and the NWA (particularly Section 19) demand reasonable pollution prevention measures where a duty of care falls to the owners, managers or land occupiers. NEMA also makes provision for the polluter to pay for rehabilitation. The MPRDA demands mines manage mine-related pollution, holds them responsible for both preventing the pollution and paying for rehabilitation, as well as dictates what must occur in the event of mine closure.[3] Thus, South African legislation imposes a duty of care on mine owners, a legal and financial responsibility for mine closure and the remediation of environmental degradation. Key compliance tools available to government officials are permits, compliance notices and directives. Non-compliance is a criminal offence (Paterson & Kotzé 2009). Despite this, Liefferink and van Eeden (2010) raise concerns that government departments do not see AMD as an urgent problem, nor is there enforcement of the legislation. Overall, South Africa has a poor track record with respect to compliance with, and enforcement of, environmental laws, and government departments, the courts, as well as public and private institutions seldom work together to ensure compliance and enforcement (Paterson & Kotzé 2009). This weak response is partly owing to the perception that the environment should be leveraged for socio-economic growth (Strydom & King 2009).

Methodology, aims and research questions

This study used an inductive, qualitative case study framework (Yin 2011). The study sought to (a) establish the pattern of ownership and management of the Grootvlei Gold Mine and (b) detail the consequences of the mismanagement of both the mine and its AMD. Historical time sequencing of events using archival material and an inductive analytical

1. Sections 2; 24; 24R; 28; 32; 33.

2. Section 19.

3. Allowing a viable mine to close because of negligence may also be known as unplanned, forced or catastrophic closure.

approach was undertaken (Eisenhardt & Graebner 2007). The historical timeline was constructed using specialised reports, newspaper articles and online archival records, and they are accordingly referenced in line as primary data, with author and exact date. A two-tier search for all available online articles was conducted. Google searches, using key words (Aurora Empowerment Systems, Pamodzi Gold, Grootvlei, AMD and Acid Mine Water) led to the following 16 source websites: Mining Weekly, News 24, SAPA, Mail & Guardian, SAPA, Eyewitness News, Business Report, The Star, TimesLive, Fin 24, The Sunday Times, Legal Brief, Associated Press, e-News online, City Press and Africa Report. Thereafter, a search of each website was undertaken in order to find all relevant articles published. These online sources totalled 272 pages, with contributions from 29 different writers/authors.[4] From this data set, information pertaining to mine ownership, government action, the behaviour of the liquidators, owners and the relevant trade unions was extracted. This study has some limitations: some of the sources presented contradictory or differing views and the authors were not able to obtain confidential government and corporate documentation. Thus, the study is limited to the extensive media reports and the Bertelsmann Judgement. Follow-up studies to clarify and support the findings presented here are recommended.

Grootvlei Mine: Its surroundings and AMD problem

Grootvlei Mine is situated in the far east of the East Rand Basin (Lea, Waygood & Duthie 2003). The mine is located 3 km east of Springs and borders Consolidated Modderfontein (Cons Modder) Mine and Nigel Mine (Thorius 2004). Grootvlei had been actively mined for more than 80 years prior to its forced closure in 2011 (Palmer, Waygood & Lea 2006). There were four production shafts (Shafts: 1, 4, 6 and 8). The primary water pumping shaft was Shaft No. 3. Grootvlei made use of a high density separation (HDS) plant and numerous settling ponds to treat AMD (Van der Merwe & Lea 2003). Subsequently, water flowed into the Blesbokspruit River, which was a typical non-perennial, meandering Highveld stream. The river also has a wetland, known as the Marievale Bird Sanctuary and Wetland, which is a designated Ramsar site. The river is a tributary of the Suikerbosrand River, which flows into the Vaal River (see Figure 3) (Dini 1998). Both the Blesbokspruit and the wetland have been degraded by both urban and mining-related developments, and its conservation status is deemed threatened (Thorius 2004).

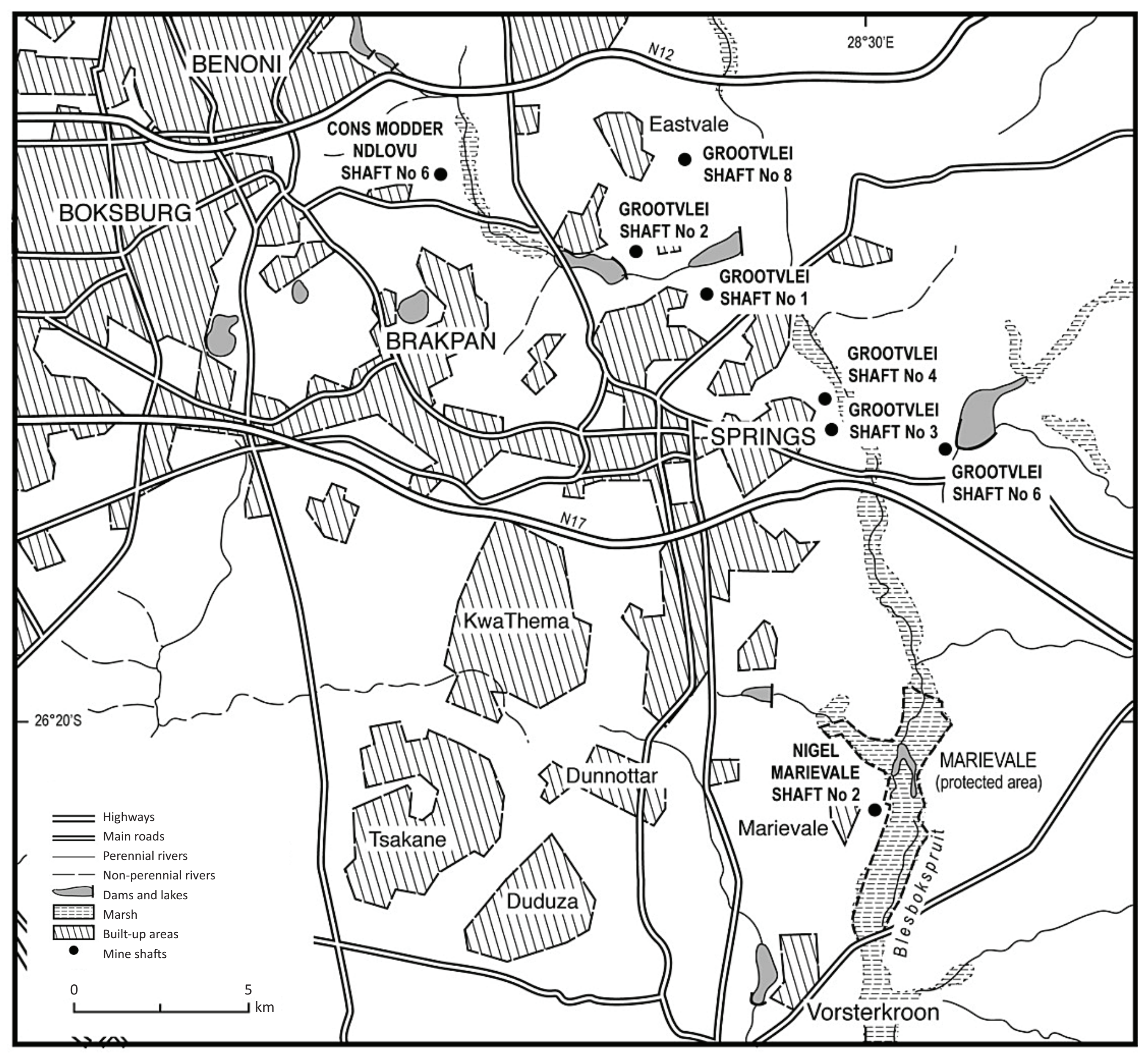
Between 1995 and 2003, a number of investigations on water ingress at Grootvlei were undertaken (see Barradas & Loggenberg 1996; Jones & Wagener (Pty) Ltd., 2003; Scott 1995; Wates, Meiring & Barnard (Pty) Ltd. 2002). These studies found that approximately 65% of Grootvlei's underground mine water originated from surface water, and thus, seasonal rainfall patterns exacerbate the underground flooding and AMD problems (Palmer et al. 2006). Jones and Wagener (2003) suggested a canal be built to reduce ingress volumes and to significantly reduce the volume of AMD and the amount of pumping and treatment required. But as another study felt that the canal would negatively affect the Blesbokspruit, it was not built (Palmer et al. 2006). No other plans to limit surface water ingress were ever tabled.

Findings: Mining operations at Grootvlei Gold Mine, a historical analysis

By the 1970s, gold mining on the East Rand was in decline. Difficult operational conditions were caused by a decline in the gold price, a decline in the already low-grade gold reserves, rising costs and increased water ingress (Baartjes & Gounden 2012). Because of the poor financial conditions, government subsidised the pumping and treatment of AMD from the East Rand with a sum of R8 million a month (Marius Keet, Parliamentary Portfolio Committee on Water and Environmental Affairs, AMD public hearings 20 April 2011). During the 1990s, GenGold Ltd. and Harmony Gold (Pty) Ltd. jointly owned Grootvlei and Consolidated Modderfontein (Cons Modder) Mine (last actively mined in 1962) (Plaut 2011). Eventually, in 1991, only Grootvlei Mine remained operational, making it the last remaining East Rand mine pumping and treating AMD (McCarthy 2011). By October 1995, the volume and the cost of pumping and treatment (of what was essentially the entire Eastern Basin) overwhelmed Grootvlei and massive volumes of untreated AMD (between 75 and 80 megalitres per day) flowed into the Blesbokspruit (McCarthy 2010). The result was salination of the soil within the region and a decrease in water quality (Thorius 2004). In 1996, the Department of Water Affairs and Forestry (DWAF) issued Grootvlei with a water permit despite the water having high levels of sulphates and iron concentrations (McCarthy 2010). This permit was revoked once it became clear that Grootvlei was contaminating the wetland with red iron oxide particulate matter (Van der Merwe & Lea 2003). In late 1996, a second dewatering permit was issued but stipulated that Grootvlei had to install six iron and sulphate settling ponds and a HDS water treatment plant to remove metal contaminants (Fourie 2009; Lea et al. 2003). Despite this, the water still contained high levels of sulphates. Once the HDS plant was fully operational, Grootvlei was issued a third permit to legalise the discharge of this partially treated water into the Blesbokspruit (Lea et al. 2003). Subsequently, HDS quantity and quality monitoring data supplied by Grootvlei indicated that the mine was operating within its (somewhat lenient) permit restrictions (de Wet & Sidu 2013).

In 1997, Harmony Gold (Pty) Ltd. bought out GenGold Ltd.'s share in the two mines. Subsequently, in 1998, both Cons Modder and Grootvlei were sold to Petmin Ltd. (Salgado, 28/02/2011). Soon thereafter (in 2000) Petrex (Pty)

4. Adriana Stuijt, Bongani Mthethwa, Christine Leondardi, Christy van der Merwe, David Fig, David Masondo, David McKay, Dewald van Rensburg, Dianne Hawker, Ernest Wolmarams, Gabi Falanga, Gertrude Makhafola, Gill Gifford, Idele Esterhuizen, Ilham Rawoot, Inge Salgado, Jana Marais, Jeanne van der Merwe, Jocelyn Newarch, Johan Jonck, Karabo Keepile, Khadija Sharife, Liesel Frankson, Loni Prinsloo, Lucky Biyase, Lynley Donnelly, Mara Kardas-Nelson, Mariaan Webb, Martin Creamer, Martin Plaut, Martin Zhuwakinyu, Megan Wait, Meshack Mbangula, Natasha Marrian, Sally Evans, Sipho Masondo, Yolandi Groenewald, Tyler Durden, Zwanga Mukhuthu. Note these media reports are referenced in line by author and the exact date of the article.



Source: Authors own work.

FIGURE 3: Location of Grootvlei mining shafts, the Blesbokspruit and Marievale Ramsar site.

Ltd. (part of Bema Gold Corporation, Canada at the time) bought both mines, as well as neighbouring Nigel Mining Company's mine (Salgado, 28/02/2011). Pamodzi Gold Ltd. purchased a controlling stake in Bema's Gold East Rand operations in December 2006 and, in doing so, took control of all three mines (Plaut 2013). Things did not go well, and by early 2009, Pamodzi Gold Ltd. began to suffer financially. Thus, the holders of the gold hedge, Unicredit and HypoVereinsbank of Germany, both had to invest money to keep the mine afloat (Creamer, 06/10/2009 & 08/06/2010). The state-owned Industrial Development Corporation (IDC) was also a major secured creditor (Creamer, 19/03/2010).

In a bid to reduce costs, the pumping and treatment of AMD, already confined to off-peak hours (to benefit from Eskom's off-peak electricity tariffs), were significantly reduced, threatening the viability of the mine as the water level rose (Creamer, 29/04/2009). With Pamodzi Gold Ltd. experiencing cash-flow problems and facing provisional liquidation, the DME allocated R7.5 million to assist the mine with some of the pumping costs (Creamer, 29/04/2009). Justification for the subsidy was based on the need to prevent the flooding of the mine 'at all costs' and that the 'fairly new pumping infrastructure … had to be saved'. This was because if AMD were to decant and remain untreated 'tons of poisonous ferrous and ferric acids will flow into the river' (Marius Keet, Deputy Director, DWS, in Stuijt, 10/03/2010). At this point, the South African government committed to spending at least R2.5 million per month to support AMD pumping and treatment in the East Rand Basin, a sum which represented roughly half of Grootvlei's monthly pumping cost (SABCs 50/50, 07/06/2010).[5] However, it seems that this money was

5. Although in July 2010 Zondwa Mandela said pumping cost R6.5 million a month (Jonck, Fin24, 27/07/2010; SAPA, 04/08/2010).

not paid across on a regular basis and mine managers often had to beg to get the transfers effected (Creamer, 29/04/2009; Stuijt, 10/03/2010). One reason for the delay in payments may be owing to Grootvlei failing to submit external laboratory certified water quality reports. Cash-flow problems had resulted in the laboratory been unpaid; consequently, they refused to do more work for the mine. The last laboratory report submitted by Grootvlei to DWS was June 2009 (SABCs 50/50, 07/06/2010). Intermittent pumping resulted in corrosion of underground steelworks and concerns began to be raised about possible underground flooding (Creamer, 19/03/2010 & 26/03/2010; Naidoo, 07/05/2009; Masondo, 18/01/2011). In a further bid to reduce costs, the treatment plant used less and less lime, flocculent and oxygen (Naidoo, 07/05/2009; Salgado, 28/02/2011). Consequently, the AMD concentrations in the Blesbokspruit worsened.

By late 2009, Pamodzi Gold Ltd. was facing provisional liquidation. Many employees were put on unpaid leave, whereas others were on a work stoppage over non-payment of wages. By September and October 2009, the company went into final liquidation (Creamer, 12/10/2009). Six liquidators were appointed. Soon thereafter, Enver Motala, as the lead liquidator, announced that Aurora Empowerment Systems (Pty) Ltd.'s bid of R495 million for Grootvlei had been accepted (Salgado, 28/02/2011). The Managing Director of Aurora Empowerment Systems (Pty) Ltd. is Zondwa Mandela (Nelson Mandela's grandson), its Chairperson is Khulubuse Zuma (Jacob Zuma's nephew), and three other directors were Sheshile Thulani Ngubane (Commerical Director), Fazel and Solly Bhana (Creamer, 12/10/2009 & 26/04/2010; Prinsloo, 07/04/2010). At the time, financial backing was said to be coming from Malaysia and the Middle East. Later on, it became clear that there was no such funders and that the liquidator had been warned of this at the time (Creamer, 12/10/2009; Hawker, 25/08/2014). Despite this, Sandra du Toit of Standard Bank testified (in a later High Court enquiry) that Motala refused to entertain any other offers for the mine (Hawker, 25/08/2014). In October 2009, Aurora paid a deposit of R10 million and took control of the shafts (four at Grootvlei; one at Nigel and one at Cons Modder) and the one pump station (Van der Merwe & Lea 2003; Wates, Meiring & Barnard 2002). Aurora promised to invest R600 million to upgrade and rehabilitate mine infrastructure, establish a community trust, provide health care services, fund housing purchases for employees, provide bursaries for employee's dependents and retain all the workers at the mine (Creamer, 12/10/2009 & 19/03/2010). Around the same time, some of the Aurora directors also offered R376 million (R296 million in cash for a 60% share, and R80 million as working capital) for DRD Gold's financially troubled, and under judicial management, Blyvooruitzicht mine on the West Rand (Creamer, 11/12/2009; Marais, 06/08/2014).

However, once Aurora took control of Grootvlei, the HDS plant was shut down (de Wet & Sidu 2013). The Financial Manager (Fazel Bhana) blamed a lack of payment of the governmental pumping subsidy for this (Stuijt, 10/03/2010). The mine was also beset with fatalities, resulting in two separate notices by the DME to cease operations, although the Aurora directors were able to make use of their political connections to continue mining (Seccombe, 29/08/2014; Bertelsmann, 25/06/2015). By January 2010, inconsistent pumping practices rendered two Grootvlei mine shafts permanently flooded (SAPA, 27/01/2010). Later, a third shaft also flooded (Stuijt, 10/03/2010; Fig, 2011). During this period, Aurora's MD maintained that Grootvlei was producing 150 kg of gold a month, although the Financial Manager said the amount of gold being mined was minimal[6] (Creamer, 11/12/2009; Stuijt, 10/03/2010). It was later established that Grootvlei had produced at least R81 million in gold between October 2009 and March 2010, although the trade union Solidarity has argued that R122 million is a more accurate figure (Groenewald & Rawoot, 26/03/2010; Wolmarans, 25/11/2011; Evans, 04/05/2012). The mine also suffered from intermittent work stoppages, as miners downed tools demanding their salaries. Aurora cajoled (some allege threatened) them into returning to work, but when promises of payment went unfulfilled, they downed tools again (Prinsloo, 31/03/2010; Creamer, 19/04/2010). Both Solidarity and another trade union, the National Union of Mineworkers (NUM), claimed that Aurora either underpaid or failed to pay its estimated 5200 employees. Nor were the other promises (such as housing) ever met (Creamer, 19/03/2010). As the mine appeared to be bereft of any on-site managers, shop stewards were forced to engage directly with the liquidators. NUM called for the DMR to intervene (Prinsloo, 25/03/2010). This did not happen, and by March 2010, Aurora laid off 1440 workers citing cash-flow problems (Creamer, 19/03/2010; Prinsloo, 26/03/2010). Various suppliers also went unpaid (Groenewald & Rawoot, 26/03/2010; Creamer, 17/06/2011). Non-payment resulted in Eskom cutting off the mine's power supply (the debt was R54 million) and the security contractor withdrawing its services, which caused a substantial increase in illegal mining (SAPA, 05/11/2014). Reports started to emerge of unpaid miners engaging in illegal mining and cable theft (Prinsloo, 07/04/2010; Prinsloo, 12/08/2010; Keepile, 07/09/2010). Rand Mutual also cancelled Grootvlei's insurance policy owing to non-payment (Groenewald & Rawoot, 14/05/2010). In April 2010, Aurora claimed it had paid wages for February 2010 and that an agreement with the trade unions had been signed to restart operations so that the remaining outstanding wages could be paid (Prinsloo, 07/04/2010; 09/04/2010; Creamer, 24/05/2010). Miners did return to work, but when only a portion of the outstanding salaries were paid, strike action recommenced (Prinsloo, 31/03/2010). Trade unions were by now openly expressing their unhappiness with the situation. For example, NUM and Congress of South African Trade Unions (COSATU) spokesperson said 'We have been very soft on the Aurora management for too long. It is about time to expose the type of management that Aurora has'

6.There were accusations that the liquidator failed to do due diligence on Aurora. For example, it emerged that Fazel Bhana had a questionable financial history having been fined by the Financial Services Board (FSB) for insider trading and arrested on charges of VAT fraud (Groenewald & Rawoot, 14/05/2010, 26/03/2010; McKay, 06/02/2011; Evans, 24/10/2014).

(in Prinsloo 31/03/2010). In turn, Aurora said wages could only be paid if the mine was in production and, as such, urged workers to return to work (Prinsloo 14/04/2010). This did not happen and the mine effectively ceased operations on 19 March 2010 (SABCs 50/50, 07/06/2010). Despite this, Aurora continued to claim that their takeover of the mine was on track, funding from a private international equity fund had been secured and the proposed listing on the Johannesburg Stock Exchange (JSE) would proceed (Prinsloo, 14/04/2010). The lead liquidator continued to support Aurora's offer to purchase, indicating that Switzerland's Global Emerging Markets (GEM) had pledged equity capital once Aurora was listed (Creamer, 26/04/2010; 08/06/2010). Later on, GEM claimed that their (one and only) investment (of R13 million) was personally facilitated by President Jacob Zuma and GEM thought the money was to pay Grootvlei wages. There is no evidence that wages were paid with GEM's money, or even that Aurora received the cash. President Zuma has not made any comments on GEM's allegation at all (Evans & Sole, 16/05/2014).

At the behest of the unions, a management and gold sales audit was undertaken. This audit revealed attempts by directors to use company cheques (that bounced) to pay personal debts (Groenewald & Rawoot, 14/05/2010). By June 2010, roughly 100 pump station workers downed tools over non-payment. At the time, Marius Keet of DWS said he was 'extremely concerned' about the situation and 'would have to intervene if pumping ceased again' as 'the department will not allow the mine to flood the pumps as this will result in the flooding of the [Eastern] basin and subsequently the decanting of acid mine drainage' (in Groenewald, 11/06/2010).

Aurora management again persuaded the workers to return to work on the promise of payment. This spurned the economist Mike Schussler to say that these Aurora workers were effectively working 'in the hope that they may be paid' and that, as they were doing so without life insurance, both the Department of Labour and South African labour laws had failed them (SAPA, 01/07/2010). During this time, allegations that political influences were enabling Aurora's bid for Grootvlei to remain in place were made by Solidarity (Prinsloo, 12/08/2010). Certainly, Enver Motala, the lead liquidator, implied this, saying that 'Aurora's BEE credentials were impressive' (Groenewald & Rawoot, 26/03/2010). Despite the urgency with which AMD pumping and treatment needed to be undertaken, by mid-2010, the six of the virtually new heavy duty pumps were removed by Aurora, who claimed the pumps had to be relocated to a higher level to protect them from possible flooding of the shaft (Bell 2011). The pumps were never reinstalled. Rather, they were sold off as scrap (Groenwald, 11/06/2010). As reports claimed that Aurora had also sold off other mine infrastructures, for scrap, such as the Cons Modder Ndlovu Shaft No 6, the ore-crushing and the gold-smelting plant, allegations of asset stripping began to emerge (Creamer, 30/07/2010). By this stage, AMD was flowing untreated into the Blesbokspruit (Creamer, 19/03/2010). This was confirmed by water samples taken by DWS officials (Frankson, 12/11/2014). DWS consequently issued a directive to the mine to both pump and treat the AMD. In May 2010, it was announced that criminal charges for ignoring the directive and polluting the Blesbokspruit had been laid against Aurora directors (Groenewald & Rawoot, 14/05/2010; SABCs 50/50, 07/06/2010; Kardas-Nelson, 26/11/2010). As Grootvlei only had two pumps left, by July 2010 only 40 megalitres of AMD was being pumped per day, causing the mine to flood. This prompted a site visit by Marius Keet of DWS, accompanied by the Democratic Alliance, South Africa's official opposition party. Keet was assured that pumping equipment had been acquired and would be installed within days (Jonck, 27/07/2010). In August 2010 when it was apparent that this had not occurred, Aurora said it needed to repair the pumping equipment, but pumping at full capacity would resume within days and the electricity to do so had been secured from Eskom. Mine management denied that untreated AMD was flowing into the Blesbokspruit. Subsequently, Marius Keet indicated that the matter had been dealt with 'at ministerial level' (in SAPA, 04/08/2010).

Owing to the ongoing non-payment of wages, Solidarity requested an insolvency inquiry relating to the activities of the directors of Aurora and their business consultants. In September 2010, Solidarity indicated that progress had been made into the matter and that a Companies Act Section 424 application, which holds directors personally responsible for the mismanagement of a company, had been made (Keepile, 07/09/2010). In response to a Labour Court ruling, brought by Solidarity and NUM, in December 2010, Aurora[7] paid over R2 million to the Department of Labour, who, in turn, paid some R800 000 to 240 miners in outstanding wages (Prinsloo, 25/01/2011). Although Aurora owed 1400 workers their wages (totalling R15 million), not all had lodged official claims and for some their information could not be verified (SAPA, 22/12/2010). Despite the ongoing AMD problems, failure to pay suppliers and workers, Motala maintained that Aurora's listing on the JSE was 'on track' and that funding had been secured from a state-owned mainland Chinese company (in Creamer, 19/11/2010). Jen-Chih Huang (Khulubuse Zuma's business partner) was actively involved in promoting this deal (News24, 22/06/2014). Thus, Aurora was given until 28 February 2011 to come up with the finance to pay for Grootvlei, a decision the employees of the mine did not support (SAPA, 17/12/2010; 22/12/2010, Masondo, 18/01/2011).

By early 2011, only a handful of employees remained. Reports indicated that the rate of underground flooding was increasing and the window of time to save the mine from being rendered unworkable (because of the gold becoming inaccessible) was down to months (Masondo, 18/01/2011; Rawoot, 11/02/2011).

7. Enver Motala said the chairman of Aurora had paid the money from his personal accounts (SAPA, 17/12/2010). Khulubuse Zuma testified to this fact as well (Evan, 04/05/2012) and Bertelsmann (25/06/2015) noted that a sum of R35million was paid in the chairman's personal capacity.

Despite this, the lead liquidator was still adamant that 'Things are 100% on track. It is just a matter of time. By February 28 [2011] the Chinese company that will partner Aurora must issue guarantees and the deal will go through' (in Masondo, 18/01/2011). NUM indicated that they did not think this was likely due to the history of 'unfulfilled promises' (in Masondo, 18/01/2011). Disillusioned with the lack of payment by Aurora of salaries, union dues and benefits to both its members and even non-members (who wished to be part of the class action),[8] Solidarity announced that it would seek a High Court liquidation order of the company (Prinsloo, 25/01/2011; SAPA, 16/02/2011). It was also reported that Aurora removed the two remaining pumps (valued at R1 million each) ostensibly to 'protect' them from rising mine water (McKay, 06/02/2011). The removal of the last two pumps meant that by February 2011, all pumping ceased and Goliath Gold had to temporarily shut its Nigel One shaft because of water seeping in from Grootvlei (Rawoot, 11/02/2011; SAPA, 09/06/2011). When Linda Page of DWS was made aware of this, she said there was 'no danger of any flooding' and that her department was 'monitoring the water levels' (in Rawoot, 11/02/2011). In April 2011, Zondwa Mandela, representing Aurora, reported to the Parliamentary Portfolio Committee on Mineral Resources that Grootvlei was suffering from cash-flow problems because of the need to pump and treat AMD, the lack of a pumping subsidy from DWS, illegal miners, as well as the actions of NUM and Solidarity (City Press, 14/04/2011). He also claimed that 80% of the outstanding wages had been paid. During this time, the Chinese deal fell though and so Aurora was unable to come up with the required funding to pay for Grootvlei. Nevertheless, the High Court gave the directors yet another extension (until 16 August 2011) to come up with the money. This prompted the South African Human Rights Commission (SAHRC) to request the Minister of Mineral Resources to intervene to get the workers paid, to prevent the rise of AMD and to come up with a plan to rehabilitate the mine. SAHRC was concerned that the granting of extensions to Aurora to finance the purchase of the mine had caused many of the resultant problems (SAPA, 15/04/2011).

In May 2011, Solidarity lodged a liquidation application against Aurora, for a sum of R3.1 million (Creamer, 20/05/2011). In the same month, the Master of the Pretoria High Court removed Enver Motala and the KPMG liquidator Gavin Gainsford as liquidators, seemingly based on a report compiled by the other liquidators and submitted to a formal Section 381 of the Companies Act enquiry (Creamer, 23/05/2011; Rawoot, 27/05/2011; SAPA, 21/09/2011). Within days of this decision, the remaining liquidators (with Johan Engelbrecht from Icon Insolvency, as the new lead liquidator), assisted by a private security firm, ousted Aurora from Grootvlei (Creamer, 27/05/2011; 10/06/2011). Motale, blaming the trade unions for his removal, did make some effort to get himself reinstated, to no avail (Rawoot, 27/05/2011; Rawoot, 03/06/2011; SAPA, 21/09/2011). He was also subsequently struck off the role as a liquidator when it emerged that he had been convicted of fraud and theft charges (City Press, 31/08/2014).

At this stage, not much was left of the mine, having being stripped of metal, wood, headgear, infrastructure, pumps and the like, by both Aurora and remaining unpaid mine workers (Rawoot, 27/05/2011; Hawker 26/03/2015). COSATU called for government to investigate the liquidators, the asset stripping that took place and the violation of labour laws (SAPA, 02/06/2011). One Aurora director, Thulani Ngubane blamed the mine itself, the workers, the media and the unions for the fate of the mine and the loss of the Chinese buyer (Rawoot, 03/06/2011). Subsequently, it was claimed that DWA was proceeding with the criminal case, with respect to the AMD pollution, with charges having been laid and advice being sought if the directors and the liquidators should be charged as well (Balzer, Parliamentary Portfolio Committee on Water and Environmental Affairs, AMD public hearings 20 June 2011). The new liquidators denied that they could be held criminally liable, maintaining that they had done all that was necessary to ensure that AMD from Grootvlei would not enter the surface water. This included approaching the DWA with a plan to prevent an AMD decant (Creamer, 17/06/2011; 23/06/2011).

In August 2011 Aurora's directors testified under Sections 417 and 418 of the Companies Act, to the Master of the Pretoria High Court with respect to allegations of asset stripping and cessation of operations at Grootvlei (Groenewald & Rawoot, 05/08/2011; Prinsloo, 11/08/2011; SAPA, 21/09/2011). On 5 October 2011, Aurora Empowerment Systems was liquidated based on a R9 million claim lodged against the company by a creditor, Copper Eagle (Wolmarans, 25/11/2011). In January 2012, another Aurora creditor, Protea Security, obtained a default judgement against Khulubuse Zuma for R10 million, based on him standing surety for their unpaid claim against Aurora (SAPA, 12/01/2012). In March 2012, lead liquidator Johan Engelbrecht issued Section 424 summonses against Aurora directors with respect to personal liability claims for damages relating to Grootvlei owing to how they had 'managed the affairs of Aurora recklessly with the intent to defraud' (Creamer, 05/03/2012; Engelbrecht in Evans, 04/05/2012). This included the failure to pay workers, stripping of assets, lying about securing funding to purchase the mine, being commercially insolvent while operating Grootvlei and the removal of gold from the mine (Evans, 04/05/2012).

Grootvlei was so irreversibly stripped of equipment and vandalised that it could not be revived as a mine. Gold One and Goliath Gold bought the remnants of the gold processing plant, the office block and the mineral rights for a sum of R70 million in 2012 (Esterhuizen, 18/04/2012; Evans & Sole, 16/05/2014; Bertelsmann, 25/06/2015). Environmental liabilities were limited to a maximum of R10 million (Esterhuizen, 18/04/2012). Marius Keet had noted that it was unlikely that the mine would have been sold if the sale

8. Solidarity claimed that Aurora failed to pay salaries, failed to pay over pension fund contributions, failed to pay UIF and PAYE, as well as deducted union membership fees but did not pay them over to the union (SAPA, 16/02/2011). This resulted in the Mineworker's Pension Fund reporting Aurora to the FSB and the National Prosecuting Authority (NPA) (Groenewald & Rawoot, 26/03/2010).

included the transfer of all the environmental liabilities (Parliamentary headings into AMD, 20/06/2011). Thus, most of the environmental liabilities fell to the State. To deal with the AMD problem, DWS applied for authorisation for the construction of an AMD treatment plant at Grootvlei's No. 3 shaft (Mukhuthu, 20/06/2014). As the AMD problem was deemed an emergency, environmental authorisation was granted quickly (as EIA requirements can be ignored if the construction is an emergency), in spite of a public outcry (Mukhuthu, 20/06/2014). The plant is yet to come online (Creamer, 02/07/2015).

As the mine was no longer a going concern, the liquidators laid fraud charges against the directors of Aurora (Evans, 04/05/2012; Hawker, 24/08/2014). A smaller claim for R15.5 million was successfully laid by the liquidators against Faizel and Suliman Bhana, Mohamed Limbada and Zeenat Laher for monies paid to them from Aurora accounts, supposedly as repayments for loans (van Rensburg & van der Merwe, 21/08/2014; Gifford, 26/09/2014). This ruling was appealed, but later upheld (Hawker, 22/03/2015). The liquidators argued that Aurora had to reinstate and restore the mine to the state it was in when Aurora took over in October 2009 (Rawoot, 03/06/2011). Failure to do so meant that Aurora faced a claim of R1.7 billion for damages, loss of gold sales and unpaid salaries (SAPA, 25/08/2014). At the same time, Sections 417, 418 and 424 hearing into Aurora went ahead. This was heard in camera, and the North Gauteng High Court refused to make the report public, despite a Promotion of Access to Information Act (PAIA) application (Harper, 26/01/2014; Hawker, 24/08/2014). At the time it was claimed because the report made damning findings, there was a potential defamation claim and that criminal charges could be laid (Rossouw in Harper, 26/01/2014; Hawker, 24/08/2014). Judge Bertelsmann finally made the transcripts of the insolvency enquiry public in August 2014. Although the report called for criminal charges to be laid, the Special Investigating Unit (SIA) claimed that only President Zuma could authorise the start of the criminal investigations into Aurora and that 'The Presidency has not given any indication of when the proclamation will be issued' (Boy Ndala in Hawker 24/08/2014). The National Prosecuting Authority (NPA) said they could not investigate, only the South Africa Police Service could, and, as such, referred the Master of the Court's report back to the court (Hawker, 24/08/2014).

The case against the Aurora directors was postponed several times. Delays were attributed to the late filing of court papers by Aurora, their lawyers requesting delays to secure funds and a lack of financial records for Aurora (Creamer, 14/10/2011; Hawker, 19/08/2014). The case was finally heard in 2015 and Judge Bertlesmann ordered that the Aurora directors be held jointly and severally liable, in their personal and private capacities, for the damages to the mine. They were also held liable for the non-payment of mine workers and creditors, as well as for gross negligence and mismanagement (such as routing money from Grootvlei to themselves instead of paying salaries and creditors) (Hawker, 22/03/2015). During the course of the case, it became clear that Aurora had bid for the mine without having the financial resources to pay for them (Maromo, 24/03/2015). The respondents were also ordered to pay the costs of the applicants (Bertelsmann, 25/06/2015). Based on this judgement, the police announced that they were investigating charges of fraud, money laundering, racketeering and misrepresentation (Brigadier Hangwani Mulaudzi in Falanga & Mabotja, 06/07/2015). The parties did lodge a request to appeal the Bertlesmann ruling, but this met with no success (Mabuza, 18/09/2015). The directors of Aurora approached the Supreme Court of Appeals with an appeal application which was rejected (Crowley & Prinsloo, 15/02/2016; Makhafola, 12/05/2016). The liquidators are now pursuing the directors and managers for the Aurora debt of R1.7 billion. The case has been postponed till March 2017 (Legalbrief, 01/04/2016). In September 2016, the Bhanas were sequestrated by the North Gauteng High Court and Khulubuse Zuma settled with the liquidators and unions for a sum of R23 million (to be paid over 52 months) for unpaid wages (IOL, 07/09/2016).

Summary and analysis

Grootvlei was historically a financially marginal mine because of frequent flooding, declining gold ore reserves and volatile gold prices. Thus, Grootvlei often required capital injections and was ill placed to deal with the cost of an AMD problem generated by the entire Eastern Basin. As the difficulties and liabilities of Grootvlei became apparent, various owners put the mine up for sale (Sharife, 21/03/2011). Between 1990 and 2014, Grootvlei underwent multiple changes of owners, with control passing from larger, established, better-funded mining companies to smaller, less well-funded junior ones (Stuijt, 10/03/2010; Salgado, 28/02/2011). These smaller Black Economic Empowerment (BEE) companies may not have fully realised Grootvlei's financial and environmental problems and were certainly not in a financial or knowledge position to deal with them. From 2009 onwards, Grootvlei faltered in meeting its AMD obligations, exposing the Blesbokspruit to untreated AMD decant (Marais, 06/08/2014). This was most certainly an indication of mine managers trying to contain costs. Although the State paid an AMD subsidy, it was insufficient; payments were intermittent and attached to stringent verifiable pumping and treatment regimes.

However, there was a significant change in management practices at Grootvlei when Aurora took control of the mine. Aurora actively hindered the ability of workers to keep the mine operational or meet its AMD obligations by removing (and selling) mine equipment, pumps and headgear. Labour practices also changed. Workers were paid late or not at all and strikes ensued. The pumping and treating of AMD became more intermittent and eventually ceased, leaving the mine permanently flooded and rendering it unworkable. The loss of the underground gold reserves can be taken as a loss to South Africa as all mineral resources are national assets (McKay, 06/02/2011). Of concern is that strikingly similar circumstances, including some of the same people, lead to the closure of the Blyvooruitzicht mine on the West Rand (Humby 2014).

As a consequence of the eventual liquidation of Aurora and the sale of the remaining assets to Gold One, most of the environmental liabilities passed to the State, with serious implications for the taxpayer (Sharife, 21/03/2011; Marais, 06/08/2014). In March 2014, the DWA announced the State would build an AMD treatment plant costing R319 million, a sum that quickly tripled to R956 million by June 2014. More recently, the plant is said to cost R10 billion (Creamer, 02/07/2015). PG Mavundla, an ANC regional branch head in KwaZulu-Natal and former ANC mayor of Umvoti municipality, has won the contract for the project (Mthethwa, 19/10/2014; Mukhuthu, 20/06/2014). Thus, the actual cost to the South African state associated with the AMD problem has escalated alarmingly. From a state pumping subsidy of between R2.5 and R6 million per month to that of R10 billion capex for a brand new AMD reverse osmosis or ion exchange treatment plant, as well as an estimated ongoing cost of R25 million per month for running costs (Molatlhwa, 19/05/2016).

Despite South Africa's mining and mine rehabilitation legislation placing legal obligations on the directors, this did not prevent (or even mitigate) the situation at Grootvlei. Law enforcement was intermittent, weak and seemingly not viewed as urgent by DWS or DMR, despite the high-level Inter-Ministerial Committee's report indicating that Grootvlei's pumping shaft had to be secured and AMD pumping and treatment had to resume (van der Merwe, 24/02/2011). Although key environmental compliance and enforcement tools such as permits, compliance notices and directives were at the disposal of government officials, very few were used. It has been argued that the AMD crisis at Grootvlei could have been avoided if law enforcement was stronger (Liefferink & van Eeden 2010). Despite the specialised cabinet commissioned AMD task team urging extreme urgency and action regarding AMD, it is clear such urgency is not government policy (McCarthy 2011).

To date, the DMR has not taken any action against the directors or mine management (McKay, 06/02/2011). Thus, NUM has argued that Aurora 'directors … are receiving preferential treatment because of their political clout' (Sharife, 21/03/2011). Solidarity also claims the first set of liquidators are partly responsible for the forced mine closure as they did not do due diligence on the directors, nor did they ensure that the mine was run properly while under Aurora's care, despite their legal obligation to preserve the asset (McKay, 06/02/2011; SAPA, 20/05/2011; Marais, 06/08/2014; Hawker, 22/03/2015). In addition, Solidarity and NUM note the Insolvency Act does not offer adequate protection for workers. They argue for tighter regulations over who can be appointed as company directors (30/05/2012, SAPA). There is also need to review South Africa's liquidation laws, as selling a mine in liquidation simply to the highest bidder may not be the best option. Importantly, the new owners should have the relevant experience and skills to run a mine and manage the attendant environmental impacts (Creamer, 27/05/2011; 03/06/2011; Marais, 06/08/2014). In addition, although the DMR has to agree to the mining rights to be transferred in the case of liquidation, the DMR has little legal standing to intervene in liquidations. There is also a compliance gap between mining law which requires mines to obtain a closure certificate and company law which allows a company to be deregistered relatively easily (Marais, 06/08/2014). Furthermore, during the period of liquidation, it is not clear who is responsible for environmental damages (Marais, 06/08/2014). It may be that the sale of near-closure mines to inexperienced, underfunded junior miners undermines the duty of care obligations embedded in mine closure legislation. The events pertaining to ownership, operations and management of Grootvlei is crucial for highlighting responsibilities pertaining to AMD. South Africa's environmental legislation framework (which encompasses AMD) is strong, but it is clear that a combination of political will and amended legislation is needed to effectively tackle abandoned mines and attendant environmental liabilities (Humby 2014). Because the 'environment as a creditor' is not prioritised and has no 'special call' on a company's assets, it behoves the State as custodian of the environment to shoulder its responsibility and uphold its creditor rights with respect to the liability of mine closure rehabilitation.

Conclusion

Grootvlei was a marginal mine, hobbled by inheriting responsibility for pumping and treating AMD for the entire Eastern Basin. Its financial difficulties resulted in its continual change in ownership, as mine companies sought to offload an underperforming, near end-of-life asset. Until 2009, however, Grootvlei was operational, paying wages and fulfilling its AMD obligations (albeit intermittently and with difficulty). The situation changed radically when Aurora took control. Mining activities ceased; mine infrastructure was dismantled and sold for scrap; AMD was no longer pumped or treated, and mineworkers went unpaid. The mine is now permanently closed. AMD now continues to rise and will certainly decant in time (DWA 2011). Despite comprehensive environmental legislation, the mine owners, mine managers and the various government officials (who should have prevented such flagrant violations) have not been brought to book. In addition, the destruction of this mine has created the impression that laws can be flouted with impunity. Fortunately, the determination of the second set of liquidators to pursue the Aurora directors civilly resulted in a judgement holding them liable for the non-payment of workers and the destruction of the Grootvlei and Cons Modder infrastructure.

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Competing interests

The authors declare that they have no financial or personal relationships which may have inappropriately influenced them in writing this article.

Authors' contributions

T.J.M.M was the Project Leader; she analysed the data and wrote and edited the manuscript. M.M. wrote and edited the manuscript.

References

Baartjes, N.L. & Gounden, K.G., 2012, *Causes of mine decline in South Africa*, EcoPartners, Johannesburg.

Barradas, F.V. & Loggenberg, A.P., 1996, *Investigation of surface water ingress to the East Rand Basin*, Directorate Mine Surveying – Minerals and Energy Affairs, Pretoria.

Bell, T., 2011, *Aurora's golden greed and liability hopes*, WordPress, viewed 8 February 2016, from http://terrybellwrites.com/2011/12/02/auroras-golden-greed-and-liability-hopes/

Blowes, D.W., Ptacek, C.J., Jambor, J.L. & Weisener, C.G., 2014, 'The geochemistry of acid mine drainage', *Treatise on Geochemistry* 9, 149–204. http://dx.doi.org/10.1016/b978-0-08-095975-7.00905-0

Bremmer, L., 2013, 'The political life of rising acid mine water', *Urban Forum* 24, 463–483.

Department of Environmental Affairs and Tourism (DEAT), 1998, 'National Environmental Management Act No. 107 of 1998 (NEMA)', *Government Gazette* vol. 401, no. 19519.

Department of Water Affairs and Forestry (DWAF), 1998, National Water Act No. 36 of 1998 (NWA), *Government Gazette* vol. 71, no. 31417.

Department of Water Affairs (DWA), 2011, 'Mine water management in the Witwatersrand Goldfields with special emphasis on acid mine drainage', Meeting no 4, Strategy Steering Committee of the Vaal River System. Department of Water Affairs, Johannesburg, 13 April.

de Wet, L. & Sidu, S., 2013, 'Water quality and compliance monitoring of treated underground and surface water at the Grootvlei Proprietary Mines and the Blesbokspruit wetland, Springs, South Africa', *Proceedings of the International Mine Water Association*, Golden, Colorado, viewed 7 June 2016, from http://mwen.info/docs/imwa_2013/IMWA2013_deWet_501.pdf

Dini, J., 1998, *Blesbokspruit Ramsar Information Sheet*, viewed 9 March 2016, from https://rsis.ramsar.org/RISapp/files/RISrep/ZA343RIS.pdf

Durand, J.F., 2012, 'The impact of gold mining on the Witwatersrand on the rivers and karst system of Gauteng and North West Province, South Africa', *Journal of African Earth Sciences* 68, 24–43. http://dx.doi.org/10.1016/j.jafrearsci.2012.03.013

Eisenhardt, K.M. & Graebner, M.E., 2007, 'Theory building from cases: Opportunities and challenges', *The Academy of Management Journal* 50(1), 25–32. http://dx.doi.org/10.5465/AMJ.2007.24160888

Ewart, T.I., 2011, 'Acid mine drainage in the Gauteng Province of South Africa – A phenomenological study on the degree of alignment between stakeholders concerning a sustainable solution to acid mine drainage', Masters dissertation, University of Stellenbosch, Stellenbosch.

Fourie, M., 2009, *Acid mine drainage for Witwatersrand Gold Mines. Environmental law remedies available to regulators and civil society*, Johannesburg, viewed 17 February 2016, from http://cer.org.za/wp-content/uploads/2011/01/Melissa-Fourie-on-AMD-Oct-2009.pdf

Hobbs, P., Oelofse, S.H. & Rascher, J., 2008, 'Management of environmental impacts from coal mining in the Upper Olifants River catchment as a function of age and scale', *Water Resources Development* 24(3), 417–431. http://dx.doi.org/10.1080/07900620802127366

Hobbs, P.J. & Cobbing, J.E., 2007, *A hydrogeological assessment of acid mine drainage impacts in the West Rand Basin, Gauteng Province, CSIR, Pretoria*, viewed 27 October 2016, from http://researchspace.csir.co.za/dspace/handle/10204/3348

Humby, T., 2014, 'Facilitating dereliction? How the South African legal regulatory framework enables mining companies to circumvent closure duties', in I.M. Weiersbye, A.B. Fourie, M. Tibbett & K. Mercer (eds.), *Mine closure 2014*, University of the Witwatersrand, Johannesburg: 1–17.

Jones & Wagener (Pty) Ltd., 2003, *Grootvlei Proprietary Mines (Pty) Ltd., A subsidiary of Petrex (Pty) Ltd.: Feasibility study on the reduction of surface water inflows to the underground workings*, Report No. JW101/03/8894, Jones & Wagener (Pty) Ltd., Sandton.

Lea, I., Waygood, C. & Duthie, A., 2003, 'Water management strategies to reduce long-term liabilities at Grootvlei Gold Mine', in *Proceedings of the 8th International Congress on Mine Water and the Environment,* Johannesburg, viewed 8 February 2016, from http://www.imwa.info/docs/imwa_2003/imwa_2003_441-449.pdf

Liefferink, M. & van Eeden, E.S., 2010, 'Proactive environmental activism to promote the remediation of mined land and acid mine drainage: A success story from the South African goldfields', in *Proceedings of the International Mine Water Association*, Sydney, Nova Scotia, pp. 537–540, viewed 7 June 2016, from https://www.imwa.info/docs/imwa_2010/IMWA2010_Liefferink_521.pdf

McCarthy, T.S., 2010, *Decanting of acid mine water in the Gauteng city-region: Analysis, prognosis and solutions*, GCRO, Johannesburg.

McCarthy, T.S., 2011, 'The impact of acid mine drainage in South Africa', *South African Journal of Science* 107, 1–7. http://dx.doi.org/10.4102/sajs.v107i5/6.712

Milaras, M., Ahmed, F. & McKay, T.J.M., 2014, 'Mine closure in South Africa: A survey of current professional thinking and practice', in I.M. Weiersbye, A.B. Fourie, M. Tibbett & K. Mercer (eds.), *Mine closure 2014,* University of the Witwatersrand, Johannesburg.

Murphy, N., Taylor, J. & Leake, M., 2012, *Coming to terms with acid mine drainage*, viewed 8 February 2016, from http://www.earthsystems.com.au/wp-content/uploads/2012/03/BestPrac_Acid_Drainage.pdf

Palmer, M., Waygood, C. & Lea, I., 2006, 'Case study on the remediation of water ingress to old gold workings linked to active mining areas in South Africa', in *Proceedings of the 7th International Conference on Acid Rock Drainage (ICARD)*, St. Louis, viewed 8 February 2016, from http://www.asmr.us/Publications/Conference%20Proceedings/2006/2281-Waygood-ZA.pdf

Paterson, A. & Kotzé, L.J., 2009, *Environmental compliance and enforcement in South Africa: Legal perspectives*, Juta Law, Cape Town.

Plaut, M., 2011, Mandela and Zuma gold mine 'exploiting workers', *BBC Radio 4, Crossing Continents*, viewed 8 February 2016, from http://www.bbc.com/news/world-africa-13275704

Plaut, M., 2013, *Johannesburg: Who pays for a century of mining?* WordPress, viewed 8 February 2016, from http://martinplaut.wordpress.com/2013/05/23/johannesburg-who-pays-for-a-century-of-mining

Scott, R., 1995, *Flooding of Central and East Rand gold mines. An investigation into controls over the inflow rate, water quality and predicted impacts of flooded mines*, Report No. 486/1/95, WRC Pretoria.

Strydom, H.A. & King, N.D., 2009, *Environmental management in South Africa*, 2nd edn., Juta Law, Cape Town.

Thorius, T., 2004, 'The effect of Grootvlei mine water on the Blesbokspruit', Masters dissertation, University of Johannesburg, Johannesburg.

Tutu, H., McCarthy, T.S. & Cukrowska, E., 2008, The chemical characteristics of acid mine drainage with particular reference to sources, distribution and remediation: The Witwatersrand Basin, South Africa a case study, *Applied Geochemistry* 23, 3666–3684. http://dx.doi.org/10.1016/j.apgeochem.2008.09.002

Van der Merwe, W. & Lea, I., 2003: 'Towards sustainable mine water treatment at Grootvlei Mine', in *Proceedings of the 8th International Congress on Mine Water and the Environment*, Johannesburg, South Africa, viewed 8 February 2016, from http://www.imwa.info/docs/imwa_2003/imwa_2003_025-036.pdf

Wates, Meiring & Barnard (Pty) Ltd., 2002, *Integrated water management plan, Geohydrological investigation*, Sappi Enstra, Springs.

Winde, F. & Stoch, E.J., 2010, 'Threats and opportunities for post-closure development in dolomitic gold mining areas of the West Rand and Far West Rand (South Africa) – A hydraulic view part 1: Mining legacy and future threats', *Water SA* 36(1), 69–74. http://dx.doi.org/10.4314/wsa.v36i1.50908

Yin, R.K., 2011, *Applications of case study research*, Sage, Los Angeles, CA.





Ekurhuleni
METROPOLITAN MUNICIPALITY

EKURHULENI METROPOLITAN MUNICIPALITY
BIODIVERSITY REPORT | 2008

LAB
Local Action for Biodiversity
AN ICLEI INITIATIVE

ENHANCING URBAN NATURE THROUGH A GLOBAL NETWORK OF LOCAL GOVERNMENTS

Local Action for Biodiversity
AN ICLEI INITIATIVE

The Local Action for Biodiversity (LAB) Project is a 3 year project which was initiated by the City of Cape Town, supported by the eThekwini Municipality (Durban), and developed in conjunction with ICLEI – Local Governments for Sustainability and partners. ICLEI is an international association of local governments and national and regional local government organisations that have made a commitment to sustainable development. LAB is a project within ICLEI's biodiversity programme, which aims to assist local governments in their efforts to conserve and sustainably manage biodiversity.

Local Action for Biodiversity involves a select number of cities worldwide and focuses on exploring the best ways for local governments to engage in urban biodiversity conservation, enhancement, utilisation and management. The Project aims to facilitate understanding, communication and support among decision-makers, citizens and other stakeholders regarding urban biodiversity issues and the need for local action. It emphasises integration of biodiversity considerations into planning and decision-making processes. Some of the specific goals of the Project include demonstrating best practice urban biodiversity management; provision of documentation and development of biodiversity management and implementation tools; sourcing funding from national and international agencies for biodiversity-related development projects; and increasing global awareness of the importance of biodiversity at the local level.

The Local Action for Biodiversity Project is hosted within the ICLEI Africa Secretariat at the City of Cape Town, South Africa and partners with ICLEI, IUCN, Countdown 2010, the South African National Biodiversity Institute (SANBI), and RomaNatura. For more information, please visit: www.iclei.org/lab

EXECUTIVE MAYOR'S MESSAGE

Ekurhuleni
METROPOLITAN MUNICIPALITY

EXECUTIVE MAYOR'S MESSAGE

The Ekurhuleni Metropolitan Municipality has set itself the goal of sustainable development, which balances the protection of the environment with the improvement of the socio-economic well being of the inhabitants of Ekurhuleni.

According to the Millennium Development Goals (Goal 7 Target 1) and the Johannesburg Plan of Implementation (24), *"Human activities are having an increasing impact on the integrity of ecosystems that provide essential resources and services for human well-being and economic activities. Managing the natural resources base in a sustainable and integrated manner is essential for sustainable development."*

Ekurhuleni's open space systems and biodiversity is under severe pressure from both competing land uses and a shortage of resources. The continued growth of Ekurhuleni's population and economy is increasing the pressure on available land. Local government is tasked with service provision and ensuring that social and economic development proceeds within the carrying capacity of the biological resource base. It is therefore a significant front-line manager of global biodiversity.

Biological and natural resources are a keystone of the global environment and provide the pillars upon which we build communities, nations and civilizations. They also maintain the life sustaining systems of the biosphere and are a fundamental part of our natural, cultural and spiritual heritage.

Ekurhuleni has joined the International Local Action for Biodiversity project, launched by ICLEI – Local Governments for Sustainability, in order to participate in the global drive towards the management and conservation of its natural resources.

Local governments globally have begun to take a fresh look at future environmental sustainability. Ekurhuleni is committed to ensure that biodiversity issues and concerns must therefore become fully integrated into local planning and policy making processes.

Clr. Ntombi Lentheng Mekgwe
Executive Mayor
Ekurhuleni Metropolitan Municipality
August 2008

PREFACE

This document forms part of a set of biodiversity reports produced by participant cities of the Local Action for Biodiversity (LAB) Project. It represents a critical starting point: a status quo assessment of biodiversity and its management in each LAB city. Each biodiversity report covers four key themes*, namely:

- Ecology
- Governance
- Integration
- Participation

Each biodiversity report will be drawn upon to contribute significant and useful information for the compilation, by the LAB Project Team, of a Biodiversity Toolkit document. This document will contain best practice theory and examples, principles, strategies etc. for use by cities to better manage and integrate biodiversity into planning. The Toolkit will in turn contribute towards further steps in the LAB process.

The five steps in the LAB process are as follows:

Step 1: Development of a biodiversity report that documents the current state of biodiversity and its management within each city

Step 2: Ensuring long-term commitment by city leadership to sustainable biodiversity management through LAB cities formally signing a local government biodiversity declaration

Step 3: Development of a 10-year biodiversity action plan and framework that will include commitments to biodiversity implementation plans and integration within broader city plans

Step 4: LAB cities' formal acceptance of their 10-year biodiversity action plans and frameworks

Step 5: Implementation of five new on-the-ground biodiversity interventions by the end of the three-year project

These reports create a unique opportunity for profiling the importance of urban biodiversity, and innovation in its management, on a global scale. They are the foundation not only of the long-term plans that each city will develop to enhance, protect and develop their urban biodiversity, but also collectively form the basis for the development of LAB as a highly effective global urban biodiversity initiative.

LAB Project Team
May 2007
Cape Town

*Some cities' Biodiversity Reports do not follow this specific order or these specific headings

ABBRIVIATIONS

LIST OF ABBREVIATIONS

CBD:	Central Business District
DEAT:	Department of Environmental Affairs and Tourism
EBOSS:	Ekurhuleni Biodiversity and Open Space Strategy
EMF:	Environmental Management Framework
EMM:	Ekurhuleni Metropolitan Municipality (also the land area it administers)
ESSDR:	Eastern and Southern Service Delivery Regions
GDACE:	Gauteng Department of Agriculture, Conservation and Environment
GDS:	Growth Development Strategy
GIS:	Geographical Information System
IAIA-CB-BIA:	International Association for Impact Assessment – Capacity Building in Biodiversity and Impact Assessment
IDP:	Integrated Development Plan
LAB:	Local Action for Biodiversity
LDO's:	Land Development Objectives
LSDF:	Local Spatial Development Framework
MSDF:	Metropolitan Spatial Development Framework
NGO's:	Non-Governmental Organisations
NSDR:	Northern Service Delivery Region
RAG:	Residents Action Group
RSDF:	Regional Spatial Development Framework
SANBI:	South African National Biodiversity Institute
SARDB:	South African Red Data Book
SEA:	Strategic Environmental Assessment
SOER:	State of the Environment Report

CONTENTS

INTRODUCTION

INTRODUCTION TO THE EKURHULENI METROPOLITAN MUNICIPALITY

The Ekurhuleni Metropolitan Municipality (EMM) covers an area of 1923 km^2. It is located on the Southern African continental divide and falls within the Highveld Region in the province of Gauteng.

The EMM has been shaped by almost continuous human occupation over the past 500 000 years. Occupation of the area began during the early Stone Age and stretches through Iron Age settlement to colonial settlement in the 1840s. In the early years, human use of the area was focussed on hunting, gathering and farming. Relatively little has remained of early settlements, except in a few places where development has not yet encroached on archaeological sites.

A considerable number of Late Iron Age stone-walled sites, dating from the 18th and 19th centuries, occur along rocky ridges/outcrops in the area. Some of these may have been occupied as early as the 16th century. Pottery shards and metal items are common on the sites.

Sotho-Tswana speaking peoples who herded livestock, probably occupied these settlements. This occupation was disrupted during the Difiqane[1] when Mzilikazi lived near the Vaal River before he moved north across the Magaliesberg.

The first Europeans appeared in the area during the early 1820s. They were hunters, traders, missionaries and explorers. Permanent occupation by Europeans started with the arrival of the Voortrekkers in the early 1840s. The farms which they occupied were only formally surveyed and mapped in the 1880s. The original farms were subdivided many times as the number of farmers increased.

The discovery of gold on the Witwatersrand completely changed the development pace and pattern of the area. The discovery of coal (gold was discovered later) in the EMM area led to the construction of railway lines to supply the Johannesburg gold fields with coal. The lines were later linked to the Orange Free State and the Cape in 1892 and to Pretoria in 1893. The railway connection to Natal followed in 1896. These lines all came together at the farm Elandsfontein (Germiston). The railway stimulated the development of villages and the supply of electricity became necessary. The first coal-fired power station north of the Vaal River was built at Brakpan in the 1890s.

MAP 1: Location

1 Zulu extermination wars of the early nineteenth century in South Africa.

Municipalities were proclaimed in the early 1900s. Gold and coal mining was the driving force of the economy until it was superseded by commerce and manufacturing in the mid 1900s.

The EMM area of jurisdiction includes the municipal areas (towns) of Kempton Park, Tembisa, Edenvale, Boksburg, Benoni (including Daveyton and Etwatwa), Brakpan (including Tsakane), Springs (including Kwa-Thema), Nigel (including Duduza), Germiston and Alberton.

The EMM population consists of approximately 2,5 million people that grows at an annual rate of 2,7% of which the majority (77%) are African.

The economic output of Ekurhuleni in 2002 was R44,5 billion measured against constant 1995 prices.

Unemployment is high at 48% and a further 34% of the population is not economically active. Only 18% of the population is employed. Employment by sector:

- Manufacturing 22,9%
- Trade 20,2%
- Community services 15,7%
- Finance 13,6%
- Households 10,7%
- Transport 8,1%
- Construction 4,6%
- Mining 2%
- Electricity 1,1%
- Agriculture 1,1%

The manufacturing and trade sectors is the mainstay of the economy. Sectors with the highest growth potential are business tourism, residential development, transport and logistics.

The transport/logistics, and business tourism sectors are stimulated by the presence of OR Tambo International Airport while the residential development sector is stimulated by a growing upper and middle class population in post-apartheid South Africa.

PLANNING AND MANAGEMENT

PLANNING AND ENVIRONMENTAL MANAGEMENT IN EKURHULENI

Spatial planning in the EMM can be divided into six broad eras, namely:

- Pre 1994 elections ("Apartheid era") - the era of Physical Development Plans and Structure Plans;
- 1994 to 2000, after the first elections and the establishment of Transitional Local Councils and Metropolitan Local Councils – the era of Land Development Objectives (LDO's) and Urban Development Frameworks;
- 2001 to 2004 when the first integrated Metropolitan Spatial Development Framework (MSDF) was compiled for the EMM;
- 2005 to 2007 which constitutes the first revision of the EMM Spatial Development Framework and the integration of more detailed planning documents and policies such as the State of the Environment Report (SOER), the Environmental Management Framework (EMF) for the Northern Service Delivery Region, Development Corridor Study, etc. More detailed definitions for the various land use categories were also introduced; and
- 2007 and beyond. During this era it is expected that the MSDF will be improved even further with the inclusion of more detailed studies and larger emphasis on multi disciplinary teams. An Environmental Management Framework for the entire EMM was also completed and adopted by the Gauteng MEC for Agriculture, Conservation and Environment which serves as the main instrument in informing development decision-making in the EMM from an environmental perspective. The EMM is also currently in the process of finalising a Biodiversity and Open Space Strategy (EBOSS) that will inform spatial development frameworks in respect to areas and sites that should be conserved or be utilised for other open space functions.

Spatial Planning in the EMM is structured on three Levels, namely:

- Metropolitan Spatial Development Framework (Strategic Plan with no site specific detail)
- Regional Spatial Development Frameworks (More detail with specific proposals for pockets of land)
- Local Spatial Development Frameworks (More than 100 detailed Spatial Plans with detail to Erf Level is proposed). Much more emphasis is currently placed on aspects such as environmental management, nature conservation, open space planning, urban design, transport planning, capacity of engineering services to accommodate development, etc with the revision of existing, and the drafting of new spatial development frameworks. Teams of professionals from different fields of expertise are being appointed to draft these plans which will be done at a very high level of detail.

In addition to the above plans there are also a series of sectoral strategic plans and various policies that guide land development in the EMM.

The EMM is one of the most densely populated areas in the country and province. The economy is large and diverse. It accounts for nearly a quarter of the Gauteng economy. Many plants for the production of goods and commodities are located in Ekurhuleni. Manufacturing in the EMM accounts for just under 20% of the GDP of Gauteng. Because of the largest concentration of industry in the whole of South Africa (and in Africa), the EMM is often referred to as "Africa's Workshop". The downside of the high dependence on the manufacturing sector is that globalisation has a definitive impact on the structure of production and on the demand for labour that is anticipated to become a major change factor in the future structure of the economy in the EMM.

Historically the mining belt was the core around which the various towns and settlements were established. In total nine towns developed in the vicinity of the mining belt with Germiston, Boksburg, Benoni, Brakpan, Springs and Nigel being part of the mining belt itself while Edenvale, Kempton Park and Alberton developed adjacent to it. The EMM has a relatively evenly distributed, multi-nodal structure with no single, dominant node of activity. This lack of a single large CBD distinguishes the EMM from other metropolitan areas in South Africa.

Environmental Context of Biodiversity

THE ENVIRONMENTAL CONTEXT OF BIODIVERSITY IN THE EMM

1. Geology

The EMM is situated on a transition zone between the formations of a large granite batholith on its western border to the formations of the Witwatersrand and Transvaal Supergroups that is dominated by dolomites overlain by younger sediments of Karoo Supergroup in places. The dominant formations in the area are:

- Granite-gneiss that is found in the north-west at Tembisa and to the west of Clayville.
- Dolomite that dominates the northern area between Clayville in the west and Bapsfontein in the east and all along the eastern boundary of the area towards Putfontein, Strubenvale as far south as Kwa-Thema and Dunnotar as well as an estensive area of dolomite in the south-west, south of Elspark and Withok Estates.
- Quartsite that dominates the north-south central area from the west of Clayville in the north through Kaalfontein, to the east of OR Tambo Airport and in a broad band from west to east from Germiston to Springs and also north of Bapsfontein.
- Surface shale is found in the west, south of Bapsfontein and in the east, south of OR Tambo Airport towards Germiston.
- Amphibolite occur in the area around Edenvale east of Kempton Park and OR Tambo. A small area of surface dolorite occurs in the extreme south between Duduza and Vosloorus.

The geological stability of an area is a key consideration in the area with a generally high possibility of sink holes and earth tremors in undermined areas.

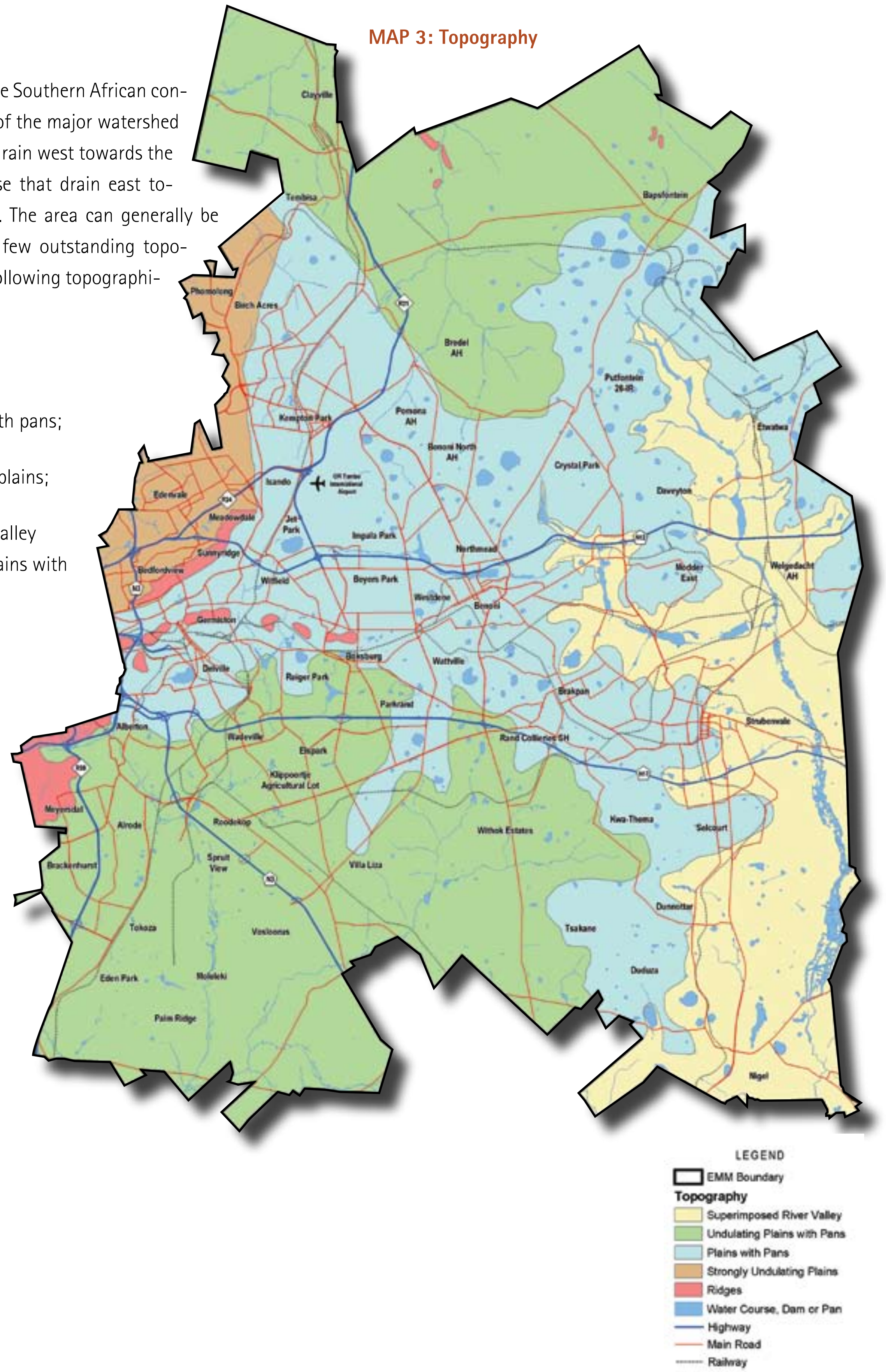
MAP 2: Geology

2. Topography

The EMM is located on the Southern African continental divide and part of the major watershed between the rivers that drain west towards the Atlantic Ocean and those that drain east towards the Indian Ocean. The area can generally be regarded as flat with a few outstanding topographical features. The following topographical features occur:

- Plains with pans;
- Undulating plains with pans;
- Strongly undulating plains;
- Superimposed river valley (Blesbokspruit) on plains with pans; and
- Ridges.

MAP 3: Topography



Environmental Context of Biodiversity

3. Sub-surface Hydrology

The study area is dominated by dolomite of the Chuniespoort Group (part of the Transvaal Sytem) and tillites of the Dwyka Group (part of the Karoo System), both of which carry water. The presence of various geological structures, such as faults, fissures, and fracture zones, as well as contact zones of intrusions such as dykes and sills, dictate the occurrence of groundwater.

Karst, Intergranular and Fractured Aquifers are the dominant aquifer types in the EMM. The Karst Aquifers occur in the dolomites of the Chuniespoort Group. This is the most important aquifer type in South Africa. Infiltrating rainwater containing weak carbonic acid dissolves dolomites resulting in caves and cavities that may facilitate the formation of sinkholes, especially if the water from these cavities is extracted through boreholes. Boreholes with the highest yield are found in the dolomites that occur from Wadeville to just south of Vosloorus. Yields of more than 10 litres per second are common. High recharge of underground water and significant underground flow result in low density surface drainage in dolomitic areas. This underground flow often supports high yielding springs at impermeable boundaries, such as dykes or lithological contact points. Ground water quality in the study area is generally acceptable for any use. In some areas contamination with chlorides, sulphates and nitrates has been recorded and care should be taken with groundwater used for human consumption.

Groundwater from the Dwyka Group is generally suitable for any use. Groundwater yield from aquifers in this formation is, however, low.

Due to the mining activities in the area, ground water quality is under threat of acid water pollution from mines.

4. Surface hydrology

The main drainage systems and other water bodies in the EMM include:

- Blesbokspruit[2]

  The Blesbokspruit originates to the north of Benoni and Daveyton and flows southwards through Springs and Nigel towards the Vaal River. A section of this spruit has been accepted as a wetland under the Ramsar Convention. The catchment also includes the Marievale Nature Reserve. The eastern part of the catchment contains extensive natural wetlands, while the western part is highly modified by agriculture and human settlement. Industries, mines (mostly mine dumps and slimes dams), waste disposal sites, intensive agriculture and sewage works impact negatively on water quality in this system.

- Klip River and its tributaries

  Rietspruit originates south-west of Benoni and joins the Klip River outside the study area. Another tributary of the Klip River, Natalspruit, rises in and around Germiston and Boksburg. The upper reaches of the Klip River proper originate in Katlehong. These spruits are all very polluted due to farming, human settlement and industries.

- Kaalspruit/Olifantspruit

  These spruits originate at Kempton Park and Tembisa and flow northwards to join the Hennops River in Centurion. Agricultural activities and human settlements are responsible for serious pollution.

- Jukskei River tributaries

  Numerous small tributaries of the Jukskei River drain a small portion of the south-western areas of the northern part of the EMM.

- Bronkhorstspruit

  Koffiespruit in the Sentrarand area and Osspruit in the Bronkhorstspruit Agricultural Holdings area drain two small areas on the eastern side of the northern part of the EMM.

- Rietvlei River and its tributaries

  This river rises in the smallholding areas of Kempton Park and flows northwards past the OR Tambo International Airport to Rietvlei Dam.

  The dam contributes a high percentage of the water supplied by the Tshwane Municipality. The primary water supply to this river originates from agricultural run-off and industrial areas. The river is also fed by tributaries, Grootvlei River, which originates in the Bapsfontein area and the Swartspruit that originates close to the Kempton Park CBD.

- Pans

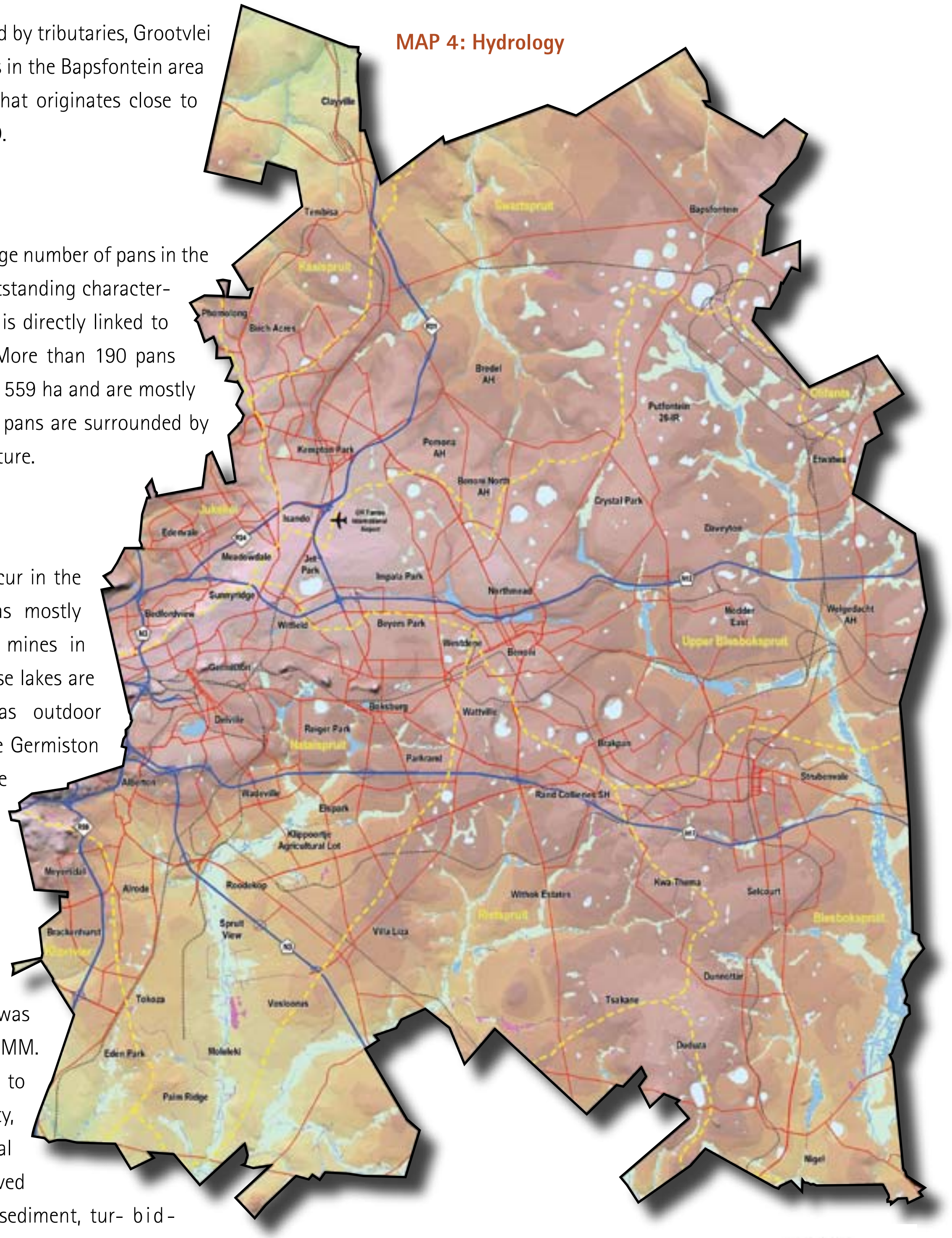
  The prevalence of a large number of pans in the EMM is one of the outstanding characteristics of the area and is directly linked to the flat topography. More than 190 pans cover a total area of 3 559 ha and are mostly seasonal. Most of the pans are surrounded by urban areas or agriculture.

- Lakes (dams)

  A number of lakes occur in the central area that was mostly created by the gold mines in the area. Some of these lakes are extensively utilised as outdoor recreational parks. The Germiston and Boksburg lakes are typical examples.

2 A spruit is a colloquial phrase for a "small" river

MAP 4: Hydrology



5. Water quality

Information supplied by the Department of Water Affairs and Forestry was used for the EMF of the EMM. Eight variables were used to determine water quality, i.e. temperature, pH, faecal coliform bacteria, dissolved oxygen, total suspended sediment, turbidity, total phosphate and total nitrate. In the ESSDR, the results from samples taken from the two major catchments, revealed that river health is below acceptable standards, but within tolerable limits. All indications are that the water quality is deteriorating, mainly due to agricultural practices, industrial pollution, inadequate sewage treatment and mining operations. At one of the sample points in the Blesbokspruit, phosphate levels due to the use of fertilizers are above tolerable levels. In the Klip River catchment, unacceptable levels of pollution were recorded at three sample points.

Most of the streams and rivers in the Northern Service Delivery Region (NSDR) of the EMM have good quality water, although very poor water quality was found in the lower reaches of the Rietvlei River and Kaalspruit. Poor water quality was recorded downstream of Tembisa and Olifantsfontein and three of the tributaries of the Jukskei River.

In the NSDR the ability of the aquatic habitats to support a wide variety of organisms was calculated through the assessment of the absence/presence of various aquatic creatures.

The river health classification in the NSDR, based on aquatic insect diversity, ranges between fair and poor. The top northern reaches of the Blesbokspruit are most probably the cleanest of the rivers in the northern region. Water in the middle reaches of the Swartspruit was found to be acceptable during a survey. The Swartspruit, however, suffers severe environmental degradation from time to time. Waste water treatment plants at Hartebeestfontein are mostly to blame. Waste water treatment at Kempton Park is similarly responsible for the polluted waters of Rietvlei River. Illegal squatting, such as at Kaalfontein and Tembisa, causes littering and dumping in river and stream beds.

Poor stormwater management also impacts negatively on streams. Only a few of the stormwater control systems include retention ponds and pollution control litter traps. A problem common to all areas of the EMM is the degradation and erosion of stream and river banks.

6. Rainfall and climate

Rainfall in the study area is typical of the Highveld summer rainfall region where more than 80% of rainfall occurs from October to April. Average rainfall is 715 mm to 735 mm annually. Hail can be expected periodically and mild damage to fruit harvests usually occurs in two out of three years, while severe damage occurs every two out of five years. According to the agricultural potential criteria of the National Department of Agriculture, the study area is suitable for rainfed crop production, provided that the crops are grown in areas with deep soil which stores water for use during dry periods in the growing season.

Severe frost occurs frequently from mid-April to September. Temperatures below freezing are common in winter. Summers are mild with temperatures seldom above 30°C.

Northerly and north-westerly winds blow during winter and spring and north-easterly to north-north-easterly winds during summer. Winds are usually gentle, and strong winds are only experienced 15% of the time. Moderately high-speed winds occur from late winter to early spring. Wind damage to field crops is rare, but damage to deciduous fruit quite common.

7. Vegetation types

The entire study area falls within the Grassland Biome in which grass dominates and geophytes occurs abundantly. Trees are usually absent, except along river courses and on koppies. Establishment of trees is curtailed by frost, veld fires and grazing. Today, only a few areas of high quality grassland remain, due to the severe transformation that has taken place. Only approximately 34% of the total area remains under natural vegetation in various states. The eastern parts of Gauteng is covered by Acocks' veld type 48 (Cymbopogon/Themeda veld). The dominant grass is red grass (Themeda triandra). It grows on sandstones and shales with deep sandy loam soils. In Ekurhuleni this veld type covers the area south of Bapsfontein and east of Benoni North, OR Tambo International Airport, and almost the entire southern service delivery area. According to the SANBI 2004 Vegetation Map of South Africa, Lesotho and Swaziland (VEGMAP), three sub-types of vegetation occur:

- Eastern Highveld Grassland;
- Soweto Highveld Grassland; and
- Tsakane Highveld Grassland.

Veld type 61 (Bankenveld) covers the area to the north. Bankenveld is found on dolomite plains in the western part of Gauteng. Dominant grass species include giant speargrass (Trachypogon spicatus), broadleaf bluestem (Diheteropogon amplectens), red autumn grass (Schizachyrium sanguineum), Loudetia simplex and many others. Trees occur in a scattered clusters with common hook thorn (Acacia caffra) dominant, and white stinkwood (Celtis africana), blue guarri (Euclea crispa) and sweet thorn (Acacia karroo) are also present.

The VEGMAP, identifies three sub-types of vegetation:

- Carletonville Dolomite Grassland;
- Egoli Granite Grassland; and
- Rand Highveld Grassland.

A small area of Mountain Bushveld occurs west and north of Alberton to the west of highway R59 and also north of the N12 highway. Small patches of this veld type also occur along the Blesbokspruit south of Springs towards Nigel.

Wetlands represent the most important habitat type in the Ekurhuleni area because of their vital role in the regulation of water, filtering capabilities and harbouring of biodiversity. Wetlands are superimposed over the grassland types of the study area and represent a transition between aquatic and terrestrial systems. Dominant vegetation in these wetlands are Phragmitis australis (reed) and Typha capensis (bulrush).

Significant areas of alien vegetation occur across the EMM and is mostly associated with mining areas and urban gardens and parks.

MAP 5: Vegetation Types

8. The use of land

The use of land in the EMM is reflected in Table 1.

TABLE 1:
USE OF LAND IN THE EMM
(SOURCE EMF FOR EKURHULENI 2008)

Category	Use of land	Area (ha)	% of Cat	% of EMM area
Agriculture	Dry Land Agriculture	25852	82.24	13.45
	Grain Storage Cilos	9	0.03	0.00
	Intensive Agriculture	329	1.05	0.17
	Irrigated Agriculture	4752	15.12	2.47
	Urban Agriculture	493	1.57	0.26
	Total	**31435**	**100.00**	**16.36**
Airfields	Airfields and landing strips	2014	100.00	1.05
	Total	**2014**	**100.00**	**1.05**
Business/ Commercial	CBD - Mixed use	492	18.19	0.26
	Commercial/Industrial	1377	50.91	0.72
	Public Garage	72	2.66	0.04
	Retail	764	28.24	0.40
	Total	**2705**	**100.00**	**1.41**
Engineering Services	Electricity Sub Station	86	19.68	0.04
	Sewage Works	259	59.27	0.13
	Water Reservoirs	92	21.05	0.05
	Total	**437**	**100.00**	**0.23**
Industrial	Industrial Use/Warehousing	7603	87.98	3.96
	Open Veld	1039	12.02	0.54
	Total	**8642**	**100.00**	**4.50**
Mining	Disturbed Land	2027	12.04	1.05
	Evaporation Paddocks	422	2.51	0.22
	Industrial Use	487	2.89	0.25
	Mine Dumps	2300	13.66	1.20
	Open Veld	4995	29.66	2.60
	Quarries/Borrow Pits	863	5.12	0.45
	Residential	257	1.53	0.13
	Sand Mines & Pits	68	0.40	0.04
	Slimes Dam	5421	32.19	2.82
	Total	**16842**	**100.00**	**8.76**
Open Space	Disturbed Land	2019	3.06	1.05
	Golf Courses	578	0.88	0.30
	Open Veld	52151	79.11	27.14
	Parks & Passive Recreation	9884	14.99	5.14
	Road & Rail Reserves	782	1.19	0.41
	Conservation Areas	510	0.77	0.27
	Total	**65924**	**100.00**	**34.31**
Residential	Farm Workers Houses	122	0.29	0.06
	Farmsteads	615	1.45	0.32
	New Residential	808	1.90	0.42
	Residential	37583	88.43	19.56
	Informal Settlements	3374	7.94	1.76
	Total	**42502**	**100.00**	**22.12**
Services	Cemeteries	595	9.69	0.31
	Community Halls	72	1.17	0.04
	Educational Facilities	1568	25.54	0.82
	Electricity Sub Stations	48	0.78	0.02
	Emergency & Security Services	63	1.03	0.03
	Hazardous Waste Disposal Sites	300	4.89	0.16
	Health Services	174	2.83	0.09
	Institutional & Government	430	7.00	0.22
	Religious	12	0.20	0.01
	Sewage Works	117	1.91	0.06
	Sport & Active Recreation	2512	40.92	1.31
	Waste Disposal	249	4.06	0.13
	Total	**6139**	**100.00**	**3.19**
Small Holdings	Commercial/Industrial	209	1.90	0.11
	Dry Land Agriculture	1860	16.93	0.97
	Irrigated Agriculture	20	0.18	0.01
	Open Veld	2981	27.13	1.55
	Residential	5798	52.76	3.02
	Unidentified	120	1.09	0.06
	Total	**10989**	**100.00**	**5.72**
Transport	Railway Stations	704	16.27	0.37
	Road & Rail Reserves	3579	82.73	1.86
	Taxi Ranks	43	0.99	0.02
	Total	4326	100	2.25
Unidentified	Unidentified	200	100.00	0.10
TOTALS	**Total**	**192154**		**100.00**

BIODIVERSITY DESCRIPTION

1. The definition of biodiversity

The EMM adopted the following definition for biodiversity from the South African National Environmental Biodiversity Act, 2004:

"Biological Diversity" or "Biodiversity" means - the variability among living organisms from all sources including, terrestrial, 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."

2. Biodiversity in the EMM

A large percentage of South Africa's biodiversity is represented in this small area of the Gauteng province. The number of species per unit area is exceptionally high. This biodiversity is, however, threatened by high levels of industrial, economic and urban development activities.

TABLE 2:
SPECIES VALUES FOR THE EMM PER TAXONOMIC GROUP

Taxonomic group	Number of species in EMM	% of grassland total[3]	% of Gauteng total[4]
Plants[5]	1644	49%	54%
Mammals[6]	Unknown	Unknown	Unknown
Birds[7]	255	73%	78%
Amphibians[8]	14	38%	56%
Reptiles[9]	41	?	47%
Invertebrates	?	?	?

Plants

Threatened plant species in the EMM is indicated in Table 3.

TABLE 3:
THREATENED PLANT SPECIES OCCURRING IN EKURHULENI

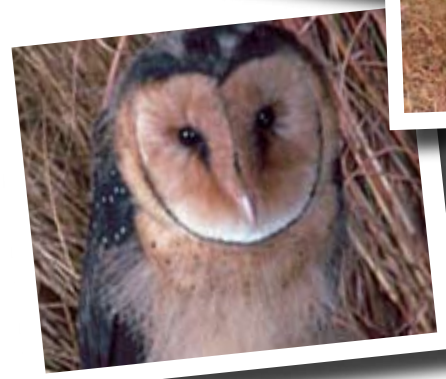
Scientific name	IUCN Species Survival Commission (2000) threatened status
Khadia beswickii[10]	CR
Delospermum purpureum[11]	EN
Cineraria longipes[12]	EN
Trachyandra erythrorhiza[13]	VU
Boweia volubilis	NT
Calamagrostis epigyus var. capensis	NT
Habenaria bicolour	NT
Kniphofia typhoides	NT

Source: Pfab & Victor (2002)

Of the threatened species that occur in EMM: approximately 50% of the total known population of Kadia beswickii occurs in the EMM (M. Pfab pers.comm.), 30% of Delospermum pupureum, 25% of Trachyandra erythrorhiza and 20% of Cineraria longipes total populations also occur in EMM.

Habitat destruction/transformation and fragmentation through urbanisation is the most serious threat posed to the survival of threatened plants in the EMM.

3 The total number of species in the Grassland biome for each taxonomic group was obtained from le Roux (2002). In the case of plants this number was taken as 3370.
4 The total number of species obtained for each taxonomic group in Gauteng was obtained from DACEL (1999).
5 The number of plants occurring in Ekurhuleni was obtained by extracting plant species found in the EMM quarter degree grids from the PRECIS database.
6 Information on total mammal species occurring in EMM was not available.
7 The bird species identified for all protected areas in the EMM were taken as a good indication of the total species present in the EMM
8 Bullfrog pan has been monitored between 1991-2003, the species sited at the pan during this period are considered to be a good indication of total frog species that occur in the EMM (Cook 2003)
9 Reptile data was derived from Jacobsen (1995).
10 Khadia beswickii is endemic to Gauteng, where it grows in open areas on shallow soil over rocks in grassland. It is predominantly threatened by imminent informal urban settlement and related development but also b6y alien vegetation, mining and perhaps collectors (Pfab and Victor 2002)
11 This succulent is confined to the Witwatersrand quartzitic ridges. The main threat to its survival is habitat tranmsformation and fragmentation through urbanisation (Pfab and Victor 2002)
12 The former distribution range of this species has been fragmented by urbanisation. It still exists on the Klipriviersberg and southwards to approximately 10 km south of Suikersbosrand, on south facing slopes of basaltic koppies. This species is threatened by urban development, habitat fragmentation and transformation, mining and alien vegetation (Pfab and Victor 2002).
13 This species grows in black turf marshes mainly in Gauteng but also the Free State and Mpumalanga. It is threatened by habitat transformation and fragmentation through urbanisation, agriculture and invasive plant species. It is conserved in the Suikerbosrand Nature Reserve (Pfab and Victor 2002).



Birds

A total of 21 threatened bird species occur in EMM. They are listed in Table 4.

TABLE4:
THREATENED BIRD SPECIES WITHIN THE EMM (SHADED CELLS INDICATE BIRD SPECIES CONSIDERED TO BE VAGRANTS TO EMM – C. WHITTINGTON-JONES PERS.COMM.).

Common name (aquatic/terrestrial)	Species	IUCN Species Survival Commission (2000) threatened status
African Marsh Harrier	Circus ranivorus	VU
Bald Ibis	Geronticus calvus	VU
Black Coucal	Centropus bengalensis	NT
Black stork	Ciconia nigra	NT
Blackwinged Plover	Vanellus melanopterus	NT
Blue Crane	Anthropoides paradiseus	VU
Blue Korhaan	Eupodotis caerulescens	NT
Caspian Tern	Hydroprogne caspia	NT
Corncrake	Crex crex	VU
Grass Owl	Tyto capensis	VU
Greater Flamingo	Phoenicopterus ruber	NT
Half-collared Kingfisher	Alcedo semitorquata	NT
Lanner Falcon	Falco biarmicus	NT
Lesser Flamingo	Phoeniconaias minor	NT
Lesser Kestrel	Falco naumanii	VU
Melodious Lark	Mirafra cheniana	NT
Openbill Stork	Anastomus lamelligerus	NT
Painted Snipe	Rostratula benghalensis	NT
Secretarybird	Sagittarius serpentarius	NT
Whitebellied Korhaan	Eupodotis cafra	VU
Yellowbill Stork	Mycteria ibis	NT

Source: Avian Demography Unit

BIODIVERSITY DESCRIPTION

Reptiles

The Striped Harlequin snake (Homoroselaps dorsalis), is the only threatened reptile species occurring in EMM. The Striped Harlequin snake is categorised as Rare according to the IUCN Species Survival Commission (2000) and prefers grassland habitats. It is endemic to the highveld of the Free State, KZN, Swaziland, Limpopo and Gauteng.

Mammals

The Rough-haired golden mole (Amblysomus hottentotus), which occurs in the EMM, is endemic to Southern Africa and is listed as vulnerable in both the SARDB and the IUCN Species Survival Commission (2000).

Invertebrates

The conservation status of many invertebrates in Gauteng is still in the process of being established. Twenty one species are currently considered to be of priority for conservation in EMM that are rare, threatened or of conservation concern. They belong to the following orders: Lepidoptera (butterflies), Arachnida (spiders and scorpions) and Coleoptera (beetles). Only three species of butterfly are listed in the South African Red Data Book (SARDB) for this area. According to the IUCN Species Survival Commission Report (2000) only two butterfly species are categorised as threatened (for Gauteng).

Hills and koppies generally have more insects (both in terms of individuals and species) than the immediate surroundings (Samways & Hatton 2000 cited in DACEL 2001a). This is also the case for EMM.

Amphibians

The Giant Bullfrog (Pyxicephalus adspersus) is classed as Near Threatened (NT) (IUCN Species Survival Commission 2000).

The protection of Giant Bullfrog populations at Bullfrog Pan and Glen Austin is considered crucial to the long-term conservation of this species in the Province.

Thirteen frog species were recorded at Bullfrog pan during the period 1991–2003 and are listed in Table 5. Although Bullfrog Pan is only one example of a wetland type in EMM and cannot be assumed to accommodate all amphibian species occurring in the EMM, it is regarded as providing a good indication of the species in EMM. In addition to the frog species observed at Bullfrog Pan, Weel's Running Frog (Femnodactylus wealii) is also anticipated to occur in EMM (Cook 2003). Four of the species in Table 5(Common River Frog, Cape River Frog, Striped Stream Frog, Weel's Running Frog) are provincially restricted and their populations are understood to be declining.

TABLE 5:
FROG SPECIES RECORDED AT BULLFROG PAN DURING THE PERIOD 1991–2003

Common Name	Species	Breeding Requirements
Common River Frog	Afrana angolensis	Rivers and permanent water, artificial habitats (dams) or pans.
Common Platanna	Xenopus laevis	Permanent water, seasonal pans.
Cape River Frog	Afrana fuscigula	Permanent water, seasonal pans.
Natal Sand Frog	Tomopterna natalensis	Shallow permanent streams or vleis in grassland.
Tremolo Sand Frog	Tomopterna cryptotis	Temporary shallow pools/ pan or large roadside pools.
Bubbling Kassina	Kassina senegalensis	Open vleis, pans, dams in grassland.
Common Caco	Cacosternum boettgeri	Marsh, vleis, inundated grassland pools.
Guttural Toad	Bufo gutturalis	Open vleis, pans, ponds, dams, slow streams. Dominates artificial habitats. Urban Exploiter
Raucous Toad	Bufo rangeri	Vegetated zones around pans or dams. Extremely rare in the Gauteng Province due to possible hybridisation with Guttural Toads, Bufo gutturalis.
Red Toad	Schismaderma carens	Emerging vegetation in deeper water (.30 cm) often around reed beds (Typha).
Giant Bullfrog	Pxyicephalus adspersus	Sedge and grass (hygrophytic) dominated seasonal pans or shallow depressions. May utilise artificial habitats such as dams, ponds. Limited numbers in urban environments. Urban avoider
Striped Stream Frog	Strongylopus fasciatus	Vegetated dams, pans and streams. Limited numbers in urban environments. Urban avoider
Snoring Puddle Frog	Phrynobatrachus natalensis	Seasonal pools, pans or around dams. Limited numbers in urban environments. Urban avoider

Source: Cook (2003)

BIODIVERSITY DESCRIPTION

Distribution of alien invasive species

Invading alien plants are a serious threat to biodiversity through alteration of habitat or disruption of ecosystem processes. Despite this, there is a lack of data on the distribution of alien invasives in the area. In Gauteng, wattle (mainly Acacia dealbata and A.mearnsii) and blue gum trees (Eucalyptus sp.) are the most widespread woody exotic (Henderson 1995).

Medicinal plants

Of the total 1644 plant species occurring in EMM, 171 are traded medicinally (Williams 2003). Ten of these species are indicators of over-exploitation, harvesting results in plant mortality and current levels of harvest are not sustainable. Further research is needed to set quotas and harvesting levels according to prevailing environmental conditions.

Areas of conservation importance/Protected areas

Historically southern African nature reserves were not established with biodiversity criteria under consideration. Protected areas were often established for the sole purpose of conserving larger mammal species. The designation and delimitation of reserves is often not based on systematic conservation planning and new reserves have often been located in areas that do not contribute to the representation of the local/regional biodiversity (Margules and Pressey 2000).

The Highveld Grassland of South Africa has been identified as being inadequately protected within the present protected area system (DEAT 1997). Only 0.97% of the EMM currently falls within protected areas, falling far short of the internationally recommended 10%. However, a large part of the EMM surface area is still in a natural state.

The focus of conservation action, in terms of biodiversity protection, is shifting from protecting individual species to conserving habitats and ecosystems.

Aquatic and hydrophilic habitats

The aquatic and hydrophilic habitats within the EMM include rivers (perennial and non-perennial), wetland areas and water bodies (natural, enoreic pans and man-made dams). Wetlands and waterbodies comprise 6.7% of the EMM surface area. The most noteworthy wetlands are situated along the Ramsar site of the Blesbokspruit, stretching north-south along the eastern boundary of the EMM. Wetlands are also located along the Natalspruit in the south-west of the EMM and the Kaalspruit in the north-western corner of the EMM. The remaining waterbodies are pans, dams and man-made lakes scattered throughout the area.

Endoreic pans, such as Bullfrog pan, are a very sensitive and highly threatened wetland type that is poorly protected in the Gauteng province. These habitats are of considerable importance to a diversity of bird and amphibian species.

More than a 190 pans occur in the EMM. Only four of these, Westdene Pan (Korsman's Bird Sanctuary), Carlos Rolfes Pan, Blaauwpan (Pamula Park Nature Reserve) and Glen Austin Pan are formally protected. Of these, only Korsman's Bird Sanctuary is considered to be adequately managed for biodiversity.

3. Threats to biodiversity

The human settlement factor associated with development and occupation of land affect the environment in the following ways:

- The natural vegetation is being fragmented by the conversion of natural habitats into by development. Many pans in the EMM have been filled in and wetlands and surface water bodies have become isolated. These pressures all lead to losses of ecosystem function and biodiversity. Fences and walls on the edges or across pans also prevent natural migration of adult and juvenile Giant Bullfrog species between foraging areas and suitable breeding sites.
- Insufficient services in impoverished settlements lead to sewage pollution, litter and solid waste pollution and deteriorating water quality in surface water bodies.
- The affordability and accessibility of basic primary health care, education, employment opportunities and the economic status of households all act as drivers that place pressure on the environment due to over-harvesting of natural resources (specifically medicinal plants). Poverty and under-development often force people to disregard resource management practices. Plant resources provide a buffer for rural communities against poverty and unemployment during cyclic economic depression and an employment prospect where formal education-reliant opportunities are lacking.

A large number of the mines within the EMM are no longer operational and most of the mining footprint in the area is made up of mine tailings and waste dumps. Mining acts as a driver that exerts pressure on natural habitat and biological diversity, in the following ways:

- Open cast mining and quarrying, require the complete clearance of vegetation, they change surface topography and the drainage characteristics of soils (even when reasonable rehabilitation is implemented), leading to the loss of habitats and of populations of plant and animal species.
- Underground mining causes surface subsidence, which leads to land degradation.
- The sector encourages an influx of job seekers, with the same consequences as for human settlement pressures.
- Large volumes of bulk waste products, in the form of tailings and waste rock dumps, require large areas of land for disposal, leading to habitat destruction.
- Water falling on these waste disposal sites leaches toxic substances into the soil, seepage of which contaminates ground and surface water, leading to poor water quality. This causes changes in species composition and loss of natural indigenous riverine biota.
- Underground mining dewaters aquifers and the excess water in the mines has to be pumped and disposed of into surface water bodies, thus increasing flows in such receiving water bodies. There are also water quality changes associated with mine water.
- Changes in water quality and quantity of surface and ground water exert pressure on the riparian vegetation and biota is dependent on the natural water bodies and wetlands. This leads to loss of biodiversity, changes in species composition and numbers and, where contamination or toxicity is severe, to physiological deformities and even mortalities. Changes in water quality resulting from contaminated run-off also increases the possibility of exotic invasion in wetlands.
- In the past many mines encouraged the planting of exotic species, notably Eucalyptus spp, known to transpire water rapidly thereby drying out soils. Eucalyptus trees have been planted on and around tailings dams all over EMM in an effort to prevent leaching of harmful substances into the surface and ground water bodies. However, these species pose a threat to ecosystem functioning since they reduce the amount of run-off that reaches rivers and streams and they out-compete many indigenous species, causing displacement of indigenous species. The invasion of exotic trees and shrubs, especially in riparian habitats, poses a severe threat to plant and animal diversity. The invasion process has many ecological impacts that include alteration of soil nutrient cycling, reduction of run-off and subsequent stream flow, increased river bank erosion and altered fire intensity.

The majority of industries are concentrated in the Southern SRD.

BIODIVERSITY DESCRIPTION

This economic sector places pressure on the natural environment in the following ways:

- Clearing of vegetation for the construction of industrial infrastructure causes habitat destruction and fragmentation.
- Increased generation of waste and pollution through the demand for products created by industry. Heavy industry is particularly concentrated along the northern banks of the Elsburgspruit River. The pollutants produced by this sector impact on the species composition of the rivers and wetlands in close proximity that experience a change in water quality.
- Industrial effluents seep into nearby water bodies and wetlands affecting the riparian habitats and biota within these systems. Industrial emissions released into the atmosphere contribute to air pollution that affects the terrestrial and aquatic biota receiving rain from the polluted atmosphere. This further leads to loss of biodiversity and breakdown in ecosystem function.

Energy generation and consumption are the largest sources of carbon dioxide and sulphur emissions in South Africa. These gases cause smog and acidification of rainwater and soil. Carbon dioxide is also to the major driver of global climate change, of which the ecological consequences remain uncertain. The loss of water quality, through acidification, exerts pressure on the biota living in or around water bodies. Smog and airborne pollutants also threaten sensitive terrestrial species and ecosystem functioning.

The road transport sector places considerable pressure on terrestrial and aquatic environments through the generation of high levels of polutants. The transport sector places pressure on the environment in the following ways:

- Pollution of the environment through the generation of "photochemical smog" which contains ozone and other gases toxic to plants and animals. The fact that the EMM is linked to all major destinations in the country through its radial freeway network suggests that the pollution generated by the sector is significant.
- In addition to generating pollutants, transport routes require the transformation of natural habitat for the creation of roads, railways, airports etc.
- The transformation of natural land is also necessary for the disposal of old vehicles that are withdrawn from use.
- Transport networks that transect or fragment interconnected water bodies/wetlands and/or natural grasslands create a barrier to the migration of species between similar resources of varying quality and increase the risk of population decline and possible extinction.

Although agricultural activities only contribute 1% to the GGP and employment market in the EMM, a large surface area of the EMM is currently under cultivation. Agricultural activities place pressure on the environment in the following ways:

- Natural grasslands containing a diversity of vertebrate and invertebrate fauna are converted to monocultures of one particular crop leading to considerable loss of biodiversity. Small tracts of indigenous grassland become surrounded by monocultures causing fragmentation of previously intact natural habitats. The remaining remnants of natural grassland are more susceptible to exotic invasion and degradation due to increased edge effects. Habitat fragmentation also eliminates corridors between similar undisturbed habitats. The fragmentation of interconnected pans from each other and their surrounding terrestrial environment threatens species that move between nearby pans and those that require intact terrestrial habitats in close proximity to pans or streams.
- Pollution of aquatic habitats: Agricultural lands pollute nearby aquatic habitats through sediment loads and contamination caused by pesticides and fertilizers that reach the water through run-off or seepage. This causes a decline of indigenous species populations and increases the chance of exotic invasion.

4. Biodiversity management

The Ekurhuleni Integrated Development Plan (IDP) is a 5 year rolling plan drawn up to guide the development initiatives in the Metro and is linked to the Growth and Development Strategy (GDS) 2025.

In an analysis of the 2003-04 IDP it was found that very little mention was made of the protection of Biodiversity and a report was approved by Council recommending that all departments should integrate biodiversity principles into their respective IDP responsibilities

One of the strategic focus areas of the EMM GDS is the environment which has as its goal by 2025 to have a substantial increase in the general quality of the environment . In order to achieve the above, the following milestones and outcomes are, inter alia, envisaged:

- All development to be guided by an Environmental Management Framework (EMF):
  - An EMF for the entire Ekurhuleni area to be in place by 2006. (completed)
- A clearly defined and functional open space network:
  - Open space strategy to be finalised by 2007 (in process).
  - 50% of open space system to be developed by 2015.
  - 100% of open space system to be developed by 2025.
- Integrated and sustainable protection of natural resources:
  - Wetland conservation strategy and programme to be in place by 2007 (in process).

The EMM Metropolitan Spatial Development Framework (MSDF) has the following as an objective:

To create a sustainable and functional open space network that is accessible to the public and which:

- Protect, highlight and link natural elements of the EMM to form a high quality, tactile and functional living environment and movement system for fauna, flora and humans;
- Link-up with, and enhance the man made elements of EMM (i.e. making open spaces such as squares (nodal), the servitudes of important internal roads (linear) and other service servitudes (linear) part of the EMM open space network; and
- Include as many of the EMM public open spaces (linear linkage/ nodal-cluster) as possible.

In terms of the present IDP the Environmental Directorate has to compile an Open Space Plan and a Strategy for protection and conservation of sensitive ecological and hydrological areas . The Parks and Cemeteries Directorate section of the IDP indicates that a Conservation Policy and Removal and control of alien invasive vegetation action plan must also be compiled.

In an attempt to address some of these issues the Environmental Management Framework (EMF) as referred to previously was completed. Following on this project a consultant was recently appointed to compile an Implementation Strategy for the Protection, Conservation and Management of Open Space Systems, Biodiversity and Ecosystems for the EMM. This project has since been renamed to Ekurhuleni Biodiversity and Open Space Strategy (EBOSS). This project forms the backbone of the LAB Biodiversity Report for Ekurhuleni.

OPEN SPACE CLASSIFICATION

1. Introduction

In Ekurhuleni, because of its topographical nature, extent and position on the continental divide, the hydrological system provides a strong and distinct natural backbone to open space. Due to the importance of the hydrological systems in terms of both biological and hydrological functioning of the area, it must remain intact and no further development (with the exception of linear infrastructure that has to cross these areas) will be allowed in these areas.

Remaining high quality vegetation areas, in addition to the hydrological system, provide significant spatial nodes with high potential for the conservation of biodiversity.

Topographical features such as ridges are relatively rare in Ekurhuleni and where they do occur in a natural state they correspond almost perfectly with the occurrence of primary vegetation. It was therefore decided not to use topographical features as a separate element in the classification of natural open space.

2. Defining natural open space in Ekurhuleni

The remaining natural open space[14], as defined in the Ekurhuleni EMF, was reassessed in terms of its quality and classified into one of the following categories:

- Hydrology, which indicates areas that are clearly discernable[15] as rivers, streams, pans, dams and wetlands.
- High, which means areas that are in a good natural state and normally consist of primary vegetation[16] and in a few instances of high quality secondary vegetation where such vegetation, despite previous disturbance, is recognised as a typical condition of the particular vegetation type especially where it occurs in combination with significant areas of primary vegetation (e.g. Egoli Granite Grassland).
- Medium, which consist almost entirely of secondary vegetation, where the present state of such vegetation is still good enough to support open space connectors and links, despite reduced species diversity.
- Low, which consist of secondary vegetation that has been heavily degraded and/or fragmented that are not in itself, without rehabilitation, suitable to serve as a natural open space, connector or link between natural open spaces.

14 Natural open space means open areas that still have a natural vegetation cover where there is little human intervention and which is not currently utilized intensively by humans.
15 This does not necessarily include all wetlands as some wetlands can only be identified through detailed site specific investigations which remain the responsibility of environmental practitioners that conduct activity specific environmental impact assessments.
16 Primary vegetation means natural indigenous vegetation that has not previously been cultivated or disturbed to the extent that it has lead to a significant reduction in its species diversity, even though there may be a degree of alien infestation and limited localised disturbance present within larger units.

This was accomplished through the detailed evaluation of new and historical aerial photographs and satellite images. Selected field verification was carried out in two stages on a large number of sites across the area.

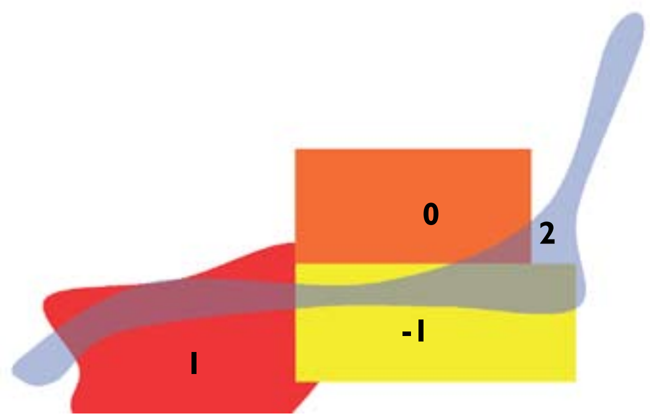
The results of this assessment are depicted on Map: Natural open space and in Table 6: Natural open space in the EMM Ekurhuleni.

TABLE 6: NATURAL OPEN SPACE IN EKURHULENI

Description	Area in hectares
Hydrological areas	16 961 Ha
High quality vegetation	10 926 Ha
Medium quality vegetation	16 108 Ha
Low quality vegetation	19 466 Ha
Total potential natural open space	63 461 Ha

In order to make further spatial analysis of the information possible a simple spatial model was constructed (depicted in Figure 1: Spatial model of existing natural open space in Ekurhuleni). It gives values to the different element to enable the compilation of secondary information in the GIS system.

**FIGURE 1:
SPATIAL MODEL OF EXISTING NATURAL OPEN SPACE IN EKURHULENI**



Colour code	Description	Value in spatial model
	Hydrological system	2
	High vegetation value	1
	Medium vegetation value	0
	Low vegetation value	-1

3. Field work

Approach

Draft versions of Map 1 (plotted in sections at appropriate scales was used to guide field activities). The entire study area was traversed by vehicle in order to assess whether open space areas were correctly categorised. Photographs and descriptive notes were collected throughout the study area and included examples of different landcover classes and mapped biodiversity categories, including:

- hydrological systems;
- natural open space;
- high quality natural vegetation; and
- urban open space.

Hydrological systems included any wetlands, drainage lines, etc. Natural open space included any areas of natural vegetation, irrespective of condition. High quality natural vegetation included any natural vegetation that was in good condition and contained moderate to high natural biodiversity. Urban open space included any open space area, whether sports field, secondary vegetation or degraded areas and did not necessarily include natural vegetation.

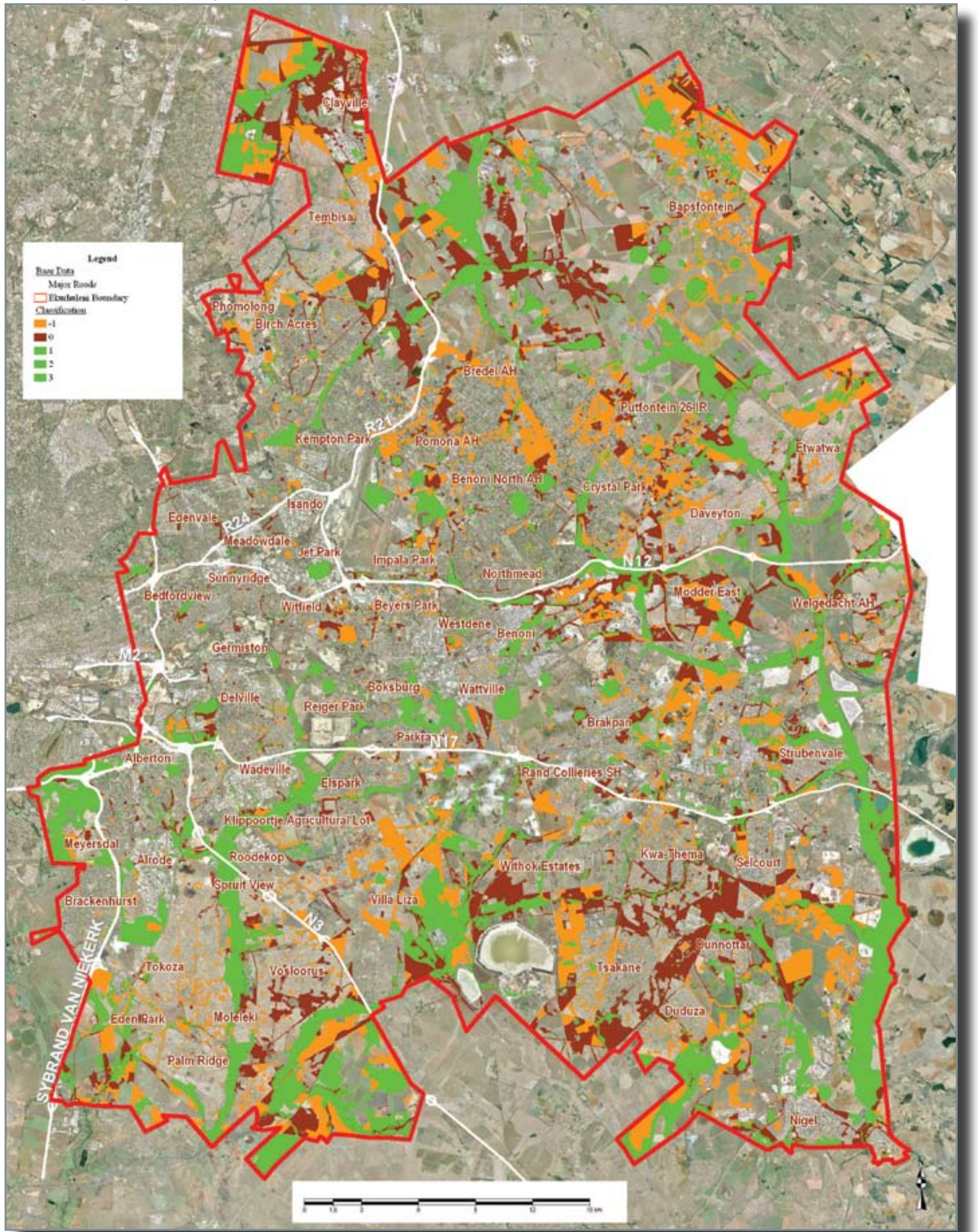
Field data was collected to provide both qualitative and quantitative information to assist in the classification of mapped areas into different classes. Qualitative field data collected included a latitude and longitude position, a photograph and short notes on the landcover.

The main vegetation found in the study area was grassland. This was difficult to evaluate from aerial photographs due to the similarity between natural grassland and either secondary grassland, old fields or sports fields. Detailed floristic information (quantitative data) was collected in selected areas in order to assess the species composition and condition of these grassland areas, as described in the following section. This provided invaluable information that could be used for classification of open spaces.

In addition to the qualitative and quantitative information collected in the field, the maps were continuously assessed while driving through the study area in order to evaluate whether they provided a realistic classification of open space. Where necessary, notes were made directly onto printed maps in order to make facilitate changes to the draft map. This form of verification can be termed "expert" and was undertaken by personnel with years of experience in vegetation mapping and classification, landcover

OPEN SPACE CLASSIFICATION

MAP 6: Open Space Quality



mapping and classification and GIS and remote sensing. There was therefore a strong linkage between the mapping process and the field verification process.

Vegetation sampling

A total of seventy-six sites were surveyed and quantitative vegetation sampling with 100m^2 sampling quadrats/plots was undertaken at these sites. All seventy-six sampled sites are listed and geo-referenced.

The stratified units were sampled using standard vegetation survey procedures following the Braun-Blanquet approach (Mueller-Dombois & Ellenberger 1974; Westhoff & Van der Maarel 1978). The sample plot size was standardized at 10 x 10 metres (100 m^2) in order to facilitate comparisons between vegetation units and for the purposes of future comparison with studies done in other parts of the country. The following floristic parameters were recorded in each plot:

- All plant taxa, identifiable at the time of sampling, rooted in the sample site;
- a growth form (tree, shrub, dwarf shrub, forb, grass) was assigned to each species; and
- projected canopy cover for each species recorded was visually estimated using the Braun-Blanquet cover-abundance scale.

Environmental parameters recorded at each stand included the following:

- Locality in degrees, minutes and seconds using a Global Positioning System (GPS) receiver;
- slope, measured in degrees;
- aspect, measured in degrees;
- elevation, measured in metres using a barometric altimeter;
- terrain unit (midslope, foot slope, etc.);
- estimated percentage surface rock cover; and
- any visible disturbances (e.g. grazing, fire, old lands).

Results of field surveys

Field data indicated that the draft EEBOSS map was well-classified and provided a good representation of open space position and quality. There was an 82.9% correlation between the mapped classification and classified field data in terms of the condition of the vegetation (Table 7). There were four sites classified as having medium value from the field data that were classified as having low value on the map. These were all very disturbed fragments of vegetation, but had remnant patches of natural vegetation. The floristic information therefore showed residual condition despite evident degradation. There were also 3 sites classified as high from the map that were found to be moderately disturbed in the field and were therefore classified as having medium condition. They were all associated with drainage lines that were automatically classified into a high value class on the map, but had localised disturbance that was captured during field work.

TABLE 7:
MATRIX INDICATING THE NUMBER OF SITES MAPPED IN DIFFERENT OPEN SPACE VALUE CLASSES IN THE EEBOSS MAP AS COMPARED TO DATA COLLECTED IN THE FIELD TO VERIFY THE MAP.

		Field		
		Low	Medium	High
Draft map	Low	38	4	1
	Medium	2	11	2
	High	1	3	14

During the earlier phases of the mapping exercise, some detailed floristic information collected in the field provided the basis for classifying some areas thought to be natural vegetation as secondary grassland and thus of lower biodiversity value, whereas the good quality of other vegetated areas was verified.

Photographic information and notes made in the field identified alien trees as a common feature that could potentially be interpreted as natural woodland. These areas were identified and the information provided justification for classifying some areas into lower biodiversity categories.

The spatial model of existing natural open space in Ekurhuleni, including field verification, was used to construct a potential natural open space utilisation model in order to facilitate further analysis of the spatial information as depicted in Figure 2.

OPEN SPACE CLASSIFICATION

MAP 7: Open Space Categories

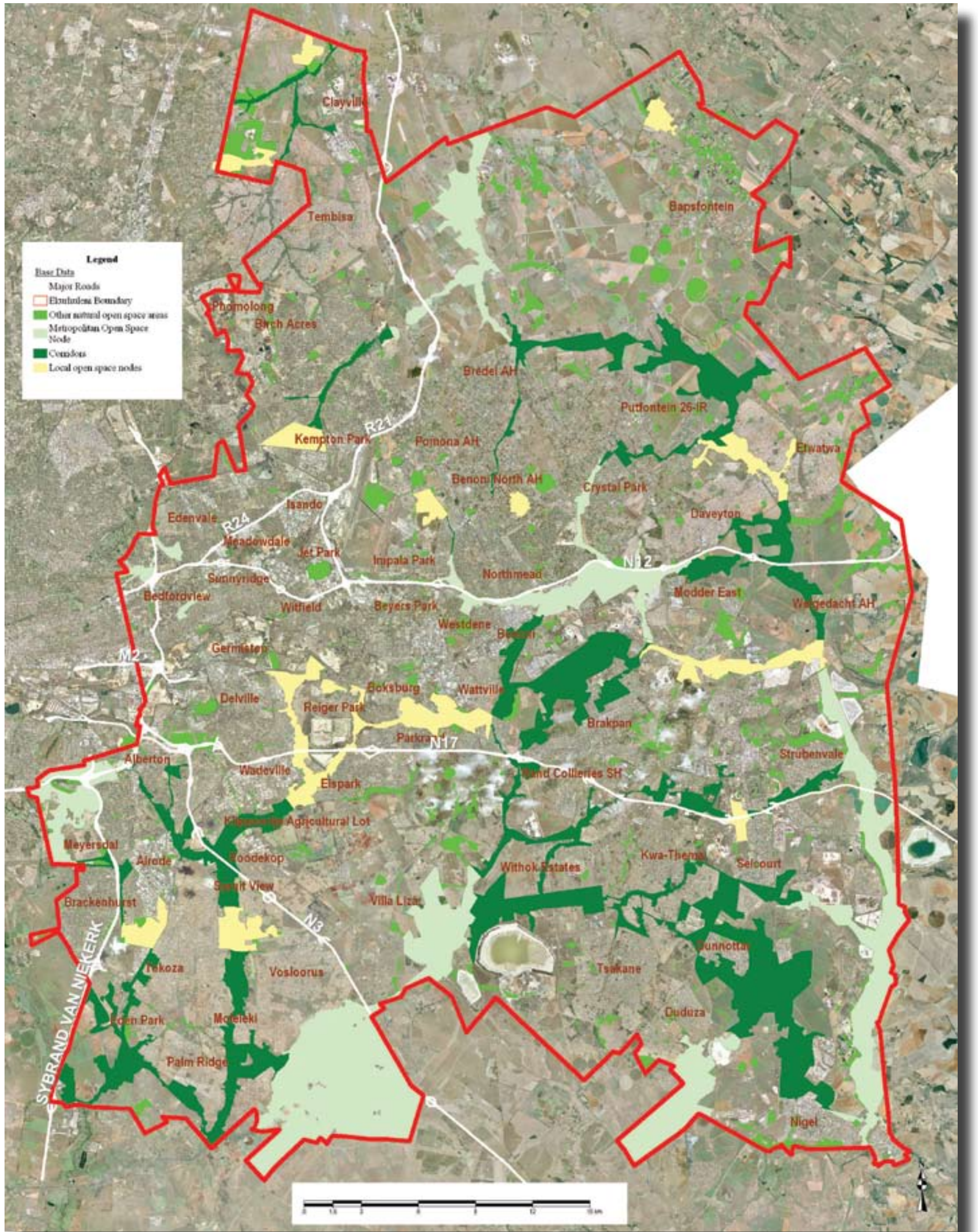


FIGURE 2:
POTENTIAL NATURAL OPEN SPACE UTILISATION MODEL

Utilisation strategy		
Cumulative value	Description	Proposed Utilisation strategy
3	Hydrological system and high vegetation value	Highest potential for conservation
2	Hydrological system and medium vegetation value	
1	High quality vegetation or hydrological system and low vegetation value	
0	Medium vegetation value	Development / conservation interface
-1	Low vegetation value	New development/ transformation

4. Identified open space elements in the EMM

As part of the EBOSS the open space in the EMM has been identified and classified in the categories indicated below and indicated on Map 7.

- Metropolitan Nodes

  Node 1: Blesbokspruit Ramsar Site / Conservation and Recreation Node

  Node 2: Rietspruit Grassland and Wetland Conservation and Recreation Node

  Node 3: Swartspruit Grassland and Wetland Conservation Node

  Node 4: Alberton Ridges Conservation and Recreation Node

  Node 5: Benoni Lakes Conservation and Recreation Node

  Node 6: Gillooly's Gateway Conservation and Recreation Node

  Node 7: Duduza Grassland Conservation and Recreation Node

- Local Nodes

  Node A: Midrand Estates Grassland Conservation Node

  Node B: Glen Austin Bullfrog and Bird Sanctuary and Recreation Node

  Node C: Babsfontein Ridge Grassland Conservation Node

  Node D: Dries Niemand Recreation Node

  Node E: Bullfrog Pan Conservation and Recreation Node

  Node F: Brentwood Grassland and Wetland Conservation Node

  Node G: Mayberry Park Urban Grassland Conservation Node

  Node H: Natalspruit Urban Wetland Conservation Node

  Node I: Klein Blesbokspruit Conservation and Recreation Node

  Node J: Blesbokspruit Dams Conservation and Recreation Node

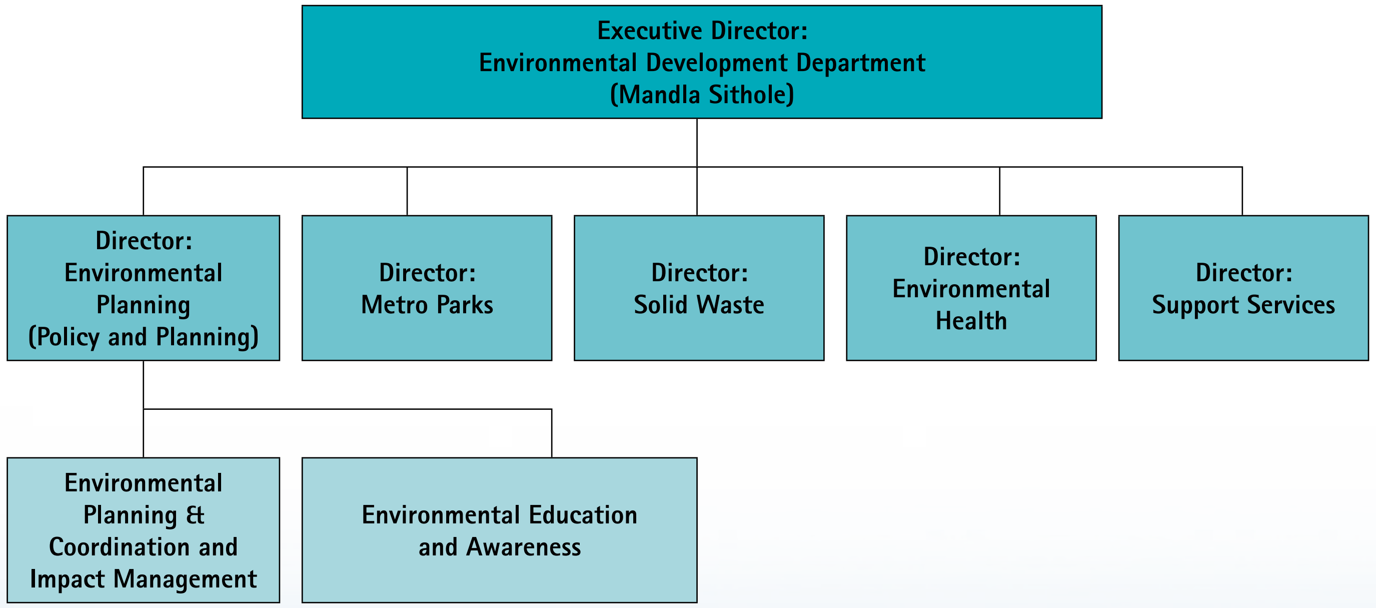
  Node K: Elsburg Conservation and Recreation Node

  Node L: Daveyton Conservation and Recreation Node

- Corridors (Not specifically named)
- Mining Belt Open Space Corridor
- Neighbourhood natural open spaces (Not specifically named)
- Existing Parks (that overlaps with in places with other categories – not indicated on the map)

1. Biodiversity in City Management

The structure of the Environmental Development Department of the EMM is indicated below:



2. Biodiversity Projects

Six biodiversity projects have been identified after assessment of the results of the EBOSS project. These projects are regarded as catalyst projects that should illustrate and test a variety of types of projects that can be implemented in the EMM. These projects will also form part of the five on-the-ground biodiversity interventions required in step 5 of the LAB process.

2.1. LAB Project 1: Rietspruit Grassland and Wetland Conservation and Recreation Project

Description

The project will incorporate a significant area of grassland and wetland areas with the existing Suikerbosrand Nature reserve. The project covers an area of approximately 5657ha of which approximately 4500ha is in a good natural state.

Functional

The following functions are proposed for the area:

- Natural open space conservation (79.68%)
- Natural open space rehabilitation (0,62%)
- High intensity recreation (1.61%)
- Sports facilities and low intensity recreation (0.16%)
- Continuation of existing agriculture (17.94%).

Ownership

The ownership of the areas is divided into the following categories:

- Privately owned (83.15%)
- Publicly owned (13.16%)
- Undetermined (3.69%).

Type of project

This is a new project with the primary aim to conserve a significant natural area while providing limited recreation and sports facilities for the communities in the broader region. It is also linked to the following initiatives:

- Earmarking the area as a Major Open Space Node in EBOSS
- Incorporation of the areas with the Gauteng Provincial Urban Biosphere Project.

Unique aspect

The area contains a unique combination of the endangered Tshakane Clay Grassland vegetation type and associated wetland and hydrological systems in a largely rural setting in close proximity to a major provincial nature reserve.

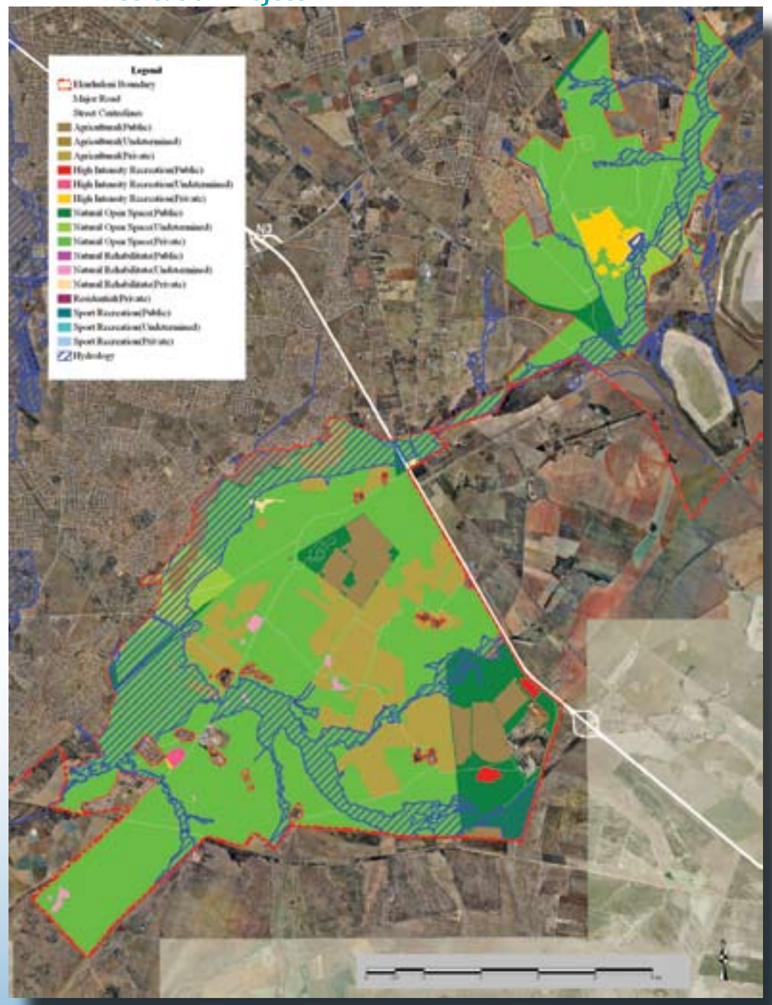
Challenges

Most of the land is privately owned and the biggest challenge is to develop an appropriate public/private conservation partnership model. Potential water pollution from slime dams in the vicinity of the area may also present significant long-term management challenges.

Influence of LAB

The LAB programme contributed to focusing the project on the biodiversity aspect within a larger open space strategy and also contributed to give the project a level of urgency and status within the EMM.

MAP 8: Rietspruit Grassland and Wetland Conservation and Recreation Project



Sustainability and benefits

The project will contribute to sustainable development by conserving a significant remaining portion of an endangered vegetation type. It will contribute to and extend an existing conservation area thereby not only enlarging the area but also

significantly increasing the diversity of the conserved unit.

Financial

The financial implication of the project will depend on the implementation model that is developed as part of the project.

Partnerships

The success of the project will depend on partnerships between the following parties:

- The EMM
- The GDACE
- The Sedibeng District Municipality
- Private and public landowners.

Implementation time line and quantifiable results

The project will be implemented over a 7 year period with the following time line:

- Incorporation of the project into the relevant LSDFs by the end of 2009
- Negotiated agreements and preferably stewardship agreements by the end of 2012
- A registered conservancy by the end of 2013
- A proclaimed protected area in terms of the protected Areas Act by 2015.

2.2. Lab Project 2: Swartspruit Grassland and Wetland Conservation and Recreation Project (correspond to Metropolitan node 3)

Description

The project will incorporate a significant area of grassland and wetland areas into a relatively large conservation area. The project covers an area of approximately 1362ha of which approximately 1323ha is in a good natural state. Hydrological features including rivers, streams, riparian zones and wetlands cover approximately 565ha in the area.

Functional

The following functions are proposed for the area:

- Natural open space conservation (97.19%)
- Natural open space rehabilitation (0.15%)
- High intensity recreation (0.05%)
- Sports and low intensity recreation (0.19%)
- Continuation of existing agriculture (2.42%).

Ownership

The ownership of the areas is divided into the following categories:

- Privately owned (87.10%)
- Publicly owned (12.90%)
- Undetermined (0.00%).

Type of project

This is a new project with the primary aim to conserve a significant natural area while providing limited recreation and sports facilities for the communities in the broader region. It is also linked to the following initiatives:

- Earmarking the areas as a Major Open Space Node in EBOSS
- Contributing to a potential larger natural open space that could be created by linking the area to the existing Rietvlei Nature Reserve to the north through a corridor along the Swartspruit.

Unique aspects

The area contains a significant area of high quality grassland consisting mostly of Carletonville Dolomite Grassland and a relatively small portion of the endangered Rand Highveld Grassland in the northern part, in a largely rural setting.

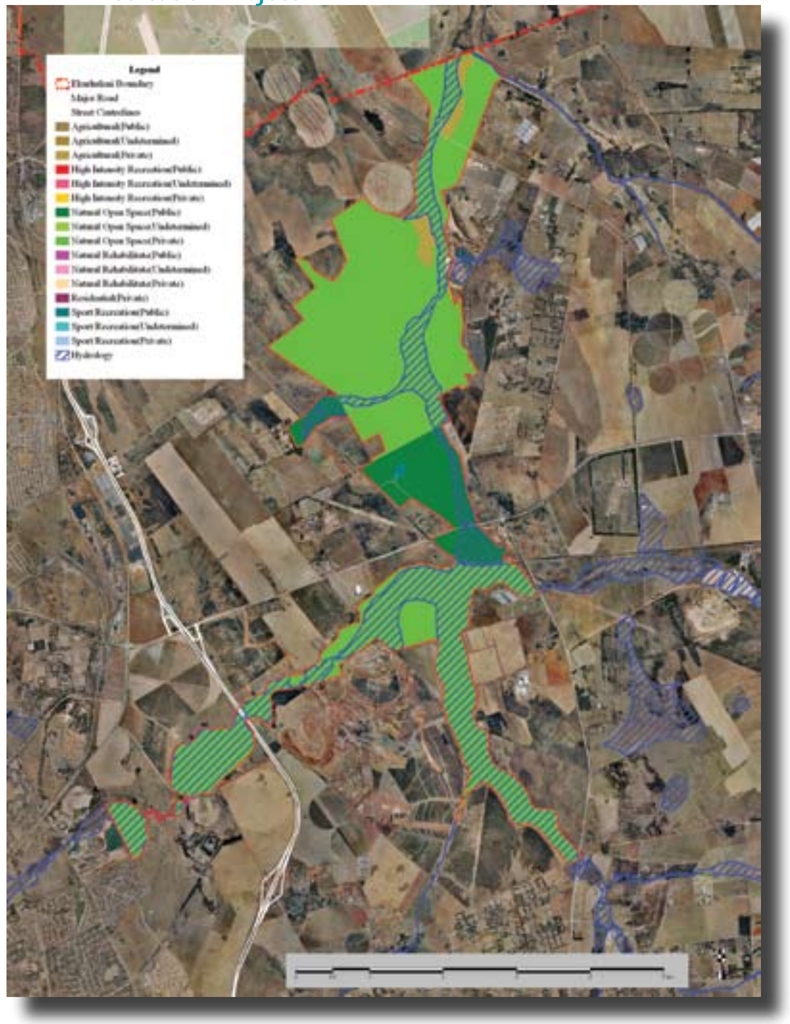
Challenges

Most of the land is privately owned and the biggest challenge is to develop an appropriate public/private conservation partnership model. Potential water pollution from the sewage works that are located in the area may also present significant long term management challenges.

Influence of LAB

The LAB programme contributed to focusing the project on the biodiversity aspect within a larger open space strategy and also contributed

MAP 9: Swartspruit Grassland and Wetland Conservation and Recreation Project



to give the project a level of urgency and status within the EMM.

Sustainability and benefits

The project will contribute to sustainable development by conserving a significant remaining portion of high quality grassland vegetation including an endangered vegetation type. It will contribute to the regional conservation structure that may lead to significantly enlarged conservation areas and also significantly increasing the diversity of the conserved unit.

Financial

The financial implication of the project will depend on the implementation model that is developed as part of the project.

Partnerships

The success of the project will depend on partnerships between the following parties:

- The EMM
- The GDACE
- The Tshwane and Kungweni District Municipality
- Private and public landowners.

Implementation time line and quantifiable results

The project will be implemented over a 7 year period with the following time line:

- Incorporation of the project into the relevant LSDFs by the end of 2009
- Negotiated agreements, preferably stewardship agreements, by the end of 2012
- A registered conservancy by the end of 2013
- A proclaimed protected area in terms of the protected Areas Act by 2015.

2.3 LAB Project 3: Elsburgspruit Urban Conservation and Recreation Rehabilitation Project (corresponds in part to Local Node: K)

Description

The project is essentially a rehabilitation project to become a central open space within Ekurhuleni that incorporates both natural and active open space elements within the wider urban fabric of an area that is currently being redeveloped and upgraded. The project covers an area of approximately 889ha of which approximately 562ha is in a good natural state. Hydrological features including rivers, streams, riparian zones, wetlands and dams covers approximately 512ha (58%) in the area.

Functional

The following functions are proposed for the area:

- Natural open space conservation (63.27%)
- Natural open space rehabilitation (19.37%)
- High intensity recreation (13.3%)
- Sports and low intensity recreation (4.02%)
- Continuation of existing agriculture (0.01%).

Ownership

The ownership of the areas is divided into the following categories:

- Privately owned (82.16%)
- Publicly owned (16.78%)
- Undetermined (1.06%).

Type of project

This is an existing project with the primary aim to restore a derelict area to a meaningful open space area that includes natural, recreational and sports uses within an area that is currently in the process of significant urban renewal. It is also earmarked as a Major Open Space Node in EBOSS.

Unique aspects

The area contains a significant area of high quality grassland consisting mostly of Soweto Highveld Grassland and a relatively small portion of the endangered Tsakane Clay Grassland in the southern part. The area is surrounded with urban development and encircles a large area of mining land including large slimes dams.

Challenges

Most of the land is privately owned and the biggest challenge is to develop an appropriate public/private conservation partnership model. Potential water pollution from the mining areas that are located in the area may also present significant long term management challenges.

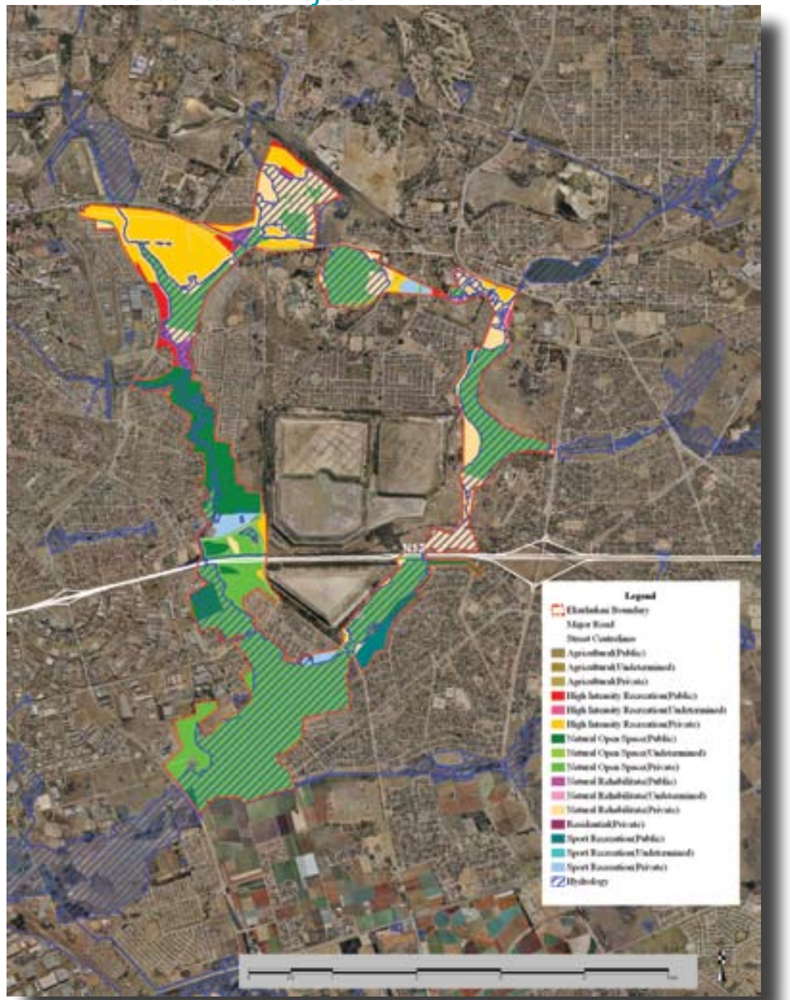
Influence of LAB

The LAB programme contributed to focusing the project on the biodiversity aspect and also contributed to give the project a level of urgency and status within the EMM. The LAB project also provides international exposure to the EMM's efforts to conserve biodiversity.

Sustainability and benefits

The project will contribute to sustainable development by conserving a significant remaining portion of high quality grassland vegetation including an endangered vegetation type.

MAP 10: Elsburgspruit Urban Conservation and Recreation Rehabilitation Project



It will also make a significant contribution to the open space needs of the surrounding communities.

Financial

The financial implication of the project will depend on the implementation model that is developed as part of the project.

Partnerships

The success of the project will depend on partnerships between the following parties:

- The EMM
- Private and public landowners.

Implementation time line and quantifiable results

The project will be implemented over a 7 year period with the following time line:

- Incorporation of the project into the relevant LSDFs by the end of 2009
- Negotiated agreements, preferably stewardship agreements, by the end of 2012
- A registered conservancy by the end of 2013
- A proclaimed protected area in terms of the protected Areas Act by 2015.

2.4. LAB Project 4: Glen Austin Bullfrog and Bird Sanctuary

Description

The project is a combination of a conservation, rehabilitation and recreation project to become a local open space within Ekurhuleni that incorporates both natural and active open space elements within the wider urban fabric of an area that is currently being developed for affordable housing. The project covers an area of approximately 268ha of which approximately 123ha is in a good natural state. Hydrological features including streams and two pans that is an important habitat for frogs and birds, covers approximately 19.ha (7%) in the area.

Functional

The following functions are proposed for the area:

- Natural open space conservation (46.11%)
- Natural open space rehabilitation and recreation (53.89%)

Ownership

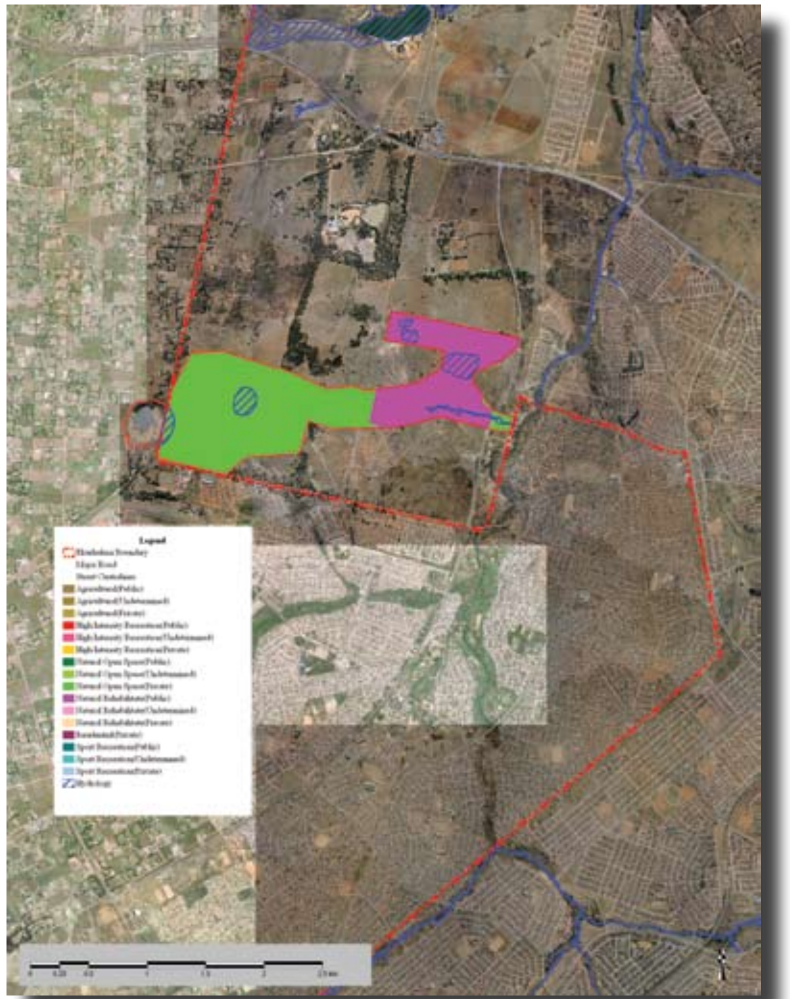
The ownership of the areas is divided into the following categories:

- Privately owned (46.11%)
- Publicly owned (53.89%)

Type of project

This is a new project with the primary aim to conserve biodiversity habitat for frogs and birds by maintaining hydrological systems within a grassland area by conserving high quality areas and restoring a derelict areas while also providing in the recreation needs of the surrounding communities.

MAP 11: Glen Austin Bullfrog and Bird Sanctuary



Unique aspects

The area contains a significant area of high quality grassland consisting mostly of Egoli Granite Grassland and two pans that form a unique intact habitat for a large number of species.

Challenges

A large portion of the land is privately owned and the biggest challenge is to develop an appropriate public/private conservation partnership model.

Influence of LAB

The LAB programme contributed to focusing the project on the biodiversity aspect and also contributed to give the project a level of urgency and status within the EMM.

Sustainability and benefits

The project will contribute to sustainable development by conserving a significant remaining portion of high quality grassland vegetation including an endangered vegetation type as well as two important wetlands. It will also make a significant contribution to the open space needs of the surrounding communities.

Financial

The financial implication of the project will depend on the implementation model that is developed as part of the project.

Partnerships

The success of the project will depend on partnerships between the following parties:

- The EMM
- Private and public landowners.

Implementation time line and quantifiable results

The project will be implemented over a 5 year period with the following time line:

- Incorporation of the project into the relevant LSDFs by the end of 2009
- Negotiated agreements, preferably stewardship agreements, by the end of 2010
- A proclaimed protected area in terms of the protected Areas Act by 2012.

2.5. LAB Project 5: Leeupan Regional Park Project

Description

The project is a rehabilitation project that is rehabilitating a wetland to a functional ecosystem and the establishing of an environmental education and cultural precinct centre that that will provide environmental and recreation activities for the surrounding communities while commemorating the life of OR Tambo via the creation of a cultural heritage precinct. The project covers an area of approximately 173ha of which approximately 154ha is in a good natural state. The wetland area is approximately 65ha (37%) of the area.

Functional

The following functions are proposed for the area:

- Natural open space conservation (89.73%)
- Natural open space rehabilitation (1.27%)
- Environmental centre, recreation and heritage (1%)
- Continuation of existing agriculture (8%).

Ownership

The ownership of the areas is divided into the following categories:

- Privately owned (0.15%)
- Publicly owned (99.72%)
- Undetermined (0.13%).

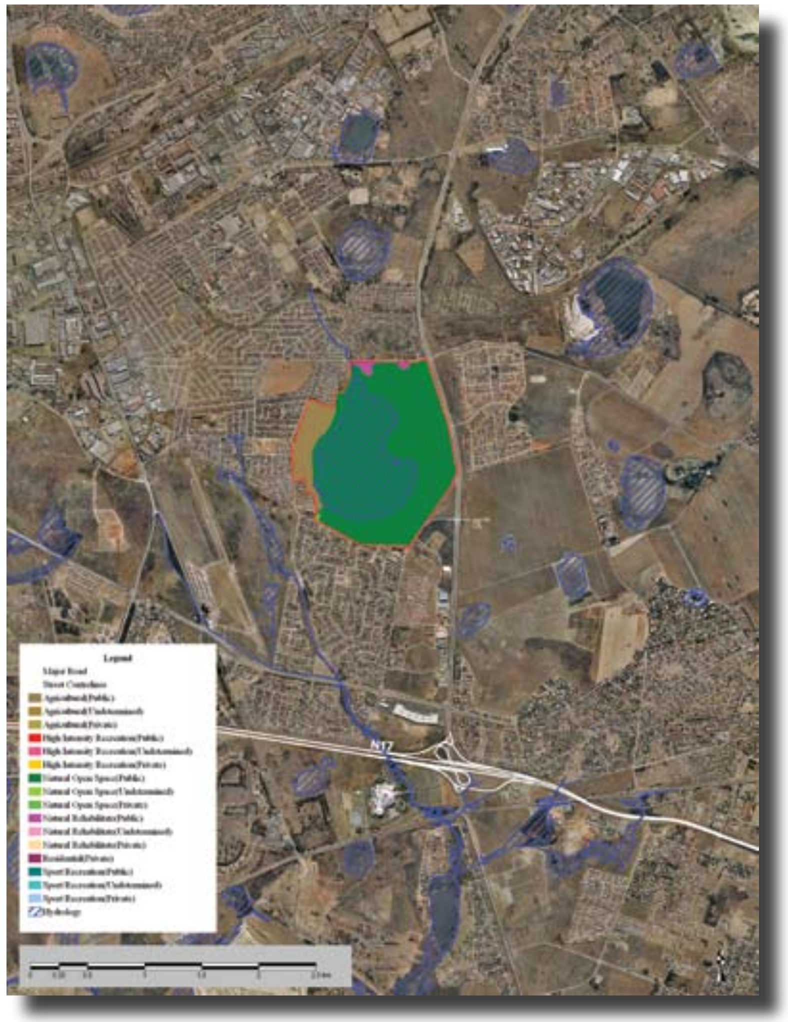
Type of project

This is an existing project with the primary aim to restore a derelict area to a meaningful open space area that includes natural, educational and cultural historical uses within an area that is currently in the process of significant urban renewal.

Unique aspect

The project combines the natural environment with socio cultural elements in a creative way to benefit the local surrounding communities.

MAP 12: Leeupan Regional Park Project



Challenges

The project will take place within a wider area where upgrading necessitates the removal of informal settlements, which may give a negative connotation to the project.

Influence of LAB

The LAB programme contributed to focus the project and also contributed to give the project a level of urgency and status within the EMM.

Sustainability and benefits

The project will contribute to sustainable development by conserving a wetland in an urban area. It will also make a significant contribution to the open space and recreational needs of the surrounding communities.

Financial

The financial implication of the project will depend on the implementation model that is developed as part of the project.

Partnerships

The success of the project will depend on partnerships between the following parties:

- The EMM
- Private and public landowners.

Implementation time line and quantifiable results

The project will be implemented over a 3 period with the following time line:

- Incorporation of the project into the relevant LSDFs by the end of 2009
- A registered conservancy by the end of 2010
- To be developed by 2010.

2.6. LAB Project 6: Bill Steward Ridge Conservation and Recreation Project

The project area is part of the Eastern Gauteng Ridge System and is an important greenbelt in the EMM. The initiative is driven by the Residents Action Group (RAG) that started in 2004. The project covers an area of approximately 86ha of which approximately 68ha is in a good natural state.

Functional

The following functions are proposed for the area:

- Natural open space conservation (79.72%)
- Natural open space with limited recreation (20.28%).

Ownership

The ownership of the areas is divided into the following categories:

- Privately owned (2.32%)
- Publicly owned (97.68%).

Type of project

This is an existing community project with the primary aim to maintain the area as a natural open space.

Unique aspect

The project combines the natural environment with socio cultural elements in a creative way to benefit the local surrounding communities.

Challenge

The safety and security of the community around the area may prove to be a challenge over the long term.

Influence of LAB

The LAB programme contributed to focus the project and also contributed to give the project a level of urgency and status within the EMM.

Sustainability and benefits

The project will contribute to sustainable development by conserving a ridge and associated grassland in an urban area. It will also make a significant contribution to the open space needs of the surrounding communities.

Financial

The financial implication of the project will depend on the implementation model that is developed as part of the project.

Partnerships

The success of the project will depend on partnerships between the following parties:

- The EMM
- Private and public landowners.

MAP 13: Bill Steward Ridge Conservation and Recreation Project

Implementation time line and quantifiable results

The project will be implemented over a 3 period with the following time line:

- Incorporation of the project into the relevant LSDFs by the end of 2009
- A registered conservancy by the end of 2010
- Declare conservation area by 2011.

3. Policies and guidelines

The integration of Biodiversity across line functions in the EMM only started with the commencement of the EBOSS and LAB initiatives in 2007. In the proses of developing EBOSS, various functional units of the EMM partook in the determination of policies and guidelines that are required for integrating biodiversity as a crosscutting element in the EMM. A significant achievement has been that the various functional units agreed on rolls in respect of policy formulation, implementation as well as long term management and maintenance. This is currently being finalised in the EBOSS project.

The following policies are currently in the process of being finalised as part of the EBOSS:

- Policy on the protection of biodiversity in the open space system, including:
  - Conservation or protection options;
  - Countering barrier effects on natural areas;
  - Avoiding or limiting habitat isolation;
  - Avoiding or limiting habitat fragmentation;
  - Intervention on private owned land i.e. insentives;
  - Maintenance and rehabilitation of river and wetland habitats;
  - Removal of alien vegetation; and
  - Access to natural open space.
- Policy on integrating natural open space into the urban context;
- Policy on the development of land surrounding the open space system;
- Policy on existing agricultural practices in the open space system;
- Environmental policy guideline for the development of spatial development ;frameworks (SDFs);
- Policy for SDFs as the main implementation instrument of EBOSS;
- Policy for detail evaluation of natural open space in a local context;
- Policy for integrating the open space system as a component of the urban fabric;
- Principles for risk averse planning and design; and
- General guideline for the EMM Parks Department, including:
  - Landscaping principles and criteria to enhance biodiversity; and
  - Selection of trees and other plants.

INTEGRATION

1. Mainstreaming biodiversity management into city governance

The Council has approved a recommendation that biodiversity must be integrated into the work of the other departments. A significant amount of work, however, still has to be done to address this issue adequately.

The Ekurhuleni Environmental policy also addresses biodiversity and conservation. As natural habitats are reduced as a result of the increased demand for development, the biodiversity and natural resources of EMM are threatened. Therefore, the EMM requires an integrated environmental strategy to ensure that development is undertaken in a manner that sustains biodiversity and natural resources in the EMM, and is socially beneficial.

The overarching goal for this principle is to ensure the long-term sustainability of the EMM's natural resources through the protection and management of renewable and non-renewable resources and biodiversity.

The following objectives should form the basis of an Environmental Strategy to be developed by the EMM:

- Ensure integrated planning and management and the optimal use of renewable and non-renewable resources.
- Ensure the sustainable use of agricultural land and resources in the EMM.
- Conserve and manage the cultural and heritage resources in the EMM.
- Promote the protection and conservation of biodiversity and natural resources in the EMM and in so doing, promote the protection of red data species habitats.
- Promote the conservation and protection of the Blesbokspruit in terms of the requirements as laid down in the Ramsar Convention.
- Manage water resources in an integrated manner in order that the quantity, quality and reliability of water is guaranteed as a right and set aside as a reserve.
- Strive to increase the area under formal protection for conservation purposes.
- Ensure the development and implementation of an alien plant management plan.
- Ensure that all applicable legislation and policy is considered and followed in land use planning and development.
- Ensure that the EMM policies are aligned with GDACE priorities in terms of conservation and protection of natural and other resources.
- Provide for and manage an effective open space system in the EMM in order to ensure long-term survival of habitats and to sustain the range of services that open spaces provide to humans and the eco-systems.

2. Interaction with other agencies

The EMM is also a partner to the South African National Biodiversity Institute's (SANBI), Urban Grasslands Project.

The goal of the Grasslands Programme is that ecological services provided by the grasslands biome are sustained and contribute to economic development and poverty alleviation. The approach is one of mainstreaming biodiversity into production sectors and decision-making about land use and development.

The urban component of the programme will concentrate on Gauteng, which because it is the economic heartland of South Africa has come under a huge amount of development pressure, much of which is not sustainable. A development path that sustains ecosystem services but provides for development needs to be found.

Three of the 12 priority sites indetified in the urban grasslands programme are located in Ekurhuleni. However, two are under major developmental pressure and the viability of the conservation of these sites is in the process of further assessment.

3. International initiatives

The EMM participates in the international LAB project and has identified several LAB biodiversity projects as indicated in this document

The EMM is also participating in the initiative of the International Association for Impact Assessment - Capacity Building in Biodiversity and Impact Assessment (IAIA-CBBIA). The EMM made a presentation on SEA practice and biodiversity at the IAIA –SEA conference'05 in Prague.

PARTICIPATION AND AWARENESS

PUBLIC PARTICIPATION AND AWARENESS

1 Public participation and access

Every landowner in the area that will be affected by the EBOSS (including the LAB Projects) was contacted via post and invited to a public open day where the project was explained and discussed. Presentations were also made to NGO's and other interest groups. Public involvement will continue for the duration of the project as buy in from the public in the EMM it is essential to the success of EBOSS and LAB in the EMM.

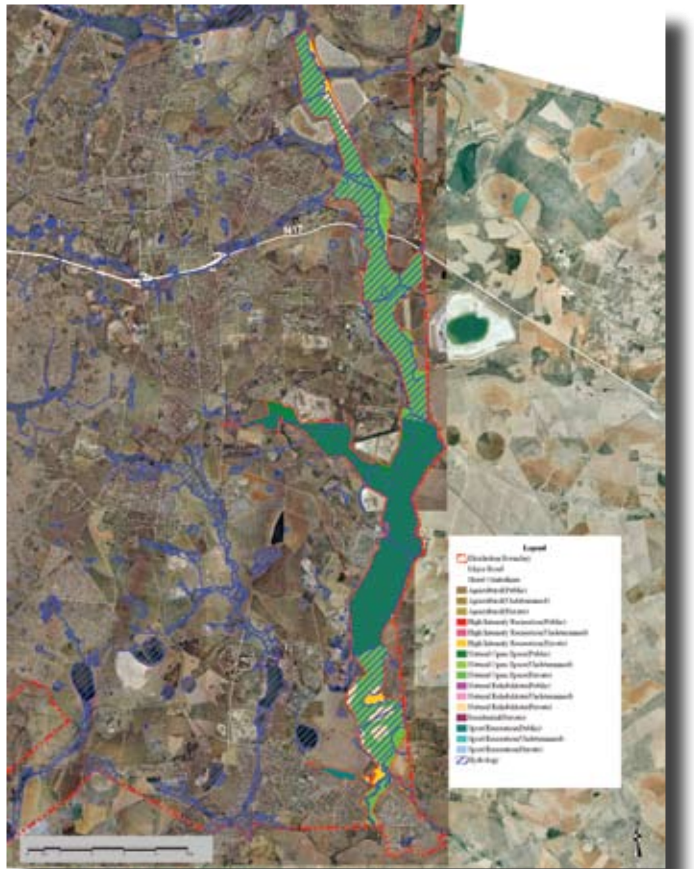
2 Biodiversity awareness-raising/ education projects

In order to raise awareness, promote private and public initiatives as well as educate the public the following projects have been identified and are in the process of being formulated:

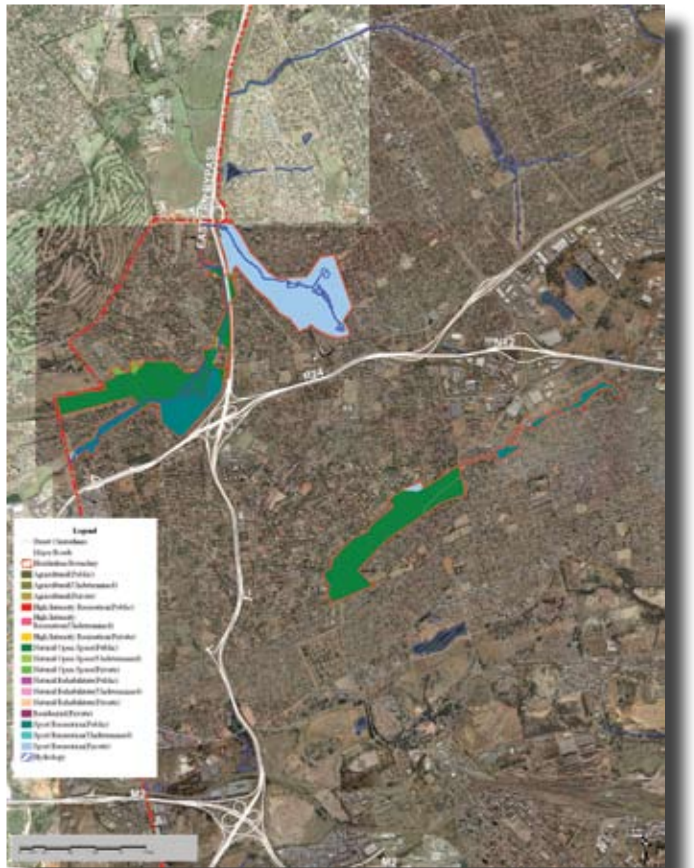
- Blesbokspruit Conservation Support Project, which entails providing support and awareness of the current provincial project associated with the Ramsar Site.
- 2010 Gateway Biodiversity Awareness Projects, which entails an awareness drive that uses the two prominent visual gateways in the EMM, that is situated on the main route between the OR Tambo International Airport and the main 2010 soccer venue in Gauteng, to promote awareness of biodiversity in the EMM.
- Meyersdal Nature Area Support Project, which entails the continued support of a public/private initiative to conserve a significant part of a ridge system with high quality vegetation and several Red Listed species.
- Midrand Estates Grassland Conservation Support Project, which entail the support of a grassland conservation area in a private development area.

In addition, it is planned to introduce the Geographic Information System (GIS) version of EBOSS to geography classes of high schools in the EMM to teach children about the biodiversity of the area as well as the use of GIS.

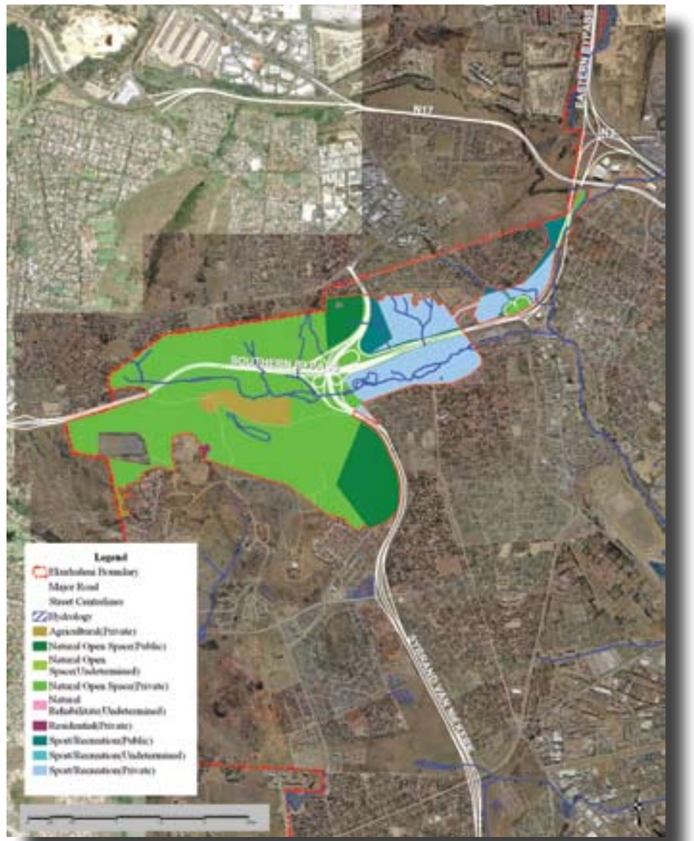
MAP 14: Blesbokspruit Conservation Support Project



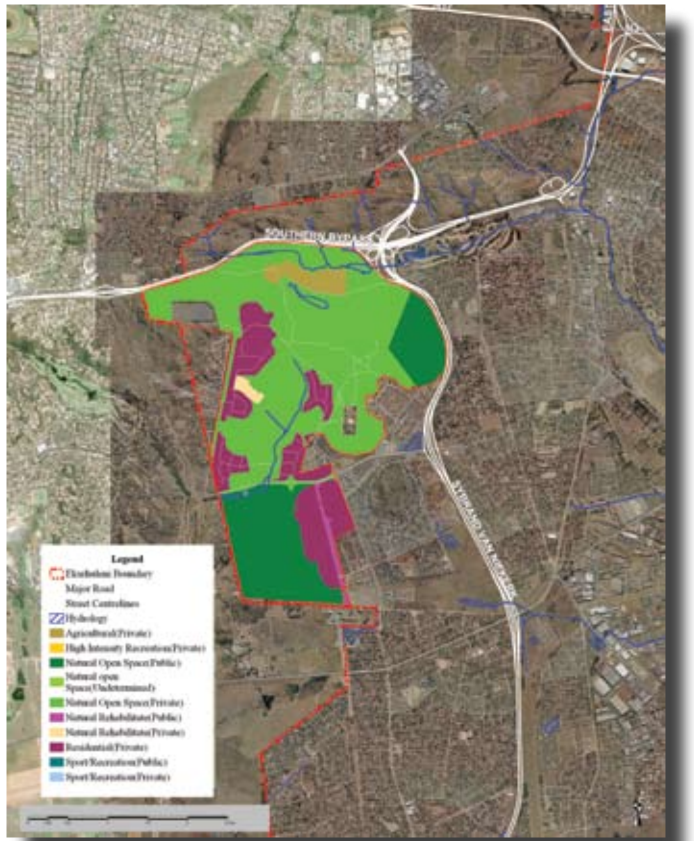
MAP 15: 2010 Biodiversity Gateway Awareness Project 1



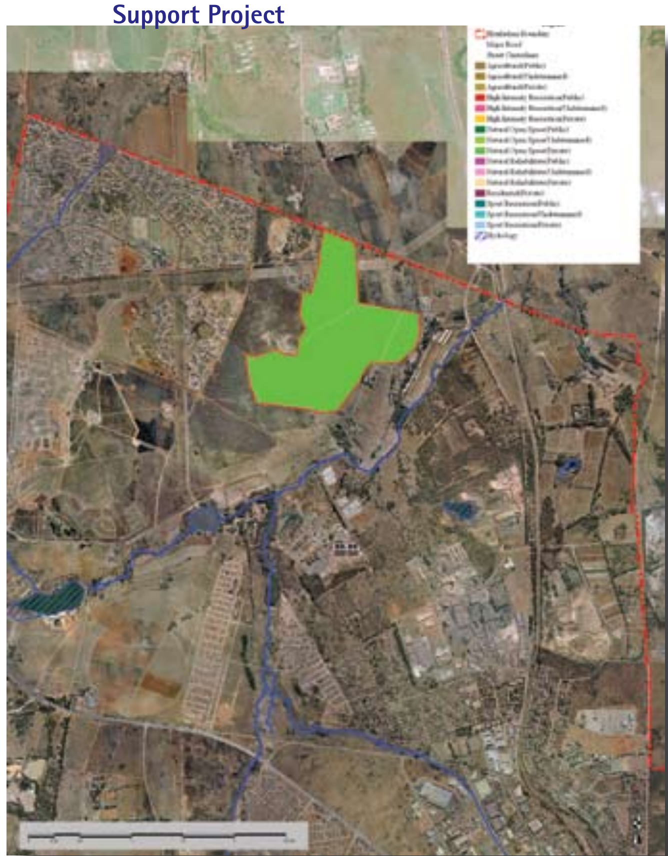
MAP 16: 2010 Biodiversity Gateway Awareness Project 2



MAP 17: Meyersdal Nature Area Support Project



MAP 18: Midrand Estates Grassland Conservation Support Project



REFERENCES

- Acocks J.P.H, 1998. Veld Types of South Africa, 3rd Edition.
- Cook, C.L. 2003. Background Information of Giant Bullfrog Populations in the Benoni Area. unpublished report.
- DEA&T 1997. White Paper on the Conservation and Sustainable Use of South Africa's Biological Diversity. Notice 1095 of 1997. Department of Environmental Affairs and Tourism, Pretoria.
- DACEL, 1999. State of the Environment in Gauteng: a preliminary report.
- Henderson, L (1995). Plant Invaders of Southern Africa. Plant Protection Research Institute, Agricultural Research Council. ISBN 1-86849-026-2
- IUCN (2002). IUCN Red List Categories. Prepared by the IUCN Species Survival Commission. Gland, Switzerland.
- Jacobsen, N.H.G. (1995). The Herpetofauna of Gauteng Province. Unpublished report for the Gauteng Directorate of Nature Conservation.
- Le Roux, J. 2002. The Biodiversity of South Africa 2002: Indicators, Trends and Human Impacts. Struik Publishers. Cape Town.
- Margules, C.R. and Pressey, R.L. 2000. Systematic Conservation Planning. In Nature Insight Biodiversity. Reprinted from Vol. 405, no. 6783: 243-253.
- Pfab, M.F. 2002. Priority ranking scheme for Red Data plants in Gauteng, South Africa. South African Journal of Botany 68:299-303.
- Pfab, M.F. and Victor, J.E. 2002. Threatened plants of Gauteng, South Africa. South African Journal of Botany 68:374-379.
- Whittington-Jones, C.A. (2003). Survey and monitoring of pans in Gauteng. First Annual Progress Report. DACEL. Unpublished report.
- Williams, V.L. (2003). Hawkers of Health: an Investigation of the Faraday Street Medicine Market in Johannesburg, Gauteng. Plant Ecology and Conservation Series No. 15. Report to the Gauteng Directorate for Nature Conservation, DACEL.
- MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and methods of vegetation ecology. Wiley, New York.
- WESTHOFF, V. & VAN DER MAAREL, E. 1978. The Braun-Blanquet approach. In: Whittaker, R.H. (ed.) Classification of plant communities. W. Junk, The Hague.
- Samways & Hatton 2000. Cited in DACEL 2001a.
- SANBI 2004 Vegetation map of South Africa, Lesotho and Swaziland (VEGMAP).

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RESEARCH ARTICLE

Cultivating more-than-human care: Exploring bird watching as a landscaping practice on the example of sand martins and flooded gravel pits

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Gravel extraction

Abstract The environmental crisis has created a demand for practices that build awareness about the interconnections of diverse forms of life, allowing humans to understand complex earthly relationships and reconnect with the land they inhabit. This paper contributes to this debate by investigating bird watching activities and their relevance for architects and landscape architects. Drawing upon multispecies studies and the notion of landscape thinking, it examines the potential of birding as a caring landscaping practice. It analyzes the relationship between birders and sand martins in two case studies and probes how birders develop attentiveness for the birds and their shared environment. The investigation suggests that birding fosters care beyond the observed species. It can trigger a landscaping practice comparable to landscape thinking that helps humans reconnect with the land, fostering response-able spatial design practices.

1. Introduction

Over the bright shallows
now no flights of swallows.
Leaves of the sheltering willow
dangle thin and yellow.

— Ursula Le Guin, extract from Six Quatrains (Le Guin, 2018).

The lines above make us imagine being immersed in the surrounding environment, attentively scanning the sky for birds. Through her work, sci-fi writer and poet Ursula Le Guin invites us to "relearn our being in [the world]" and build fellowship with non-human others (Le Guin, 2014, min. 22:18). In the context of the environmental crisis, Le Guin's work becomes highly topical. As anthropocentric actions show dramatic consequences on landscapes and their biodiversity, there is an emergence of theoretical approaches that aim at reviving the connection to the land and resonate with Le Guin's ideas. Scholars of multispecies studies call for attentiveness and care for other-than-

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human species (Tsing, 2015; Puig de la Bellacasa, 2017; van Dooren et al., 2016), while contemporary philosophers promote situated practices (Latour, 2018; Berque, 2013) such as "landscape thinking" (Berque, 2013, p. 3). In this paper, I want to emphasize the value of these approaches for spatial practitioners: looking outside the architectural discipline can help gain new perspectives on the land and inspire caring practices. I will take bird watching as an example to investigate this idea.

Most recently, the global COVID-19 pandemic fostered activities that allowed people to be outdoors "connecting with nature" (O'Brien and Forster, 2020, p. 22; Müller, 2020). In this context, also bird watching experienced a revival. Cornell Lab of Ornithology — a citizen science organization run by birding enthusiasts (Cornell University, 2022) — reported the highest number of global bird sightings ever recorded in May 2020 (Fortin, 2020). These recent developments invite reflection on human-bird interactions and on the relationships between birders, birds, and their surroundings. The spatial characteristics of birding have rarely been studied; most literature focuses on social, historical or environmental aspects of the practice (Moss, 2004; Callahan and Mitchell, 2014; McFarlane, 1994). Geographer and birder Mark Bonta (2010), however, gives a rare insight into the intimate relationship that emerges between bird watchers and their birding territory: Using the example of eco-tourist-birders in the Honduran rain forest, he describes how humans become attuned to the landscape and how birding can be understood as "geographically charged" (Bonta, 2010, p. 155). Building on these findings, my article explores the spatial implications of birding through the notion of "landscape thinking" (Berque, 2013, p. 3), hence revealing insights for spatial practitioners: *Does bird watching resemble a landscape thinking practice? Does it allow us, through immersion in the environment, to re-connect to the land? What can spatial designers learn from this practice?* To explore these questions, I investigate how birders cultivate attentiveness. I will start the essay with an introduction to the concept of landscape thinking (Berque, 2013) and explore its parallels to the methods of multispecies studies. Based on this investigation, I propose indicators that help identify landscape thinking in practice and test them on two case studies focusing on birders and sand martins. Rather than taking traveling birders as an example (Bonta, 2010), I focus on bird watchers whose birding territory constitutes their immediate neighborhood.

Landscape Architect Jane Hutton has shown the importance for spatial practitioners to pay attention to the sites where construction material is extracted and produced (Hutton, 2013). Taking her research into consideration, my paper explores anthropogenic quarry landscapes that form the habitat for the endangered migratory birds through the people who look after them. Having lost their habitat due to the industrialization of European hinterlands, sand martins have found refuge in the steep walls of quarries — often former mining sites that supplied material for resource-driven urbanization processes (Pannach, 2006; Münch, 1983). My first example illustrates a landscaping practice by an early birder in 19th century Britain, namely the poet and naturalist John Clare. The second one focuses on contemporary human-bird relationships and builds on interviews undertaken in the field with two birders who monitor a sand martin colony in a flooded gravel pit in the Upper Rhine Plain in Germany. The research opens up a different perspective on the environment and attempts to inspire spatial practices that reflect greater sensitivity towards more-than-human worlds.

2. Methods: connecting to the land and its multispecies dwellers

In his book "Thinking through Landscape", philosopher Augustin Berque (2013) discusses the origins of landscape as a concept and laments the loss of connection to the land. He distinguishes between two essential notions that formed the human relationship with the environment: *landscape theory*, which "has the landscape as subject of thought" and summarizes the writing produced about the landscape (Berque, 2013, p. 3), and *landscape thinking*, which describes an immersive, situated practice of landscaping that reflects "the deeper meaning of the landscape" (Berque, 2013, p. 36). According to Berque, with the arrival of landscape theory in the West around 1300, landscape thinking vanished. Landscape theory brought about an abstraction of the land and enabled both its objectification and its destruction (Berque, 2013). Acknowledging "the unsustainability of our way of living, of our thinking and acting on Earth", he (Berque, 2013, p. 5) calls for landscape thinking to be revived. For Berque, this concept is reflected in the work by Watsuji Tetsurō, namely in his book "Fudo" (1961).[1] Here the Japanese philosopher discusses the interrelation between human existence and climate (Watsuji, 1961). Berque makes a connection between landscape thinking and Watuji's "fudosei", which he translates as mediance (Berque, 2013, p. 56): "Mediance is the constitutive and dynamic complementarity, the structural moment between two sides of the human being: his animal half, which is individual ..., and his medial half, which is collective, transindividual, and intersubjective in space and time" (Berque, 2013, p. 60). Berque's quote suggests that landscape thinking requires rediscovering this intrinsic balance between individual subjectivity and transindividual "human milieu" (Berque, 2013, p. 62), and acting according to it: "Landscape thinking is the way in which each human translates this mediance from his flesh to his actions" (Berque, 2013, p. 59). Hence landscape thinking enables a vital human—environment relationship that brings humans closer to the land.

The notions of transindividuality and intersubjectivity can also be traced in work by scholars of multispecies studies, which allows me to draw parallels between landscape thinking and the "arts of attentiveness" (van Dooren et al., 2016, p. 17). To understand the worlds of non-human beings scholars of multispecies studies challenge the idea of individual bodies and immerse themselves passionately in the study of interconnected, diverse lives on Earth (Tsing, 2011; van Dooren et al., 2016). Their work also involves understanding contexts — or relationships with the land — as "dynamic milieus that are continually shaped and reshaped, actively ... crafted through the sharing of 'meanings, interests and affects' (Lestel et al., 2006, p.

[1] I write Japanese names in their normal, East Asian order, the family name comes first.

155)" (van Dooren et al., 2016, p. 4). The methods which can be described as "both a practice of getting to know another in their intimate particularity ... and, at the same time, a practice of learning how one might better respond to another might work to cultivate worlds of mutual flourishing" (van Dooren et al., 2016, p. 17), are influenced by ethology and biology (Swanson, 2017). When exploring the world of Pacific salmon, multispecies anthropologist Heather Swanson describes her own way of working as a dialogue with another species that emerges through attunement (Swanson, 2017). In this way, the multispecies approach allows for means of engagement with the surroundings that reflect a situated, immersive practice (Tsing, 2011; Tsing et al., 2017).

In this essay, I will use the methods of multispecies studies as a guide to trace landscape thinking in cultural practice on the example of birding (Fig. 1). The actions that define the approach, such as attuning (Morton, 2018), noticing (Tsing, 2015), caring (Puig de la Bellacasa, 2017), "making kin" (Haraway, 2016, p. 103), and developing "response-ability" (Haraway, 2016, p. 2) for more-than-human worlds work as indicators. To find out if these behaviors can be found in the case studies, the relationships between the following actors need to be identified: first, the human agent whose practice can be studied; second the withdrawn non-human agent that evokes attentiveness; and third, the land as the shared environment. Figure 1 illustrates how the human, by paying attention to more-than-human life, transcends individual experience and discovers "a sense of milieu" (Berque, 2013, p. 56). In my example of birders and sand martins, the human element is represented by bird watchers (a), the sand martin constitutes the non-human actor (b), and the land takes the form of a gravel quarry (c). More than a by-product but a veritable counter-product to the production of space, this typology is especially relevant for spatial designers. Omnipresent in their work, the extracted material is indispensable for the infrastructure and construction industry (Plankenhorn, 2018), whereas the left-behind pit lakes often remain out of sight. Gaining a different perspective on their afterlife through the multispecies relationships they host can be an opportunity for re-thinking both extractive practices and the value of such disturbed landscapes.

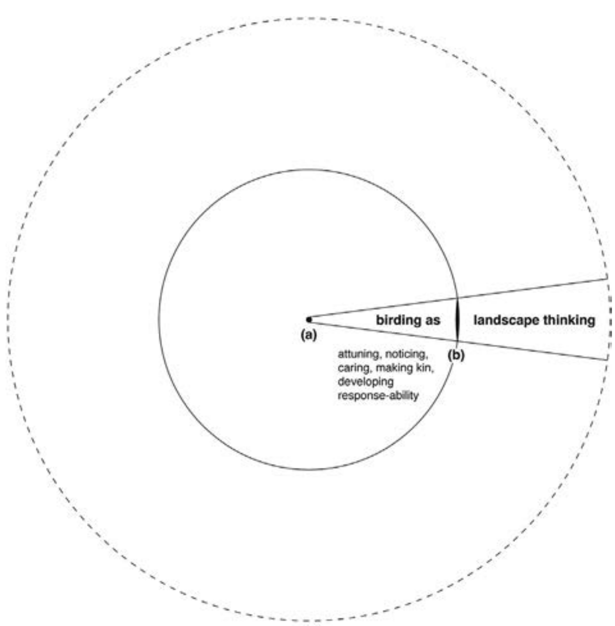

Fig. 1 Diagram showing the relationship between (a) human (birder), (b) non-human (sand martin), and (c) land (flooded gravel pit) (Image by the author).

In my first case study, John Clare (1793—1864) describes a quarry that might be one of the gravel extraction sites north of his cottage in Helpston, where he spent most of his life (Clare Cottage, n.d.; Hatton, 2019). In my second case study, the quarry is a flooded gravel pit — one of many nondescript places that emerged in South-West Germany through groundwater influx during gravel mining (Landesanstalt für Umwelt Baden-Württemberg (LUBW), n.d.). Today, many pit lakes are used for leisure activities or re-naturalized (Plankenhorn, 2018).

3. Material: inhabiting humanly-modified ground

Sand martins are small migratory birds of brown color with a white belly (Fig. 2). Three spatial regions define their yearly rhythm — breeding habitat, wintering ground, and the migration between the two (Pannach, 2006). About 10 000 years ago, in the Post Glacial Period, they started settling on the banks of European rivers. The versatile bird adapted to the streams that kept changing course and constantly formed new cliffs (Pannach, 2006). Since many natural riverbanks vanished due to straightening, they depend on human-made landscape patterns where they dwell as cultural successors of surface mining (Sandmann-Funke, 1972).

The poet John Clare already noticed their appearance in disturbed spaces in the 19th century (Gordon, 1983). He observed the birds nesting in quarries — likely in a gravel pit in his neighborhood in Cambridgeshire (Hatton, 2019; Northamptonshire II.8, 1886). Along the Upper Rhine, their survival is similarly linked with the gravel industry (Rupp, 1996): Here, their nesting sites were lost when the river

Fig. 2 A sand martin approaching a burrow (Image by Klaus Lechner).

was channelized at the turn of the 19th century (Boschert, 2002). Gravel mining in the area accelerated after WW2 when concrete became the number one construction material for rebuilding the ruined towns and cities (Münch, 1983). Meanwhile, gravel extraction has produced more than 600 flooded pits in the valley (LUBW, n.d.) and influenced the region on a territorial scale. Amongst other species, the sand martin found refuge in flooded gravel pits, almost exclusively nesting in cliffs where dredgers cut off the soil along the lakes' shorelines (Boschert, 2002). These often only temporary formations became the species' secondary habitat wherever natural banks were rare. Today, birding associations closely monitor protected species ('WISIA', n.d.; 'Brutbestandsmonitoring Uferschwalbe', n.d.), inviting more birders to pay attention to the birds' way of life. These human-bird interactions form the basis for the following case studies.

4. Case study I — the poetry of birding: John Clare's more-than-human writings

Human-bird relationships date back to prehistoric times. Around 10 000—8000 years ago, bird watching was practiced for agricultural benefits: Farmers observed migrating birds that indicate seasonal changes to identify ideal seeding and harvesting times (Moss, 2004). In the 19th century, naturalists started noticing birds when their natural habitats were lost due to the industrialization of the countryside (Moss, 2004). However, the leisure activity of birding as we know it today only originated in the last century (Moss, 2004).

British poet and naturalist John Clare represents one of the earliest birders engaging in birdwatching as a way of life. Growing up in the British countryside and witnessing industrialization and the enclosure of the commons, he noticed the rapid change in the familiar landscape surrounding him (Moss, 2004). He spent much time outside, immersing himself in the surroundings. "He is … no passive observer, letting nature get to him …; rather, he searches, hunts, crawls on all fours, the better to see what is happening in the fields, heaths, hedges, woods, and undergrowth" (Duddy, 2011, p. 64). His writings, comprising a large sum of bird poetry (Chun, 2005), reflect a practice of "careful noticing" (Swanson, 2017, p. 86) that he developed, engaging in a "creative alchemy of walking" (Gandy, 2020, p. 161). Compared to his contemporaries, he did not portray birds as mythical creatures but rather "wrote about real birds" (Moss, 2004, p.22). He described what he saw with attentiveness: "Clare simply gives expression to what he so carefully — and so caringly — observes" (Duddy, 2011, p. 64). Looking at a map showing the surroundings of Helpston near Peterborough, where Clare grew up, one notices several gravel pits north of the village near river Welland (Fig. 3). Here the poet might have observed the birds during one of his countless walks in the area (Blythe, 1999) almost 200 years ago when small quarry lakes emerged due to gravel extraction (Hatton, 2019; Gibbard et al., 2018). While some of the lakes remain active quarries today, others have been turned into nature reserves and continue to be popular bird sighting spots (Callahan, 2020). The following poem, devoted to the sand martin, reveals Clare's awareness about the role of anthropogenic habitats for the species while simultaneously reflecting his grief (Gordon, 1983).

Thou hermit haunter of the lonely glen

And common wild and heath – the desolate face

Of rude waste landscapes far away from men

Where frequent quarrys give thee dwelling place

With strangest taste and labour undeterred

Drilling small holes along the quarrys side

More like the haunts of vermin than a bird

And seldom by the nesting boy descried

Ive seen thee far away from all thy tribe

Flirting about the unfrequented sky

And felt a feeling that I cant describe

Of lone seclusion and a hermit joy

To see thee circle round nor go beyond

That lone heath and its melancholly pond

— John Clare, The Sand Martin, (Sale, 2013).

The Sand Martin shows Clare's ability to attune to and make kin with a non-human species. In times of industrialization he purposefully selected the bird for his poem: The sand martin, which finds refuge in 'frequent quarries', allows him reflecting on natural habitats lost due to resource exploitation. Inhabiting 'rude waste landscapes', the bird's appearance to Clare seems 'haunted'. As 'hermit', it settles where no one else wants to be and gives disturbed landscapes an afterlife. The birds' isolated way of life in human-made environments also reflects Clare's emotional state and makes him express his compassion (Gordon, 1983). Especially the lines 'a feeling that I cant describe / Of lone seclusion and a hermit joy' give evidence of his attunement to the species; While he cannot fully understand its inner world, he makes an emotional connection through careful observation. Literary scholar Sarah M. Zimmerman (2015, p. 66) puts it this way: "He can't describe it because it is not within his realm of experience, but he can feel it in the sand martin's 'Flirting' flight".

Almost 200 years before scholars of multispecies studies, Clare developed a great sensibility to understand and describe other-than-human worlds. His way of engaging with birds shows parallels to the "arts of attentiveness" (van Dooren et al., 2016, p. 17) and reveals a situated practice that can be compared with Berque's notion of landscape thinking: Rather than speaking of the landscape, Clare communicates a "sense of place" (Moss, 2004, p. 23). In his writings, he "manages to recreate the atmosphere of a specific experience in a particular location" (Moss, 2004, p. 23). Without describing the actual scene, he conveys a

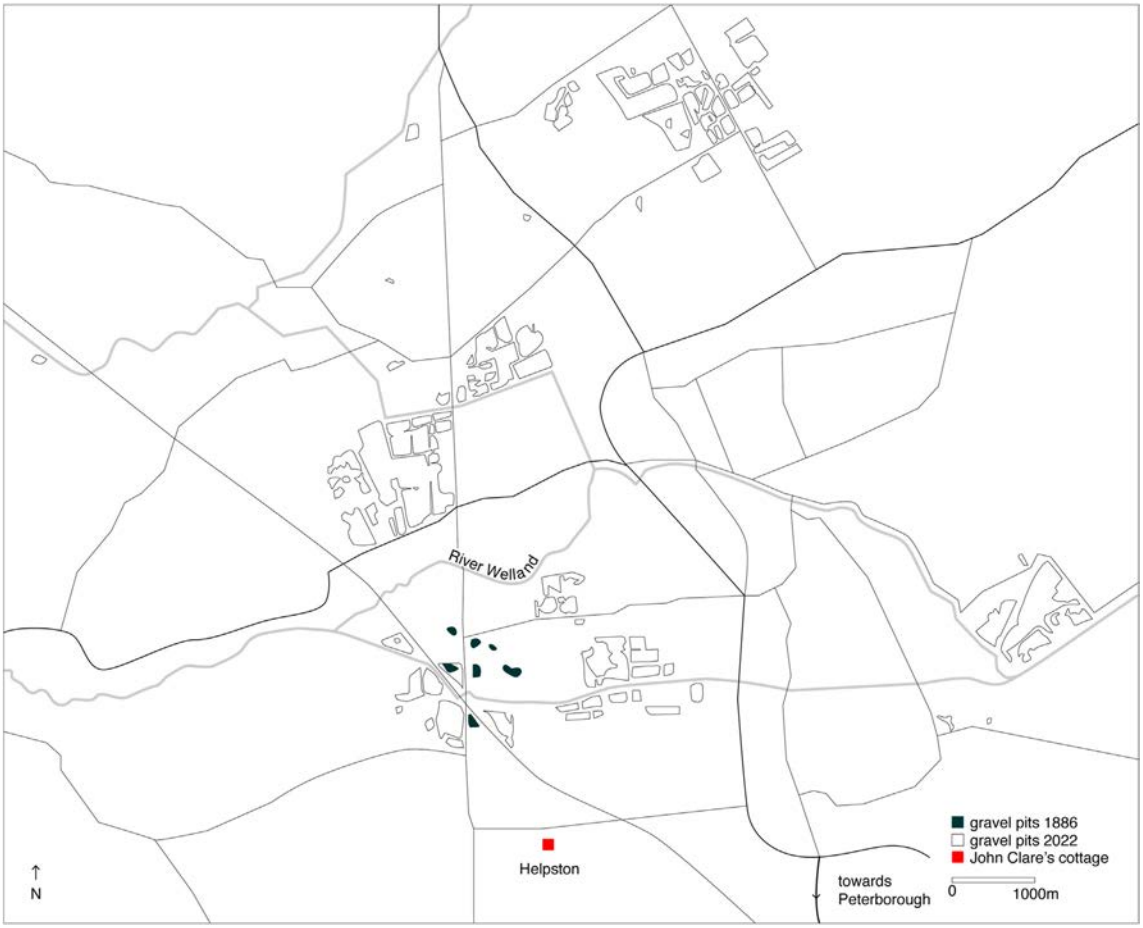

Fig. 3 Map showing surroundings of Clare's cottage in Helpston (Image by the author).

localized event where bird-sighting and surroundings form a "dynamic milieu" (van Dooren et al., 2016, p. 4). Clare's writings show his ability to notice and attune non-human species while simultaneously reflecting a sense of awareness about the environment and its changing conditions. His work proves his groundedness and connection to the land — showing a practice of attentiveness and care that might have influenced contemporary birders and is still reflected in birding activities today.

5. Case study II — cultivating care: sand martin monitoring in the Upper Rhine Plain

Epplesee is one of the many pit lakes that emerged due to gravel extraction in the Upper Rhine Plain in South-West Germany (Fig. 4). Mining operations began in 1937 and continue until the present day ('Der Epplesee', n.d.). Like most flooded gravel pits in the area, the topography of the extraction site — which at first glance looks unintentional — is shaped by industry requirements, safety measures, environmental protection guidelines, and the interests of local stakeholders (Ministerium für Umwelt, Klima und Energiewirtschaft Baden-Württemberg (UMBW), 2021). The design of such anthropogenic sites is highly political, as many actors have conflicting interests that range from mining to nature protection, swimming and water sports (Landesanstalt für Umweltschutz Baden-Württemberg (LfU), 2004). At Epplesee, the mining company occupies a fraction of the lakeshore. Most of the latter is divided between diverse public beaches and water sport areas. A smaller section belongs to a nature reserve ('Der Epplesee', n.d.).

In an active mining site, re-naturalization and re-cultivation measures are intertwined with the mining activities and considered as compensation for land loss (LfU, 2004). While the most common re-use strategies address human needs such as angling and swimming (Westermann, 1996), nature is seen as a flexible agent that follows where extraction has finished, often referred to as "temporary nature" (in German "Natur auf Zeit") (UMBW, 2021, p. 84). Also on Epplesee leisure activities dominate the scene; but neighboring the lake are two former gravel pits that have been fully re-naturalized and have restricted access. As a habitat for resting winter birds, rare songbirds, and protected sand martins, Epplesee and its surroundings form an ideal birding territory (Lechner, personal communication, July 21, 2021). Bird protection also plays a role in the planning of extraction sites. However, some species have it easier than others — the guidelines issued by the local environmental agency recommend flat water zones as the ideal embankment design. These can offer nesting

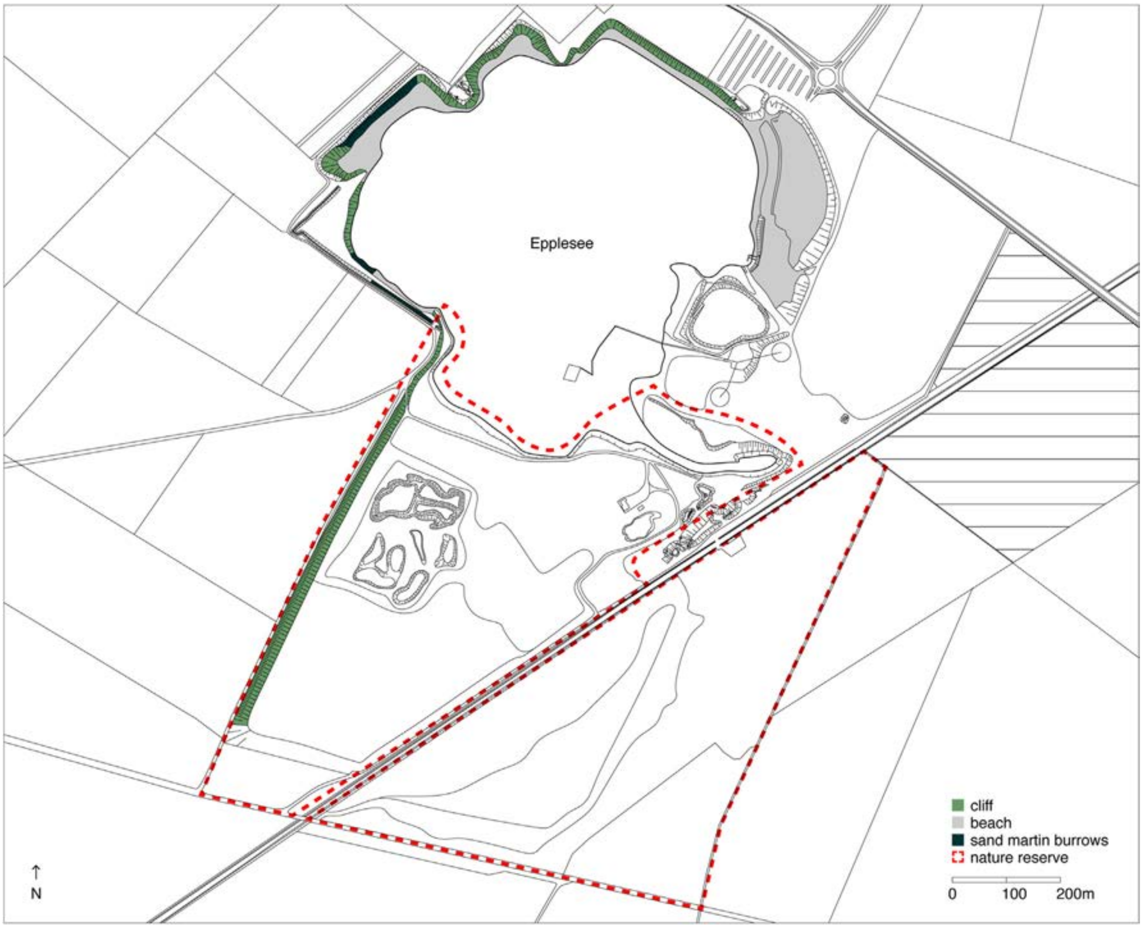

Fig. 4 Map of Epplesee (Image by the author).

places for water birds and are low maintenance. Cliffs that result from the extraction processes — which sand martins need for nesting — are suggested only for exceptional bird protection measures as they pose dangers to human visitors and need to be secured (LfU, 2004; UMBW, 2021).

During my fieldwork in 2021, I had the chance to interview birders that monitor sand martins on the lake. Our conversations made evident that there are different types of bird watchers: the "dedicated ones" who participate in the monitoring activities and those who chase after the rare species to tick them off a list or photograph them as a personal challenge (Lechner, personal communication, July 21, 2021). In the bird watching community, the first type is referred to as birders, whereas the second ones are described as "twitchers" (Moss, 2004, p. 263). My interview partners consider themselves as birders; therefore, this case study focuses on the first type.

On a rainy July morning, I met Klaus Lechner at a bus stop near Karlsruhe, where we took his car to Epplesee. Lechner is a dedicated birder. He became interested in the activity after buying his first set of binoculars about ten years ago. For Lechner, bird watching is not his hobby; he doesn't like the term as it devalues the practice. It is a "calling" (Lechner, personal communication, July 21, 2021) — birding has become his way of life: Recently retired, he structures his time according to breeding seasons and the arrival and departure of migratory birds. He participates in monitoring programs of various species that can be observed around Epplesee throughout the year. Noticing birds is a complex endeavor. Learning to understand their song and flight pattern takes time and can't be rushed, and it involves regular training — but Lechner enjoys the opportunity to contribute to science by providing data about the birds (Lechner, personal communication, July 21, 2021). During our walk along Epplesee, Lechner stopped now and then, contemplating with a pointed finger to indicate he just noticed a rare birdsong. On the lake, we met with Stefan Eisenbarth: Lechner's fellow birding colleague, city gardener, and guardian of the local stork population (Eisenbarth, personal communication, July 21, 2021). Together they monitor a small colony of sand martins nesting in the cliffs. The day we met, they gathered to count them (Fig. 5). Unremarkable in their appearance, sand martins are not sought after by twitchers (Lechner, personal communication, July 21, 2021) but are instead monitored as their numbers are declining in the region (Boschert, 1999; 'Brutbestandsmonitoring Uferschwalbe', n.d.).

Upon return from their winter habitat in the Sahel Zone, around April, the birds start nesting (Bairlein et al., 2014) in the cliffs on the South-West side of Epplesee. Here the adult birds carve deep burrows into the sandy soil in which

Fig. 5 The birders K. Lechner and S. Eisenbarth discussing the condition of the cliff on Epplesee (Image by the author).

they lay their eggs (Fig. 6). The overlapping uses on the lake make it difficult for the species: Swimmers, anglers, and sunbathers appropriate each possible spot along the shore during the hot summer months. Avoiding the populated flat beaches, people disturb the colony by climbing over the cliffs and occupying the small strip of beach right in front of the nesting sites (Lechner, personal communication, July 21, 2021).

In July, during the official monitoring season, Lechner and Eisenbarth take a boat to row along the shore, counting holes in the cliffs and patiently waiting for the feeding birds to enter. This allows them to distinguish between inhabited burrows and vacant ones from last year (Lechner, personal communication, July 21, 2021). They mark their findings on photographs of the cliffs and finally enter the numbers and their location according to a protocol into a smartphone application provided by the birding association ('Brutbestandsmonitoring Uferschwalbe', n.d.). Over time, both noticed the potential danger of human disturbance and developed an eye for identifying ideal nesting sites based on the ground conditions. Sand martins have a unique relationship with the soil. Sandy soils with a small amount of clay, loam, or humus — like at Epplesee — are ideal: stable enough to support the burrows and soft enough for digging the tunnels (Sandmann-Funke, 1972). Lechner and Eisenbarth know that the birds dislike the gravelly layers but prefer the upper soil horizons with a high sand ratio (Eisenbarth, personal communication, July 21, 2021). They also observed that vegetation along the cliffs prevents the birds from entering the tunnels, while erosion helps predators chase them (Lechner, personal communication, July 21, 2021). Their knowledge about the bird's way of life encouraged Lechner and Eisenbarth to actively engage in maintenance practices to keep the cliffs accessible to birds and obstruct access by human and non-human predators: Cutting down shrubs and trees on the cliffs keeps the borrows clear and prevents erosion while distributing dry branches along the cliff edge stops humans from getting close (Eisenbarth and Lechner, personal communication, July 21, 2021). From the boat, Lechner noticed suitable nesting sites for the future — locations where artificial cliffs could be created with the help of the mining company (Lechner, personal communication, July 21, 2021). All these landscaping measures are carefully performed not to interfere with the breeding season — human time is structured according to bird time. Lechner describes his engagement on Epplesee as an "inner urge" (Lechner, personal communication, July 21, 2021). He mentions that for birding, one needs "a certain humility": "I just need to accept what I see, what is there. I know many people who don't know how to do that [anymore], they usually want to see something specific, but [in birding] it doesn't work like that" (Lechner, personal communication, July 21, 2021).

Since Lechner and Eisenbarth monitor the colony, they developed a unique connection to the sand martins: attuning to the species allowed them to see Epplesee from a more-than-human lens. Their behavior and conversations clearly show that birding reaches beyond the fascination for a species — attentiveness for birds fostered an awareness for the shared environment. Furthermore, it triggered a need to care for it and encouraged a practice of maintaining the disturbed landscape. Their relationship to the sand martin clearly shows parallels to the methods described by scholars of multispecies studies. Their immersion in the land, defined by "careful noticing" (Swanson, 2017, p.86), developing "response-ability" (Haraway, 2016, p.2), and involvement over time can be compared with Berque's notion of landscape thinking.

Fig. 6 Sand martin burrows on Epplesee (Image by the author).

6. Discussion and conclusion

In this paper, I discussed birding as a landscaping practice that allows humans to reconnect to the land. Referring to the methods of multispecies studies, I have made a connection between bird watching and Berque's landscape thinking. This allowed me to analyze the behavior of birders in two case studies focusing on sand martins that inhabit quarries. In this way, the paper brought these anthropogenic landscapes to attention through the multispecies actors that inhabit and look after them.

By tracing the birders' caring practices, the paper has shown that birding makes humans aware of both the observed species and their environment. John Clare's way of close listening and observing involves attunement and patience corresponding to the methods proposed by scholars of multispecies studies. Following two birders on Epplesee and observing their engagement shows that contemporary birding activities likewise represent an "art of attentiveness" (van Dooren et al., 2016, p.17). Their engagement with the landscape reveals how tuning into non-human worlds can trigger a situated practice of landscaping that reflects care and responsibility for a shared environment. The yearly cycle of birding activities corresponding to breeding seasons and bird migration patterns creates an awareness of more-than-human temporal scales. In both cases, the persons engaged in bird watching develop attentiveness for more-than-human interactions with the land. It becomes clear that birding triggers a caring practice for the environment that correlates to landscape thinking. Therefore, birding-as-landscape-thinking allows humans to reconnect to the land through immersion and situatedness.

The example of a flooded gravel pit in Germany has also shown that disturbed landscapes are shaped by layers of engagement that transcend the scope of the most prominent stakeholders, such as mining companies and local authorities: A humble occupation like bird watching — which is primarily not considered a landscaping practice — can have great implications on environments. Birders build a connection to the observed species and the surroundings that form their habitat and "common world" (Haraway, 2016, p.41). Gaining a more-than-human perspective helped the birders discover a potential that lay dormant in the land; observing the sand martins in their habitat encouraged them to modify the surroundings to improve the birds' living conditions in the anthropogenic space. These findings have implications for architects and landscape architects, both for theory and for practice: Taking a species' way of life into account, a disturbed extraction site suddenly becomes a habitat thriving with life — Bonta (2010) mentiones this changing notion of a landscape's "beauty" (p.146) when he describes how dump sites can become "sacred" places in the eye of a birder (p.147). These findings also challenge the notion of aesthetics in urban or landscape design: *thinking-with* another species affects design decisions, which are subsequently reflected in the image of urban or rural places. Geographer Matthew Gandy (2019) has shown that spaces which support biodiversity not always align with what is deemed aesthetically pleasing. This also concerns flooded gravel pits, where exposed cliff edges — potential sand martin habitats — are often removed in favor of flat beaches (LfU, 2004; UMBW, 2021). Following birders, this research has shown how these disturbed landscapes can indeed become significant for more-than-human life: as an "always-in-the-making world of possibilities ... to which organisms, including humans, respond" (Hoag et al., 2018, p. 24).

In the face of the environmental crisis, the spatial domain can benefit from interdisciplinary encounters that can teach attentiveness and care for the world we inhabit — Le Guin invites us to "relearn our being in it" (Le Guin, 2014, min. 22:18). As one of potentially many ways, birding-as-landscape-thinking might offer a starting point for the spatial discipline to learn how to be, and to build in the world. It requires us to be present on site for a certain time, immersed in the surroundings, acknowledging what it means to be indivisibly intertwined with the environment: that we are "an element in the mutual relationship" with the land (Watsuji, 1961, p. 5). Beyond offering architects and landscape architects a new perspective on the context they are designing for, birding-as-landscape-thinking invites the discovery of other-than-human needs and temporalities, fostering "response-able" spatial projects (Haraway, 2016, p. 20).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

Bairlein, F., Dierschke, J., Dierschke, V., Salewski, V., Geiter, O., Hüppop, K., ... Fiedler, W., 2014. Atlas des Vogelzugs Ringfunde deutscher Brut- und Gastvögel, first ed. Aula-Verlag, Wiebelsheim.

Berque, A., 2013. Thinking through Landscape (A.-M. Feenberg-Dibon, Trans.). Routledge, London; New York.

Blythe, R., 1999. Talking about. *John Clare*. Trent, Nottingham.

Bonta, M., 2010. Ornithophilia: thoughts on geography in birding. Geogr. Rev. 100 (2), 139—151.

Boschert, M., 1999. Riparia Riparia, (Linnaeus 1758), Uferschwalbe. In: Hölzinger, J. (Ed.), Die Vögel Baden-Württembergs. Bd. 3,1: Singvögel: 1, Passeriformes—Sperlingsvögel: Alaudidae (Lerchen)—Sylviidae (Zweigsänger), vol. 3. Ulmer, Stuttgart.

Boschert, M., 2002. Natürlicher Brutplatz der Uferschwalbe (Riparia riparia) am südlichen Oberrhein, pp. 167—171.

Brutbestandsmonitoring Uferschwalbe, n.d. Retrieved from https://www.ornitho.de/index.php?m_id=20105 (accessed 06.09.2021).

Callahan, D., 2020. Where to Watch Birds in East Anglia: Cambridgeshire, Norfolk and Suffolk. Bloomsbury Publishing, London.

Callahan, D., Mitchell, D., 2014. A History of Birdwatching in 100 Objects. Bloomsbury, London.

Clare Cottage, n.d. *John Clare Cottage — Home*. Retrieved from https://www.clarecottage.org/(accessed 1.2.2022).

Chun, S., 2005. An Undiscovered song': John Clare's 'Birds Poems. Interdiscip. Lit. Stud. 6 (2), 47—65.

Cornell University, 2022. Cornell Lab of Ornithology — about. Retrieved from. https://www.birds.cornell.edu/home/about/, 01.02.2022.

Der Epplesee, n.d. Retrieved from https://www.rheinstetten.de/de/see (accessed 23.6.2021).

Duddy, T., 2011. John Clare and the poetry of birds. Poetry Irel. Rev. 104, 60—73.

Fortin, J., 2020, May 29. The Birds Are Not on Lockdown, and More People Are Watching Them. The New York Times. Retrieved from. https://www.nytimes.com/2020/05/29/science/bird-watching-coronavirus.html, 1.2.2022.

Gandy, M., 2020. Queering the transect. In: Gandy, M., Jasper, S. (Eds.), The Botanical City. Jovis, Berlin.

Gandy, M., 2019. The fly that tried to save the world: saproxylic geographies and other-than-human ecologies. Trans. Inst. Br. Geogr. 44 (2), 392—406.

Gibbard, P.L., West, R.G., Hughes, P.D., 2018. Pleistocene glaciation of Fenland, England, and its implications for evolution of the region. R. Soc. Open Sci. 5 (1), 2—52.

Gordon, J.V., 1983. *John Clare: The Theme of Isolation in His Poetry* (Thesis). Durham University, Durham.

Haraway, D.J., 2016. Staying with the Trouble: Making Kin in the Chthulucene. Duke University Press, Durham; London.

Hatton, A.J., 2019. *Stowe Farm, Lincolnshire: A Multi-Period Archaeological Site in its Landscape* (Thesis). The University of Sheffield Faculty of Arts and Humanities, Department of Archaeology, Sheffield.

Hoag, C., Bertoni, F., Bubandt, N., 2018. Wasteland ecologies: undomestication and multispecies gains on an anthropocene dumping ground. J. Ethnobiol. 38 (1), 88—104.

Hutton, J., 2013. Reciprocal landscapes: material portraits in New York City and elsewhere. J. Landsc. Architect. 8 (1), 40—47.

Landesanstalt für Umweltschutz Baden-Württemberg (LfU), 2004. Kiesgewinnung und Wasserwirtschaft Empfehlungen für die Planung und Genehmigung des Abbaues von Kies und Sand. Landesanstalt für Umweltschutz Baden-Württemberg, Karlsruhe.

Landesanstalt für Umwelt Baden-Württemberg (LUBW), n.d. Baggerseen. Retrieved from https://www.lubw.baden-wuerttemberg.de/wasser/baggerseen (accessed 5.5.2021).

Latour, B., 2018. Down to Earth: Politics in the New Climatic Regime, English edition. Polity Press, Cambridge, UK; Medford, MA.

Le Guin, U.K., 2018. So Far So Good: Final Poems: 2014-2018, first ed. Copper Canyon Press, Port Townsend, WA.

Le Guin, U.K., 2014, May 8. Anthropocene: Arts of Living on a Damaged Planet. UC Santa Cruz. Retrieved from. https://www.youtube.com/watch?v=6BW8YmRAoW4, 1.2.2022.

Lestel, D., Brunois, F., Gaunet, F., 2006. Etho-ethnology and ethno-ethology. Soc. Sci. Inf. 45 (2), 155—177.

McFarlane, Bonita L., 1994. Specialization and Motivations of Birdwatchers. Wildl. Soc. Bull. 22 (3), 361—370.

Ministerium für Umwelt, Klima und Energiewirtschaft (UMBW), 2021. Nachhaltige Nutzung mineralischer Rohstoffe in Baden-Württemberg—Konzept. Ministerium für Umwelt. Klima und Energiewirtschaft, Stuttgart.

Morton, T., 2018. Being Ecological. The MIT Press, Cambridge, MA.

Moss, S., 2004. A Bird in the Bush: A Social History of Birdwatching. Aurum Press, London.

Müller, N., 2020. April 24. *Coronavirus: 8 Ways to Connect with Nature during Lockdown*. Retrieved from. https://www.dw.com/en/coronavirus-8-ways-to-connect-with-nature-during-lockdown/g-53161124, 1.2.2022.

Münch, W.D., 1983. 100 Jahre Kiesabbau in der nordbadischen Rheinebene (Regierungsbezirk Karlsruhe). Carolinea 41, 9—20.

Northamptonshire II.8 [64.4 cm x 96.6 cm], 1886. National Library of Scotland. Retrieved from. https://maps.nls.uk/view/114476045, 1.2.2022.

O'Brien, L., Forster, J., 2020. Engagement with Nature and Covid-19 Restrictions — Quantitative Analysis 2020. The Research Agency of the Forestry Commission.

Pannach, G., 2006. Die Uferschwalbe Riparia Riparia, first ed. Westarp Wissenschaften, Hohenwarsleben.

de la Bellacasa, M.P., 2017. Matters of Care: Speculative Ethics in More than Human Worlds. University of Minnesota Press, Minneapolis, Minn; London.

Plankenhorn, U., 2018. Reich an Kies und Sand. Wirtschaft im Südwesten Retrieved 7.11.2020 from:.

Rupp, J., 1996. Brutverbreitung und Bestand der Uferschwalbe (Riparia riparia) am rechtsrheinischen südlichen Oberrhein, pp. 131—140.

Sale, R., 2013. Closer to home: English writers and places, 1780—1830. In: Closer to Home. Harvard University Press, Cambridge, MA; London, UK.

Sandmann-Funke, S., 1972. Untersuchungen zur Anlage von Uferschwalbenkolonien in Abhängigkeit von Bodentypen. Abhandlungen aus dem Westfälischen Provinzial-Museum für Naturkunde 88—94.

Swanson, H.A., 2017. Methods for multispecies anthropology: thinking with salmon otoliths and scales. Soc. Anal. 61 (2), 81—99.

Tsing, A.L., 2011. Arts of inclusion, or, how to love a mushroom. Aust. Humanit. Rev. 5 (50), 5—22.

Tsing, A.L., 2015. The Mushroom at the End of the World: on the Possibility of Life in Capitalist Ruins. Princeton University Press, Princeton, NY.

Tsing, A.L., Swanson, H.A., Gan, E., Bubandt, N. (Eds.), 2017. Arts of Living on a Damaged Planet: Ghosts of the Anthropocene. University of Minnesota Press, Minneapolis, Minn.

van Dooren, T., Kirksey, E., Münster, U., 2016. Multispecies studies: cultivating arts of attentiveness. Environ. Humanit. 8 (1), 1—23.

Watsuji, T., 1961. A Climate, A Philiosphical Study. Printing Bureau, Japanese Government, Japan.

Westermann, K., 1996. Kiesabbau und Naturschutz in der Region Südlicher Oberrhein - Eine Stellungnahme des Naturschutzbundes Deutschland (NABU). Naturschutz südl. Oberrhein 1, 227—238.

WISIA Wissenschaftliches Informations system für den internationalen Artenschutz, n.d. Retrieved from https://www.wisia.de/prod/FsetWisia1.de.html (accessed 19.9.2021).

Zimmerman, S.M., 2015. John Clare's conspiracy. In: McEathron, S., Kvesi, S., Series (Eds.), New Essays on John Clare. Cambridge University Press, Cambridge, UK ; Medford, MA, p. 258.

Mining Word Search

J	G	X	J	E	X	P	L	O	R	A	T	I	O	N	N	N	E	J	J	S	W	K	A
A	G	N	I	N	I	M	D	N	U	O	R	G	R	E	D	N	U	V	S	R	Y	R	O
P	Q	M	W	H	M	V	F	G	R	A	S	F	A	X	F	R	M	N	P	E	V	M	J
N	U	M	F	K	U	D	E	E	Q	B	S	Y	E	E	E	Q	C	Z	T	H	R	Q	P
P	E	V	S	S	U	T	L	V	F	Q	I	H	Q	P	G	F	C	V	W	A	A	Z	O
Q	T	C	U	N	C	Z	V	H	C	G	H	X	P	N	Y	L	O	J	B	B	H	U	T
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W	O	V	I	H	H	G	M	F	P	T	C	N	I	S	H	M	K	K	J	L	J	J	S
U	A	Z	J	P	O	S	X	S	R	W	I	M	I	J	J	E	A	X	O	I	G	H	H
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G	D	V	U	S	L	M	Y	I	D	E	T	C	B	U	I	V	V	O	T	T	L	A	V
H	R	B	N	R	I	I	P	N	R	D	P	E	E	Q	A	T	S	O	G	I	A	L	A
K	C	D	V	N	G	N	O	K	I	X	N	R	O	R	R	M	A	D	E	O	B	O	O
L	S	A	I	D	E	M	B	C	A	Q	L	L	G	O	E	R	I	L	M	N	L	C	J
A	S	N	W	P	A	O	R	S	P	V	L	U	P	L	W	V	Q	G	P	A	S	B	C
E	G	D	O	I	T	A	I	L	I	N	G	S	T	G	A	G	N	O	R	R	Q	L	K
L	O	C	D	Y	H	U	G	M	W	Z	I	I	O	A	T	I	C	E	G	S	L	U	P
D	N	N	I	C	K	E	L	U	T	S	N	P	U	J	L	B	N	T	B	X	Z	A	I
A	Y	A	G	P	N	M	Z	I	X	G	L	Z	B	L	G	I	A	D	C	H	Q	M	X
I	M	H	D	X	B	Q	S	N	Y	E	I	B	I	J	M	S	F	S	T	P	Q	O	W
S	D	H	T	S	Z	T	D	A	V	C	H	M	F	R	S	D	W	A	Z	Q	S	H	D
O	S	Q	O	U	K	X	Y	R	K	S	G	O	T	S	J	V	O	W	J	J	Y	Z	X
F	W	Q	M	K	A	J	D	U	Z	V	Y	V	V	B	F	D	S	D	O	W	T	L	X

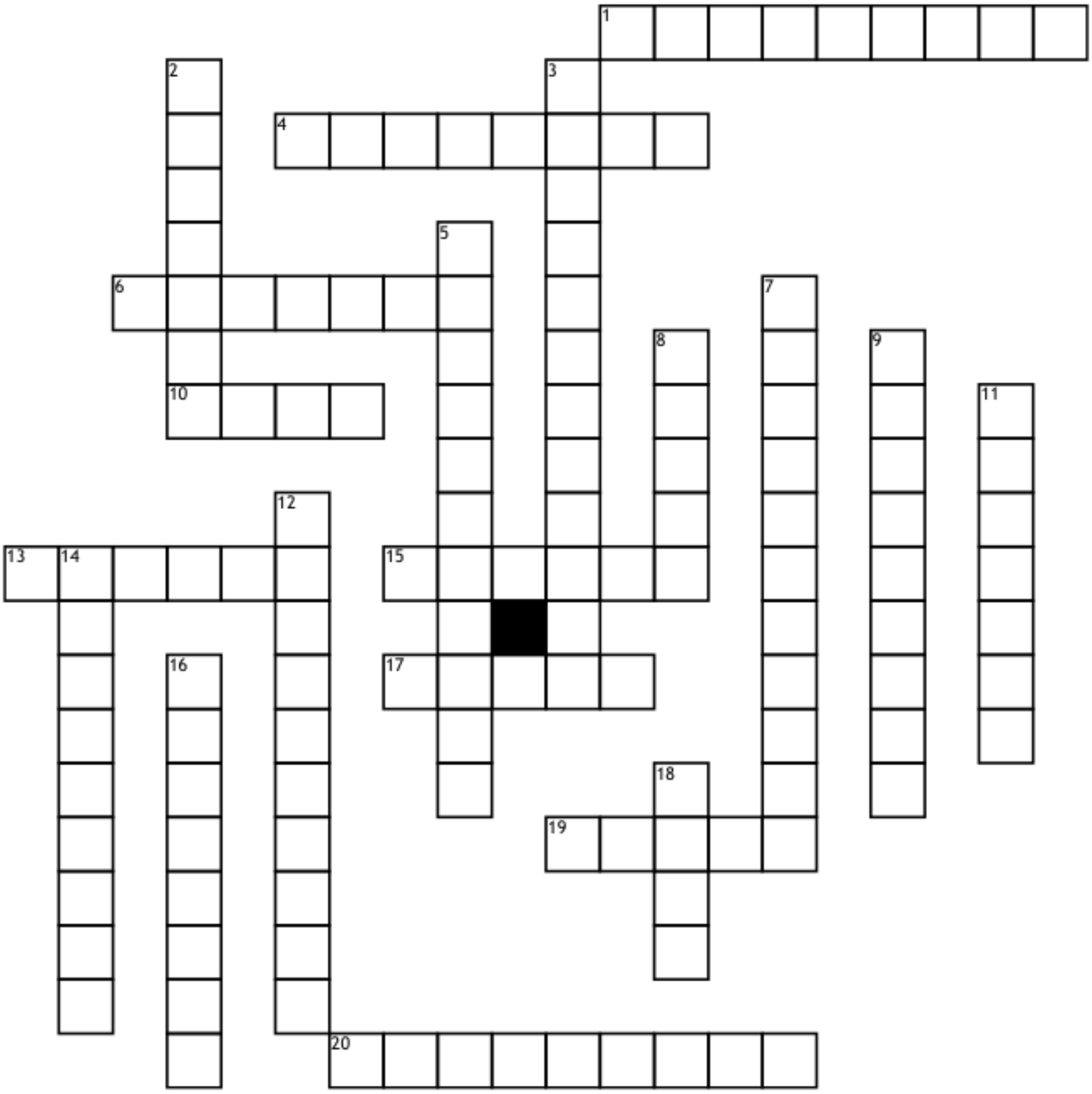
diamonds	platinum	zinc	uranium
strip mining	nickel	copper	gravel
ore	mineral	potash	rehabilitation
exploration	underground mining	open pit mining	smelting
milling	tailings	silver	gold

Geology Word Search

M	I	O	O	U	T	E	R	C	O	R	E	P	T	S	T	L
O	S	P	R	U	R	C	E	I	L	N	K	L	A	O	P	G
T	G	E	M	S	T	O	N	E	E	Y	A	R	T	N	A	L
C	Y	T	I	M	I	N	I	N	G	R	U	C	C	N	A	E
E	N	R	L	S	E	G	K	O	E	O	Q	I	L	T	A	T
I	T	O	A	R	M	L	L	N	N	I	H	A	S	O	M	M
L	E	L	C	T	E	O	I	P	E	P	T	Y	T	K	V	F
A	P	O	U	Y	N	M	L	G	R	E	R	O	S	I	O	N
U	R	G	C	A	A	E	M	O	H	C	A	R	O	S	A	E
E	E	Y	C	G	F	R	M	A	G	A	E	T	S	C	L	G
F	P	L	M	G	E	A	O	I	H	Y	O	I	R	I	L	Y
T	U	A	G	R	T	T	E	G	D	K	L	T	O	N	U	G
V	O	A	G	E	O	E	F	N	O	E	C	L	G	O	V	O
T	L	A	M	G	T	E	R	E	H	P	S	O	H	T	I	L
E	Y	Y	V	A	R	O	L	O	G	T	S	U	R	C	U	O
I	A	N	L	T	C	R	R	U	C	O	A	G	E	E	M	E
A	E	P	M	E	O	L	M	S	M	K	T	A	G	T	E	G

Aggregate
Alluvium
Conglomerate
Crust
Crystal
Earthquake
Erosion
Fault
Fossil
Gemstone
Geology
Igneous
Inner Core
Lithosphere
Loupe
Magma
Mantle
Metamorphic
Mineral
Mining
Outer Core
Petrology
Plate
Rock
Rock Hammer
Sedimentary
Seismology
Tectonics
Volcano
Vulcanology

Rocks and Minerals



ross
;edimentary rock consisting of d or quartz grains cemented ether

Aatter that settles to the tom of a liquid

\ very hard, granular, stalline, igneous rock consisting inly of quartz.

Hot molten or semifluid rock pted from a volcano

A hard crystalline metamorphic n of limestone, typically white.

A metamorphic rock with a ided or foliated structure

Hot fluid or semi fluid material ow or within the earth's crust.

19. A hard, solid, nonmetallic mineral matter of which rock is made

20. A hard sedimentary rock, composed mainly of calcium

Down

2. A solid inorganic substance of natural occurrence

3. The change of minerals or geologic texture in pre-existing rocks.

5. Types of rock that are formed by the deposition of material at the earth surface.

7. An aluminosilicate mineral typically occurring as fibrous masses.

8. A various colored or transpa mineral.

9. A hard, non-foliated metamorphic rock which was originally pure quartz.

11. Rocks formed through the cooling and solidification of ma or lava.

12. sedimentary rocks being exposed to extreme weather.

14. A class of rock-forming silic or aluminosilicate minerals.

16. The continuous physical for exerted on or against an object

18. The solid mineral material forming part of the surface of t earth

Metals and mining

Name: ______________________

1 Complete the crossword puzzle using the clues below.

Across:

3 Gold and silver are used to make beautiful _____.

6 Mining is _____ because it creates jobs. (opposite of negative)

9 Humans _____ rocks from the ground. (another word for remove)

10 The metal found in rocks is called _____.

Down:

1 When ore is heated to get the metal out, it is called _____.

2 Rocks are _____ and heated to get the metal out.

4 A minus of mining is that it can destroy the _____.

5 Copper is used in electrical wires because it _____ electricity so easily.

7 _____ is a strong metal that is used to make steel.

8 _____ is a very precious metal found in rocks, rivers and streams.

Answers

Across:

3 jewellery

6 positive

9 extract

10 ore

Down:

1 smelting

2 crushed

4 environment

5 conducts

7 iron

8 gold