ECO-ELEMENTUM (PTY) LTD

NNDANGANENI MINING RIGHT

SOIL AND AGRICULTURAL POTENTIAL STUDY DRAFT REPORT

04 NOVEMBER 2022

DRAFT

NNDANGANENI MINING RIGHT

SOIL AND AGRICULTURAL POTENTIAL STUDY

ECO-ELEMENTUM (PTY) LTD

DRAFT

PROJECT NO.: 41103848
DATE: NOVEMBER 2022

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1 INTRODUCTION

WSP in Africa (WSP), a wholly owned affiliate of WSP Global Inc., was appointed by Eco-Elementum (Pty) Ltd to undertake a Soil and Agricultural Potential Assessment as input into an Environmental Authorisation for Nndanganeni Colliery - IPP Mining Equipment (Pty) Ltd (Nndanganeni). The project site is the Nndanganeni Colliery near Middleburg in the Mpumalanga Province of South Africa.

The aim of this assessment was to identify potential impacts to soil as a result of the proposed opencast mining project and to recommend associated mitigation measures. In order to do so the soil forms and their distribution within the project area were classified on site, and the typical properties of the soils identified. Current land use and land capability were also assessed.

1.1 PROJECT DESCRIPTION

Nndanganeni is planning to expand its operations around a pan on its existing Mining Right 299MR at Nndanganeni Colliery. The mine site lies 25km east of Middelburg in the Mpumalanga Province of South Africa. The study site within the mine borders a small pan on three sides (see **Figure 1**). The majority of the broader area is disturbed, having previously been mined or cultivated. The study site comprises 3.5ha and is focussed on an area that hasn't previously been mined. A small portion of the study site is currently under cultivation (see **Figure 2**).

1.2 LEGISLATIVE CONTEXT

The legislation that has direct implications for how soils are managed is the Conservation of Agricultural Resources (Act 43 of 1983) (CARA). Other environmental legislation such as the National Environmental Management Act (Act 107 of 1998) and the National Water Act (Act 36 of 1998) provide guidance on environmental activities and sets out the principles of Duty of Care, Pollution Control and Waste Management. The relevant sections of the CARA are discussed below.

The purpose of the CARA is to provide for the control over the utilization of the natural agricultural resources of the Republic so as to promote the conservation of the soil, the water sources and the vegetation and the combating of weeds and invader plants. The Act states that control measures may be applied to (amongst others):

- The utilization and protection of land which is cultivated;
- The prevention or control of waterlogging or salination of land;
- The restoration or reclamation of eroded land or land which is otherwise disturbed or denuded.

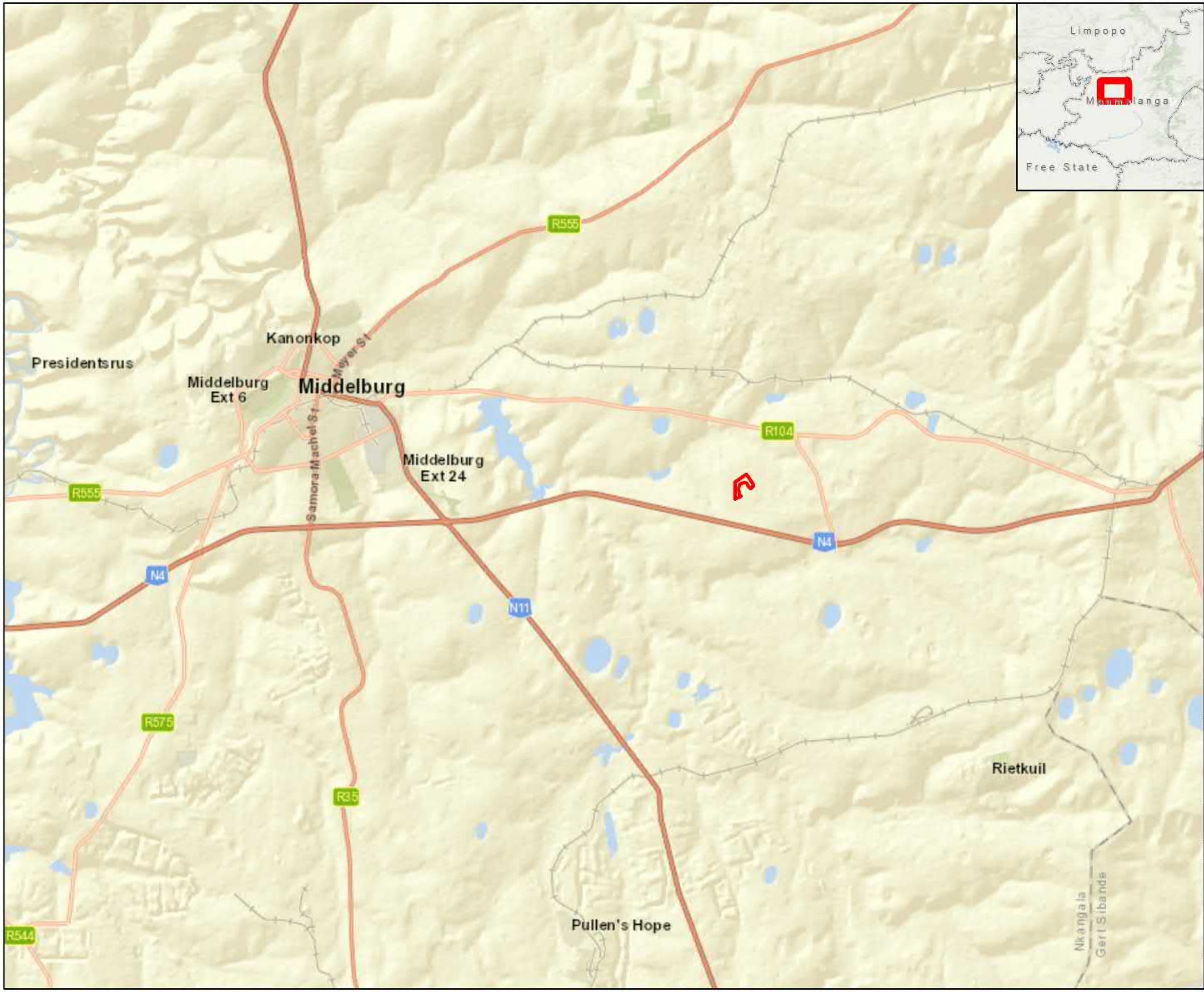
The Act further states that different control measures may be prescribed in respect of different classes of land users or different areas or in such other respects as the Minister may determine, stipulating that:

- Any land user who refuses or fails to comply with any control measure which is binding on him, shall be guilty of an offence.

The implication of this for the project is that, should the project go ahead, control measures will be required to manage and where possible mitigate the impacts of the project on soil and land capability.

1.3 STUDY SPECIALIST

This report was prepared by Ms Karen King, a professional soil scientist (Pr.Sci.Nat, M.Sc.). Ms King has 17 years' work experience and specialises in agricultural studies, soil science and related risk assessments and management plans. Ms. King's Curriculum Vitae is included in Appendix A. Site notes and photographs have been included in Appendix B.



NNDANGANENI

LOCALITY

Legend

Site Boundary

N

0 2 200 4 400 6 600 8 800

Metres

DISCLAIMER

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PROJECTION: Hartebeesthoek94 Lo29

PROJECT TITLE:

NNDANGANENI SOILS

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NNDANGANENI

STUDY AREA

Legend

Site Boundary

N

0 90 180 270 360

Metres

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PROJECT TITLE:

NNDANGANENI SOILS

SCALE: 1:10 000	DRAWN BY: TS
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FIGURE NO:	PROJECT NO: 41104511	REV:

2 BASELINE ENVIRONMENT

2.1 CLIMATE

The climate of the Middleburg region can be described as a subtropical highland climate with dry winters and falls into Köppen climate type: Cwb. The average annual temperature is 16.5 °C and the average annual rainfall is 714 mm. The summers are long and warm, and the winters are short, cold, dry and clear. The month with the most precipitation on average is January and the month with the least precipitation on average is July. These climatic conditions frequently give rise to chemically weathered red and yellow soils that are typical of subtropical upland areas, as were seen across much of the site (see **Figure 3** and Appendix B).

Figure 3: Subtropical Weathered Soil (Clovelly)

2.2 GEOLOGY

The site geology is dominated by fine- to course-grained sandstone, shale and coal seams. The sandstone has given rise to sandy soils across much of the site, as expected (see **Figure 4**).

Figure 4: Sandy Soil (Clovelly)

2.3 TOPOGRAPHY

The site is not steep but does slope gently toward the pan on all sides (see **Figure 5**). The only low-lying areas where signs of surface wetness are evident is the area immediately around the pan, and this falls just outside of the boundary of the soils study site.

Figure 5: Site Sloping Toward the Pan

3 METHODOLOGY

3.1 DESKTOP ASSESSMENT

A desktop assessment was undertaken for the site. This included assessing relevant literature, site characteristics using Geographic Information System (GIS) and aerial imagery, and soils and geology databases.

3.2 SITE ASSESSMENT

A site visit was conducted during the summer season from the 24th-25th October 2022. A classification survey of the study area was undertaken on foot, using a hand-held bucket auger and a spade to classify the soil forms and measure their depths at 33 points on site (see **Figure 6**). Activities at the site and in the vicinity were noted.

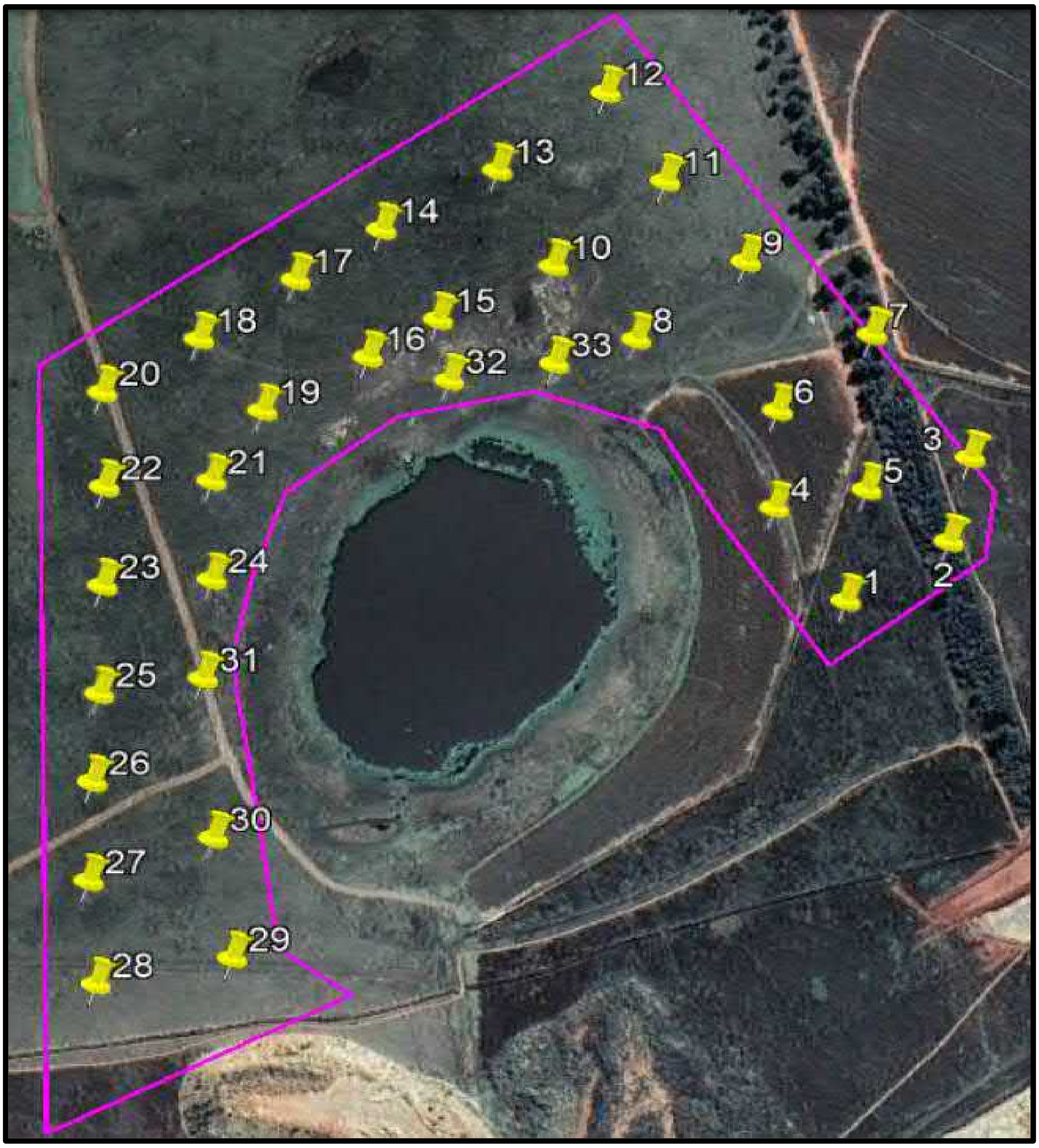

Figure 6: Soil Classification Points

3.3 SOIL CLASSIFICATION

Classification of the soil forms identified on site was undertaken using the South African soil taxonomic system (Soil Classification Working Group, 1991). All South African soil forms fall within 12 soil types; Duplex (marked accumulation of clay in the B horizon), Humic (intensely weathered, low base status, exceptional humus accumulation), Vertic (swelling, cracking, high activity clay), Melanic (dark, structured, high base status), Silicic (Silica precipitates as a dorbank horizon), Calcic (accumulation of limestone as a horizon), Organic (peaty soils where water inhibits organic breakdown), Podzolic (humic layer forms beneath an Ae or E), Plinthic (fluctuating water table causes iron re-precipitation as ferricrete), Oxidic (iron oxides weather and colour soils), Hydromorphic (reduced lower horizons) and Inceptic (young soils - accumulation of unconsolidated material, rocky B or disturbed) soils.

3.4 LAND CAPABILITY ASSESSMENT

The area's land capability was mapped based on the results of the soil classification outcomes, using both the Chamber of Mines (Hattingh, 2019) guidelines (**Table 1**) and the South African land capability classification system by Scotney *et al.* (1987) (**Table 2**). These systems are useful in that they are able to quickly provide an overview of the agricultural capability and limitations of the soils in question and are useful for soil capability comparisons.

Table 1: Land Capability Classification System (Hattingh, 2019)

Land capability class		Classification criteria: Pre-mining	Classification criteria: Post-mining
I	Wetland	• Usually a water table present at shallow depth in the soil (vleis, swamps, marshes, peatbogs, etc.). • A diagnostic[8] organic (O) horizon at the surface. • A horizon that is gleyed throughout more than 50 percent of its volume and is significantly thick, occurring within 750 mm of the surface.	• Soil depth >250 mm. • Specific wetland soil used, as stockpiled from pre-mining delineated wetland areas.
II	Arable	• Does not qualify as wetland. • Has soil that is readily permeable[9] to the roots of common cultivated plants throughout a depth of 750 mm from the surface. • Soil pH value between 4,0 and 8,4. • Electrical conductivity (EC) of the saturation extract less than 400mS/m at 25°C, and an exchangeable sodium percentage less than 15 through the upper. • Soil depth of ≥750 mm of soil. • Permeability of at least 1,5 mm per hour in the upper 0.5 m of soil. • <10 percent by volume of rocks, or pedocrete fragments larger than 100 mm in diameter in the upper 750 mm of soil. • Slope (in percent) and erodibility factor[10] (K) such that their product is less than 2,0. • Occurs under a climate regime which permits, from soils of similar texture and adequate effective depth (750 mm), the economic attainment of yields of adapted agronomic or horticultural crops that are at least equal to the current national average for those crops. • Is either currently being irrigated successfully or has been scheduled for irrigation by the DAFF.	• Soil depth > 600 mm • Soil material must not be saline or sodic. • Slope (%) will be such that when multiplied by the soil erodibility factor K, the product will not exceed 2,0. • For typical coal fields' soils, slopes must be flatter than 1:14, and free draining.
III	Grazing land	• Does not qualify as wetland or as arable land. • Has soil or soil-like material, permeable to the roots of native plants, that is more than 250 mm thick and contains less than 50 % by volume of rocks, or pedocrete fragments larger than 100 mm diameter. • Supports or is capable of supporting a stand of native or introduced grass species or other forage plants utilisable by domesticated livestock or game animals on a commercial basis.	• Soil depth ≥ 250 mm • Slopes between 1:7 and 1:14

Land capability class		Classification criteria	
		Pre-mining	**Post-mining**
IV	Wilderness land	• Land that has little or no agricultural capability by virtue of being too arid, too saline, too steep or too stony to support plants of economic value. • Its uses lie in the fields of recreation and wildlife conservation. It does, however, also include watercourses, submerged land, built-up land and excavations. • Defined by exclusion, namely: land that does not qualify as wetland, arable land or grazing land.	• Soil depth between 150 – 250 mm.

Table 2: Land Capability Classification System (Scotney *et al.*, 1987)

Land Capability Group	Land Capability Class	Increased intensity of use									Limitations
Arable	I	W	F	LG	MG	IG	LC	MC	IC	VIC	No or few limitations. Very high arable potential. Very low erosion hazard
	II	W	F	LG	MG	IG	LC	MC	IC	-	Slight limitations. High arable potential. Low erosion hazard
	III	W	F	LG	MG	IG	LC	MC	-	-	Moderate limitations. Some erosion hazards
	IV	W	F	LG	MG	IG	LC	-	-	-	Severe limitations. Low arable potential. High erosion hazard.
Grazing	V	W	-	LG	MG	-	-	-	-	-	Water course and land with wetness limitations
	VI	W	F	LG	MG	-	-	-	-	-	Limitations preclude cultivation. Suitable for perennial vegetation
	VII	W	F	LG	-	-	-	-	-	-	Very severe limitations. Suitable only for natural vegetation
Wildlife	VIII	W	-	-	-	-	-	-	-	-	Extremely severe limitations. Not suitable for grazing or afforestation.

W - Wildlife
MG – Moderate grazing
MC - Moderate cultivation
F - Forestry
IG - Intensive grazing
IC - Intensive cultivation.
LG - Light grazing
LC - Light cultivation
VIC – Very intensive cultivation

3.5 IMPACT ASSESSMENT METHODOLOGY

3.5.1 ASSESSMENT OF IMPACTS

The assessment of impacts and mitigation evaluates the likely extent and significance of the potential impacts of a proposed project on identified receptors and resources against defined assessment criteria, to develop and describe measures that will be taken to avoid, minimise or compensate for any adverse environmental impacts, to enhance positive impacts, and to report the significance of residual impacts that occur following mitigation.

The key objectives of the impact assessment methodology used within this study were to identify potential environmental issues and associated impacts likely to arise from the proposed Project. These aspects were reviewed and ranked against a series of significance criteria to identify and record interactions between activities and aspects, and resources and receptors to provide a detailed discussion of impacts. The significance of the environmental aspects was determined and ranked by considering the criteria presented in **Table 3** (Eco-Elementum, 2002).

Table 3: Impact Assessment Criteria and Scoring System

INTENSITY/MAGNITUDE		
The intensity of the impact is considered by examining whether the impact is destructive or benign, whether it has a significant, moderate or insignificant		
(L)OW	The impact alters the affected environment in such a way that the natural processes or functions are not affected.	1
(M)EDIUM	The affected environment is altered, but functions and processes continue, albeit in a modified way.	3
(H)IGH	Function or process of the affected environment is disturbed to the extent where it temporarily or permanently ceases.	5
DURATION		
The lifetime of the impact that is measured in relation to the lifetime of the proposed development		
(S)HORT TERM	The impact will either disappear with mitigation or will be mitigated through a natural process in a period shorter than that of the construction phase.	1
(SM) SHORT - MEDIUM TERM	The impact will be relevant through to the end of a construction phase.	2
(M)MEDIUM	The impact will last up to the end of the development phases, where after it will be entirely negated.	3
(L)ONG TERM	The impact will continue or last for the entire operational lifetime (i.e. exceed 20years) of the development, but will be mitigated by direct human action or by natural processes thereafter.	4
(P)ERMANENT	This is the only class of impact, which will be non-transitory. Mitigation either by man or natural process will not occur in such a way or in such a time span that the impact is transient.	5
SPATIAL SCALE / EXTENT		

Classification of the physical and spatial aspect of the impact		
(F)OOTPRINT	The impacted area extends only as far as the activity, such as footprint occurring within the total site area.	1
(S)ITE	The impact could affect the whole, or a significant portion of the site.	2
(R)EGIONAL	The impact could affect the area including the neighbouring Farms, the transport routes and the adjoining towns.	3
(N)ATIONAL	The impact could have an effect that expands throughout the country (South Africa).	4
(I)NTERNATIONAL	Where the impact has international ramifications that extend beyond the boundaries of South Africa.	5
PROBABILITY		
This describes the likelihood of the impact actually occurring. The impact may occur for any length of time during the life cycle of the activity. The classes are rated as follows:		
(I)MPROBABLE	The possibility of the Impact occurring is none, due to the circumstances or design. The chance of this Impact occurring is zero (0%)	1
(P)OSSIBLE	The possibility of the Impact occurring is very low, due either to the circumstances or design. The chance of this Impact occurring is defined as 25% or less	2
(L)IKELY	There is a possibility that the impact will occur to the extent that provisions must therefore be made. The chances of Impact occurring is defined as 50%	3
(H)IGHLY LIKELY	It is most likely that the Impacts will occur at some stage of the development. Plans must be drawn up before carrying out the activity. The chances of this impact occurring is defined as 75 %.	4
(D)EFINITE	The impact will take place regardless of any prevention plans, and only mitigation actions or contingency plans to contain the effect can be relied on. The chance of this impact occurring is defined as 100 %.	5
WEIGHTING FACTOR		
Subjective score assigned by Impact Assessor to give the relative importance of a particular environmental component based on project knowledge and previous experience.		
(L)OW		1
LOW- MEDIUM		2
MEDIUM (M)		3
MEDIUM-HIGH		4
HIGH (H)		5
MITIGATION EFFECTIVENESS		
HIGH		0.20

MEDIUM-HIGH	0.40
MEDIUM	0.60
LOW -MEDIUM	0.80
LOW	1.00

3.5.2 IMPACT MITIGATION

Potential impact mitigation measures were recommended. Impacts without mitigation measures in place are not necessarily representative of the proposed development's actual extent of impact and are included to facilitate understanding of how and why mitigation measures were identified. The residual impact is what remains following the correct application of mitigation and management measures and is thus the final level of impact associated with the development. Residual impacts also serve as the focus of management and monitoring activities during project implementation to verify that actual impacts are the same as those predicted in this report.

4 RESULTS AND DISCUSSION

4.1 DESKTOP REVIEW

According to the WR90 soils database (WRC, 1996), the site area is underlain by structureless soils with generally favourable physical properties and limitations that could include restricted soil depth, excessive or imperfect drainage and high erodibility.

4.2 SOIL FORM IDENTIFICATION AND CLASSIFICATION

The soil forms identified within the study site included Clovelly soils in the main – which agrees with the WR90 database **-** as well as Mispahs, as presented in **Figure 9**.

4.2.1 CLOVELLY

The Clovelly soil form was identified across much of the site (see **Figure 7**). This soil form is characterised by an orthic topsoil over a yellow brown apedal (devoid of macrostructure) B horizon over an unspecified horizon. In the case of the Clovelly soils identified at the study site, this unspecified horizon was sandstone in various states of weathering. The B horizon varied in depth across the site and in all cases was stony.

Figure 7: Clovelly Soils

4.2.1 MISPAH

The Mispah soil form was identified in and around a single rocky outcrop area across a portion of the centre of the site. This soil form is characterised by a thin orthic A horizon over hard rock, so is a very shallow soil.

Figure 8: Mispah Soils

4.3 LAND CAPABILITY ANALYSIS

Land capability is the inherent capacity of land to be productive under sustained use and specific management methods. The land capability of an area is the combination of the inherent soil properties and the climatic conditions as well as other landscape properties, such as slope and drainage patterns.

Using the Hattingh (2019) system, the majority of the site's land capability is III – Grazing as the area is capable of supporting grass species but is too shallow and stony to be considered arable. The very shallow Mispah area's land capability is IV – Wilderness as it is too shallow to support grazing. Using the Scotney *et al.* (1987) system, the majority of the study site's land capability class is Grazing IV, which means that it has limitations that preclude cultivation but can support natural and perennial vegetation. The very shallow Mispah area's land capability is VIII as it is not suitable for grazing (see **Figure 10**). The main limitations in the case of the Clovelly soils identified at the study site are a lack of depth and a stony B horizon. It is apparent that the areas that are currently under cultivation are not deep and are clearly stony throughout, yet mielies are being cultivated there. This does not mean that the land capability in these areas is different, only that the farmer has overcome these limitations (see **Figure 11)**.

4.4 SOIL DEPTH

For site rehabilitation purposes it is important to have an understanding of the depths of the topsoil and subsoil across the study site in order to strip and stockpile these correctly (as elaborated upon in Section 4.5 and Appendix B). While the cultivated soil areas appear to be disturbed Clovelly soils, these no longer comprise a topsoil and a subsoil component owing to ploughing practices. The Clovelly soils in the north-eastern portion of the site appear shallower than those across the rest of the site. Their topsoil depths were around 10 cm and (stony) subsoils up to 25cm. Across the rest of the site (except in the Mispah area) roughly the top 10 cm of the Clovelly soil constituted topsoil and the subsoil ranged from 25 cm to 50 cm (see **Figure 12**). Subsoil depths varied from classification point to point with no obvious patterns emerging.

NNDANGANENI

SOIL
TYPES

Legend

Site Boundary

Soil Types

Clovelly

Mispah

N

0 90 180 270 360

Metres

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PROJECT TITLE:

NNDANGANENI SOILS

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NNDANGANENI

LAND
CAPABILITY

Legend

Site Boundary

Land Capability

Grazing III

Wilderness IV

N

0 90 180 270 360

Metres

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NNDANGANENI

LAND USE

Legend

Site Boundary

Land Use

Cultivation

Grassland

N

0 90 180 270 360

Metres

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NNDANGANENI SOILS

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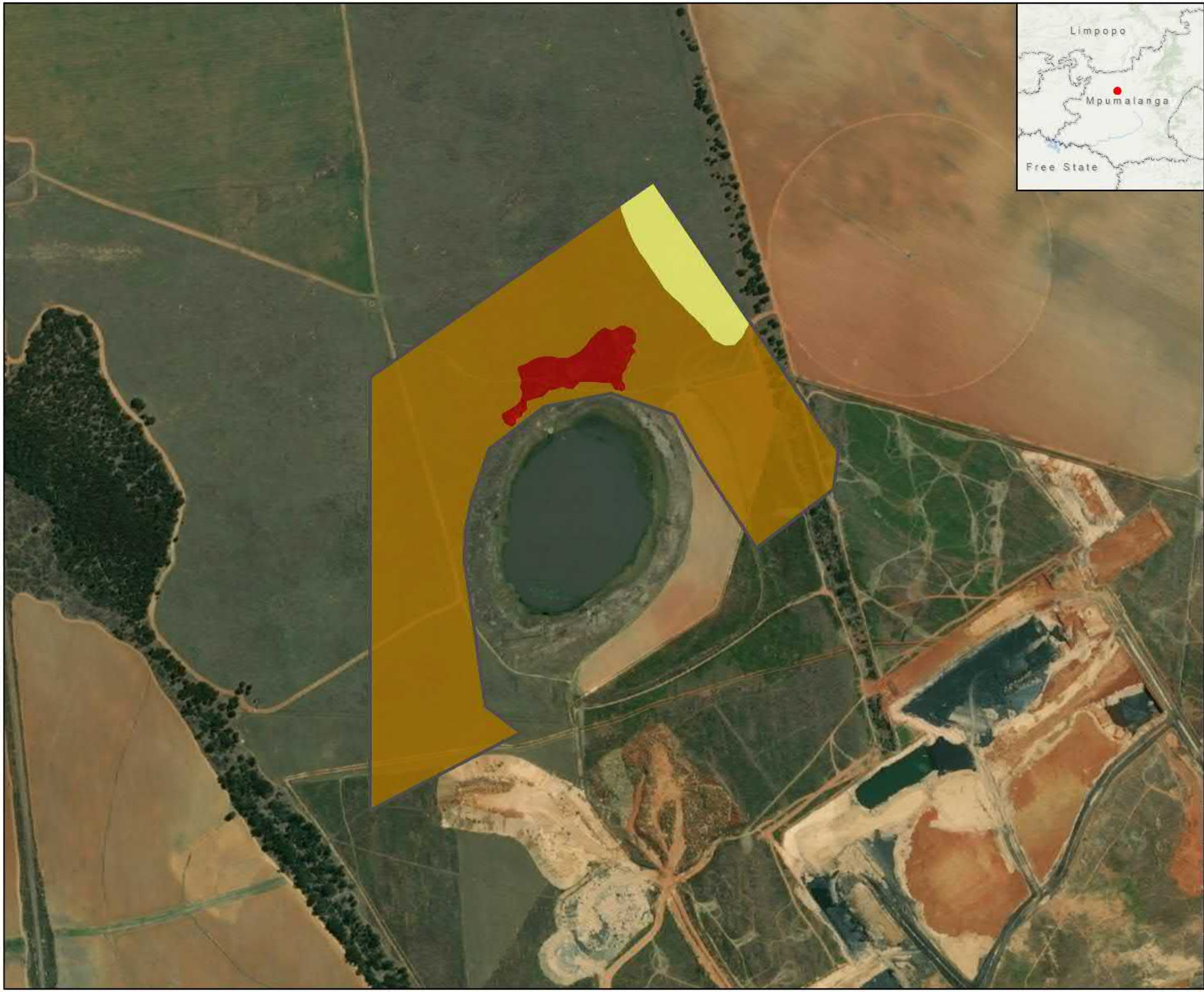

NNDANGANENI

SOIL
DEPTHS

Legend

Site Boundary

Soil Depths

0 - 2 cm

10 - 25 cm

25 - 50 cm

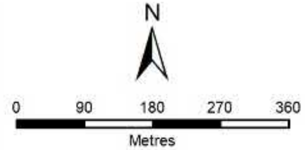

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FIGURE NO:	PROJECT NO: 41104511	REV:

4.5 IMPACT ASSESSMENT

An obvious sensitive receptor of the potential soil-related impacts of the proposed mining extension is the pan that the study site surrounds. The following potential soil-related impacts were identified as applicable in respect of the proposed project.

- Loss of soil
- Erosion and Sedimentation
- Change in surface profile
- Change in land use
- Change in land capability
- Contamination

The assessment of impact significance considers pre-mitigation as well as post-mitigation scenarios. Potential impacts associated with the construction, operation and closure of the site have been assessed and discussed in the following sections, along with identification of recommended mitigation measures. The soil protection strategies identified are, in part, taken from the International Finance Corporation (World Bank) Environmental, Health and Safety Guidelines for Mining, 2007 (IFC, 2007).

4.5.1 CONSTRUCTION PHASE

This phase refers to the period when the proposed infrastructure is built/installed and usually has the largest direct impact on soils and land capability. This phase includes one of the major activities ahead of mining, which is to strip all useable soils for stockpiling and later rehabilitation use. It also includes site preparation prior to construction activities, involving vehicular movement (transportation of construction materials) and the removal of vegetation within the development footprint and associated disturbances to soil, and access to the site. Site preparation is followed by earthworks required for establishment of structures, leading to stockpiling and exposure of loose soils, as well as movement of construction equipment and personnel within the project area. The following potential impacts on soils were considered for the proposed project.

IMPACT 1: LOSS OF SOIL

The stripping of soil, especially topsoil ahead of mining, will lead to a significant loss of usable soil if not undertaken correctly. Soil needs to be kept aside for later concurrent and then final closure rehabilitation. The soil horizons need to be separately stripped, stockpiled and replaced. The most common loss of soil is likely to be under stripping (not stripping all usable soil) resulting in soil be lost to the overburden spoiling process. A further potential risk is over stripping, which occurs when topsoil is stripped too deeply, so is removed with too much subsoil. This negatively affects the texture of the surface soils upon rehabilitation by changing their hydropedological properties.

In the case of this proposed project, using the impact assessment methodology described in Section 3, the impact significance without mitigation is High and with mitigation is Medium-High. Recommended mitigation measures are as follows:

- Strip **all** useable soil material for rehabilitation.
- Topsoil stockpiles should be kept low (below 3m tall).
- Irrespective of where topsoil is stockpiled, it should be kept moist and vegetated as soon as possible to protect against erosion, discourage weeds and maintain active soil microbes.
- The shallower Clovelly soils should be stripped to a depth of 25 cm and this 25 cm stockpiled as topsoil only. The deeper Clovelly topsoils should also be stripped to a depth of 25 cm and stockpiled separately from the underlying 25cm of stripped subsoil (see **Figure 12**). The Clovelly soils that have been cultivated should be considered to comprise only topsoil and should be stripped to 30cm and stockpiled with the other Clovelly topsoils. All stripping and stockpiling should be undertaken according to the guidelines below.

- Demarcate the area to be stripped clearly, so that the contractor does not strip beyond the demarcated boundary.
- The stripped soil should be relocated by truck along set removal paths.
- The area to be stripped requires storm water management and the in-flow of water should be prevented with suitable structures.
- Prepare the haul routes prior to stripping.
- Stripping should not begin in wet conditions.

IMPACT 2: EROSION AND SEDIMENTATION

Soil stripping, clearing of vegetation, movement of vehicles, mobile plant and equipment, as well as earthworks is very likely to result in increased loose material being exposed and consequent erosion. The Clovelly soils are largely devoid of macrostructure, so are prone to erosion. As the study site surround a pan, the potential impact of sedimentation is linked to that of erosion. Although the magnitude and extent of erosion and sedimentation are likely to be limited if the recommended mitigation measures are properly implemented, some erosion is inevitable when clearing an area and erosion and sedimentation are not easily reversible. In the case of this proposed project, using the impact assessment methodology described in Section 3, the impact significance without mitigation is Medium-High and with mitigation is Medium. Recommended mitigation measures are as follows:

- Limit earthworks and vehicle movement to demarcated paths and areas.
- Limit the duration of construction activities, especially those involving earthworks / excavations.
- Access roads associated with the development should have gradients or surface treatment to limit erosion, and road drainage systems should be accounted for.
- Removal of vegetation must be avoided until such time as soil stripping is required and similarly exposed surfaces and soil stockpiles should be re-vegetated or stabilised as soon as is practically possible.
- A construction phase-specific storm water management plan should be designed for the site and adhered-to.
- Soil stockpiles should be vegetated as soon as possible.

IMPACT 3: CHANGE IN SURFACE PROFILE

Earthworks required for establishment of support structures, as well as establishment of access tracks, will result in a change of surface profile within the project area. A change in the surface profile would be long-term and inevitable as a result of earthworks. The current surface profile can only be re-established during mine closure. Although the site is not steep and the surface profile would not be changed to a large extent, the combination of the study site slope toward the pan and well drained soils lead to hydropedological processes that help to maintain the pan. The impact significance with mitigation is thus High and without mitigation is Medium-High.

IMPACT 4: CHANGE IN LAND USE

Clearance of vegetation on site and establishment of infrastructure will result in a change of land use within the study area and affect the pan. The site is currently mainly grassland, and a small portion thereof is cultivated. The degree of alteration is very high (a complete change in land use), the change will definitely take place and will be irreversible for at least the duration of the project life (the impact will take place in the construction phase but will remain as long as the project infrastructure is in place). The change in land use will significantly increase the potential for negative impacts on the pan in the form of inputs of contaminants and sediment. The impact significance without mitigation is thus High and with mitigation is Medium-High.

IMPACT 5: CHANGE IN LAND CAPABILITY

The movement of mobile plant / equipment is very likely to result in compaction, disturbance and possible sterilization of soils and associated change in land capability to the site and affect the processing of the pan. The degree of alteration is very high (complete loss of land capability) the change will definitely take place and will be irreversible for the duration of the project life (the impact will take place in the construction phase but will remain as long as the project infrastructure is in place). The largest disturbance in opencast mining is the pit itself. As mentioned, the study site capability is largely grassland. The impact significance without mitigation is thus High and with mitigation is Medium-High.

IMPACT 6: SOIL CONTAMINATION

Movement of vehicles and plant / equipment on site could result in leaks and spills of hazardous materials including hydrocarbons. Contaminated soil is expensive to rehabilitate and contamination entering the apedal soils of the project area will infiltrate into the ground as well as migrate from site and toward the pan during rainfall events. With the correct implementation of mitigation measures, the probability and duration of the impact can be reduced, thereby reducing the potential impact from High to Low-Medium. During construction all potentially contaminated runoff including hydrocarbons and sediment must be prevented from entering the pan. Contaminated runoff should be contained using bund walls, sumps and sediment traps where necessary.

- Correctly implement and monitor a construction-phase storm water management plan.
- On-site vehicles should be well-maintained.
- Drip trays should be placed under stationary vehicles / plant.
- On-site pollutants/hazardous materials should be contained in a bunded area and on an impermeable surface.
- Ensure proper control of dangerous substances entering the site.
- Adequate disposal facilities should be provided.
- A non-polluting environment should be enforced.

4.5.2 OPERATION PHASE

This phase refers to the period of operation of the mine (i.e. following commissioning through project life). As indicated above, the identified impacts to soil often take place during the construction phase but the impact is felt throughout the operation phase. The impacts to focus on during the operation phase are a Loss of Topsoil, Soil Contamination and Erosion and Sedimentation.

IMPACT 1: LOSS OF TOPSOIL

The major ongoing impact throughout operations is the loss of topsoil owing to ongoing stripping ahead of mining. The aforementioned mitigation measures should continue to be adhered to and an operation phase-specific storm water management plan should be devised. The impact significance without mitigation is High and with mitigation is Medium. Vegetative cover of the stockpiles should be monitored.

IMPACT 2: EROSION AND SEDIMENTATION

Ongoing erosion and consequent sedimentation throughout the operational phase of the project should be monitored and mitigated against. The impact significance without mitigation is High and with mitigation is Medium. Mitigation should focus on erosion monitoring, vegetation of any bare areas on site, and correct implementation of an operation-phase Storm Water Management Plan as the pan is a sensitive receptor. This needs to minimize dirty water areas, separate clean and dirty water areas, release clean water from the site and store contaminated water until it has been treated suitably for discharge into the environment (water quality guidelines as specified in the relevant EIAs and WULs).

IMPACT 3: SOIL CONTAMINATION

Everyday movement of vehicles and employees once the development is operational will likely lead to some soil contamination. The impact significance without mitigation is High and with mitigation is Low-Medium. Again, the operational phase Storm Water Management Plan should be adhered to, especially to prevent hydrocarbons from entering the soils and the pan. This needs to minimize dirty water areas and separate clean and dirty water areas through the use of Pollution Control Dams, bunded areas, sediment traps, berms, channels and sumps. Clean water must be released from the site and contaminated water stored until it has been treated suitably for discharge into the environment (water quality guidelines as specified in the relevant authorisations).

4.5.3 CLOSURE PHASE

The closure phase will be similar to the construction phase as large vehicles will be on site and earth will be moved. Erosion and Sedimentation, and Soil Contamination are the most likely negative impacts.

IMPACT 1: EROSION AND SEDIMENTATION

Site rehabilitation associated with mine closure will involve movement of vehicles, mobile plant and equipment, as well as removal of structures. These activities are very likely to result in increased loose material being exposed. The site's apedal soils are susceptible to erosion and likely to add to sedimentation. The impact significance without mitigation is Medium-High and with mitigation is Low.

Mitigation should focus again on limiting earthworks and vehicle movement to demarcated paths and areas, as well as limiting the duration of the activities. Establishing vegetation as soon as possible is very important, making concurrent rehabilitation throughout the construction phase vital. During the closure phase, as soon as an area becomes available, it should be revegetated.

IMPACT 2: SOIL CONTAMINATION

Movement of vehicles and plant / equipment on site could result in spills of hazardous materials. Contaminated soil is expensive to rehabilitate and contamination entering the soils of the project area infiltrate into the ground as well as migrate from site during rainfall events. The impact significance without mitigation is Medium-High and with mitigation is Low.

4.5.4 CUMULATIVE IMPACTS

The proposed study site is within a largely disturbed broader area. It is directly next to an existing mine, with other mines in the area, and the broader area is extensively cultivated. As mentioned, the study site borders a pan on 3 sides. Some larger pans exist within a 10 km radius of the site.

IMPACT 1: EROSION AND SEDIMENTATION

As the study site is proposed as an extension of an existing mine, the cumulative impacts of causing further soil erosion will be significant. Erosion will cause sediment to enter the pan and the nearest alternative pan is almost 5 km away.

IMPACT 2: SOIL CONTAMINATION

Again, as the study site is proposed as an extension of an existing mine, the cumulative impact of potential leaks and spills of contaminants, especially hydrocarbons, will be significant. As the study site soils are sandy and apedal, they are well-drained, so the contaminants will be mobile, and the pan is a likely receptor thereof. As this is a sensitive landscape, extreme effort will need to be undertaken to protect it. This is a legal requirement.

IMPACTS 3 AND 4: CHANGE IN LAND USE AND CAPABILITY

The current study site land capability and land use is mostly grassland. The larger area has been extensively cultivated. The change in land use of the study site is significant because it will affect the processes that support the functioning of the pan.

4.5.5 MONITORING REQUIREMENTS

Should the project go ahead, the site should be monitored for erosion and for spills that could lead to contamination of the environment throughout all three of the abovementioned phases. Signs of erosion and soil contamination should be monitored visually. The vegetative cover and fertility levels of stockpiled soil should also be monitored. Further to this, the monitoring of all stormwater infrastructure will be critical to protect the pan.

5 CONCLUSIONS

The proposed development area is currently largely grassland with small, cultivated areas. The soils identified at the site are shallow and moderately shallow Clovellys and shallow Mispahs. The capability of the majority of the site is Grassland. The major limitations to cultivation are stoniness and overall depth.

As the soils are apedal and the site borders a pan on three sides, a number of the identified potential impacts remain Medium to High post-mitigation. These include a Loss of Topsoil, Erosion and Sedimentation, Change in Land Use and Change in Land Capability. The pan represents sensitive wetland habitat with wetland land capability, so protecting the pan is extremely important for mining in the proposed study site. Further to this, the study site would be an extension of an existing mine, so the potential cumulative effects of the proposed mining project could be significant, especially the impacts of a loss of soil and a change in land capability.

It is the specialist's opinion that the impacts of this potential mining project on the site soils have the potential to be high because developing the area could affect the soils in such a way that the pan could cease to exist. Recommendations made within this report should be read in conjunction with the site Water Use License and other specialist studies, especially the wetland study.

6 REFERENCES

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APPENDIX

A

SPECIALIST CV

KAREN KING, M.Sc., Pr.Sci.Nat.

Senior Associate (Hydrologist & Soil Scientist), Environment & Energy

Years with the firm

5.5

Years of experience

16.5

Professional qualifications

Pri.Sci.Nat (Earth Science)

Areas of expertise

Soil Science

Hydrology

Languages

English

Afrikaans

Italian (learning)

CAREER SUMMARY

Ms King is a professional soil scientist and hydrologist (Pr.Sci.Nat, M.Sc.) with WSP Engineering and Environmental Consultants in Johannesburg. She has 16+ years' work experience and specialises in local and international soil classification systems, soil capability and suitability assessments, land use assessments and associated risk and mitigation assessments and monitoring plans, as well as agricultural studies. She also specialises in mining/development hydrology, water resources planning, catchment-scale hydrological modelling, flood studies, storm water management planning, wetland delineation, water research, and related risk assessments and management plans. She has been primarily involved in the environmental and engineering hydrology and soil science fields, initially as a soil science lecturer at UKZN for 3 years, and then as a soil scientist and hydrologist in various engineering and environmental consultancies both in South Africa and in the United Kingdom.

EDUCATION

Master of Science, University of KwaZulu-Natal, South Africa	2004
Bachelor of Science (Honours), University of Natal, South Africa	2002
Bachelor of Science, Hydrology and Soil Science, University of Natal, South Africa	2001

SELECTIONS AND AWARDS

Golder Technical Conference Abstract Selection	2022
WSP Group Unity Award	2019
WSP Environmental Collaboration Award	2018
Golden Key Honour Society Selection	2002
A series of academic and sports scholarships	1994-2003

PROFESSIONAL MEMBERSHIPS

South African Council for Scientific Professions – Professional Natural Scientist (Earth Scientist) (Reg. No. 400035/11)	SACNASP
Water Institute of South Africa (member 23404)	WISA
The Golden Key Honour Society (member 1264480)	-
International Water Association (member 01053990)	IWA

MODEL PROFICIENCY

SAPWAT Crop Irrigation Model

HYDRUS Soil-Water Interaction Model

Agricultural Catchments Research Unit (ACRU) Model

Pitman Water Resources Assessment Model

SOIL SCIENCE PROFESSIONAL EXPERIENCE

- Richbay Chemicals South Africa Extension Project – Soils Study (2021-2022). Project Director. Client: Richbay Chemicals.

  Assessment of any potential agricultural and social uses of an area of land earmarked for industry extension in a light industrial/residential area of KwaZulu-Natal.

- Ghana Genser Power Project – Soils Study (2021-2022). Project Soils Specialist. Client: Genser Power.

  Agricultural Soils Classification, Capability and Impacts Assessment, and Mitigation Measures Recommendations for a Power Plant and Pipeline in Ghana.

- Liberia Gold Mine Biomass Project – Soils Study (2021-2022). Project Soils Specialist. Lient: MNG Lebetse Gold Mine.

  Agricultural Soils Classification, Capability and Impacts Assessment, and Mitigation Measures Recommendations for a proposed biomass project in Liberia.

- Guinea Project – Interdisciplinary Soils Study (2021-2022). Project Soils Specialist. Client: Confidential.

  Multidisciplinary Potential Impacts and Mitigation Measures Assessment under very difficult conditions

- Lebombo Cape Soils Study. Soils Compliance Study for Fruit Export – Physical and Chemical Assessments (2021-2022). Project Director. Client: Lebombo Cape.

  Classification of soil forms according to the South African taxonomic system, soil capability and impact assessment, and mitigation recommendations.

- DRC Kamoa Copper Mine ESIA – Soils Study (2021). Project Soils Specialist. Client: Ivanhoe Mines.

  Agricultural soils study according to IFC standards that involved World Resource Base classification of lateritic and non-lateritic soils across developed and undeveloped areas of Kamoa Copper Mine. The soil agricultural capability and suitability were assessed and management plans for top- and sub-soil stripping and for soil erosion were developed.

- Etihad Rail Saudi Arabia to Oman Rail - Desert Soils Study (2020-2021). Project Director. Client: Etihad Rail.

  Soils study centred on the establishment of soil properties and thus Curve Numbers to inform desert soil hydropedological processes.

- Swaziland Nondvo Dam Morphodynamic and River Basin Specialist Studies – (2018-2021): Project Director and Reviewer. Client: Swaziland DWS

  Soil-centred studies that assessed the potential for landscape changes due to soil erosion and sedimentation associated with the development and raising of dam walls in Swaziland.

- Calodex Soils and Hydropedological Assessments (2021). Project Director. Client: Calodex.

  Soils study centred on the agricultural classification of a number of local soils. Potential effects of soil-water movement on local wetlands was established.

- Jet Park Soils and Hydropedological Assessment (2021). Project Director. Client: Abbeydale Construction.

Soils study centred on the agricultural classification of a number of local soils. Potential effects of soil-water movement on local wetlands was established.

- Sasol Soils and Hydropedological Study (2021). Project Director. Client: Sasol.

  Soils study centred on the agricultural classification of a number of local soils. Potential effects of soil-water movement on local wetlands was established.

- Sapref Soils and Hydropedological Study (2019-2020). Project Manager. Client: Sapref.

  Soils study centred on the agricultural classification of a number of local soils. Potential effects of soil-water movement on local wetlands was established.

- Ethiopia Agri-Industrial Zone ESIA. Soils Classification, Land Use, Land Capability, Risk Assessment and Management Plan Study (2017-2018). Client: UNOPS.

  Agricultural soils study according to IFC standards that involved World Resource Base classification of a wide range of soil forms. Agricultural soil capability and suitability was established, an impact assessment was undertaken and mitigation and management plans recommended.

- Richards Bay Minerals Sokhulu Remediation Plan, South Africa (2017). Soil Assessment. Client: Rio Tinto

  Soils were classified by form according to a local agricultural taxonomic system.

- Zambia Olam Soils Study (2016): Project Manager. Soil Classification, Land Use and Land Capability Study. Client: NCCL.

  Agricultural soils study according to IFC standards that involved World Resource Base classification of a range of soil forms. Land capabilities were established.

- Glisa Soils Study, Gauteng, South Africa (2015): Project Manager. Soil Classification, Land Use and Land Capability and Suitability Study. Client: Exxaro Resources.
- Philippi Sand Mine Soils Study, Western Cape, South Africa (2015): Project Manager. Hydrology, Storm Water Management Plan, Risk Assessment, Reporting and Project Management. Client: Consol Glass.
- Madagascar Molo Graphite Mine Soils Study. (2014): Project Manager. Soil Classification, Land Use and Land Capability Study with Management Plan and Staff Capability Outputs. Client: Energiser Resources.
- Wits Gold Mine Soils Study, Gauteng, South Africa (2014): Project Manager. Soil Classification, Land Use and Land Capability Study. Client: Wits Gold.
- Soil Monitoring Study, Gauteng, South Africa (2013-2014). Project Manager. Client: Total Coal South Africa.
- Kangra Coal specialist input – soils. (2013). Project Manager. Soil Classification, Land Use and Land Capability and Suitability Study. Client: Kangra Coal.
- Two Rivers Platinum EIA specialist input – soils. (2012). Project Manager. Soil Classification, Land Use and Land Capability and Suitability Study. Client: Two Rivers Platinum.
- Witkop EIA specialist input – soils. Witkop Exploration and Mining (2012). Project Manager. Soil Classification, Land Use and Land Capability and Suitability Study. Client: Witkop Mine.
- Matimba EIA specialist input – soils. (2012). Project Manager. Soil Classification, Land Use and Land Capability and Suitability Study. Client: SiVest.

- Sasol Fuel Department Due Diligence (2011). Project Manager. Establishing whether the soil in one of Sasol's tank farms was contaminated. This required soil sampling and analysis, as well as report writing. Client: Exxaro Coal.

HYDROLOGY PROFESSIONAL EXPERIENCE

- Lebombo Cape Water Study. Surface Water Fruit Export Compliance Assessment (2021-2022). Project Director. Client: Lebombo Cape.
- Etihad Rail Saudi Arabia to Oman Railway Line - Desert Hydrology Study (2020-2021). Project Director. Client: Etihad Rail.
- De Wittekrans WULA, IWWMP and specialist studies (2019). Project Director. Client: Canyon Coal.
- Trans-Alloys WULA, IWWMP and specialist studies (2019). Project Director and Reviewer. Client: Eskom.
- Eskom Lethabo WULA and IWWMP Amendment (2019). Project Director and Reviewer. Client: Eskom.
- Kimberly Clark WULA (2019). Project Director. Kimberly Clark.
- Sappi Ngodwana WULA Advisory Services (2019). Project Director. Client: Sappi.
- Sapref WULA, IWWMP and specialist studies including Storm Water Management Plan, Groundwater and wetland studies (2019). Project Director and Reviewer. Client: Sapref.
- Southern Cross Foundry WULA, IWWMP and specialist studies including a Storm Water Management Plan and Groundwater Study (2018-2019). Project Director and Reviewer. Client: Southern Cross.
- Nondvo Dam Morphodynamic and River Basin Specialist Studies – Swaziland (2018-2019): Project Director and Reviewer. Client: Swaziland DWS
- Transnet Monthly Surface Water Monitoring (2018-2019). Project Director and Reviewer. Client: TPT
- AMSA Stormwater Dam Complex Assessment (2018-2019). Report Reviewer. Client: Arcelor Mittal SA
- Alliance Mining Commodities Guinea Mine Water Study (2018-2019): Report Reviewer. Client: AMC.
- Yanfolila Mali Gold Mine Water Study (2018-2019): Project Reviewer. Client: Hummingbird Resources.
- Thabametsi Coal-fired power station water study (2017-2019). Water Use License Application and Storm Water Management Planning specialist advisors. Client: Marubeni.
- Turfontein Underground Mine WULA and IWWMP (2017-2019). Project Manager and Reviewer. Client: Samancor Chrome.
- Kalgold Mine Surface Water Assessment (2018): Project Director. Client: EIMS
- Tau Lekoa Gold Mine Surface Water Assessment (2018): Project Director. Client: EIMS
- Sappi Ngodwana WUL and IWWMP study (2018). Project Reviewer. Client: Sappi.
- Agriprotein Storm Water Management Plan (2018): Project Reviewer. Client: Agriprotein Industries.
- Sundumbili Wastewater Treatment Works upgrade potential water quality changes calculations (2018). Project Reviewer. Client: RHDHV.

- Glendale Distillery Water Use License Application study (2017 - 2018). Project Reviewer. Client: Illovo.
- GDC Wastewater Treatment Works Water Use License Application study (2017). Project Reviewer. Client: Illovo.
- Hwange District Plant Drain System Study, Zimbabwe (2017): Project Manager. Water Balance and Storm Water Management Plan review and recommendations. Client: ZimPower and the African Development Bank.
- Ethiopia Agri-Industrial Zone ESIA (2017): Project Manager, reviewer and soil scientist. Surface and groundwater, wetlands and soils assessment and risk and mitigation assessment. Client: UNOPS.
- Zambia Coal-fired power station Water Assessment (2017): Project Reviewer. Water Availability Assessment. Client: Black Rhino.
- Richards Bay Water Quality Monitoring Study (2017): Report reviewer. Compliance assessment. Client: Transnet Port Terminals.
- Oranjemund Mine Conjunctive Water Use Study (2016): Project Manager. Strategic Surface Water and Groundwater Assessment, Desalination, Project Management. Client: Freedthinkers.
- SKA Antennae Extensive Flood Lines Assessment (2016): Project Reviewer. Client: SKA.
- Avondale Housing Estate Hydrology and Flood Lines (2016): Project Reviewer. Client: Triplo4.
- Avon Power Plant Surface Water Assessment (2016): Project Reviewer. Client: Triplo4.
- Molopo Gas Study (2016): Project Reviewer. Sensitivity Assessment, Risk Assessment, Surface Water Assessment and Project Management. Client: EIMS.
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- Pumpi Mine Integrated Water Management Study, Mozambique (2015): Project Manager: Flood Lines, Storm Water Management Plan, Review, Project Management. Client: Lamikal.
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- Wits Gold Mine Surface Water Study, Gauteng, South Africa (2014): Project Manager. Hydrology, SWMP, Water Balance, Reporting, Project Management. Client: Wits Gold.
- Olam Zambia Surface Water Study, Zambia. (2014): Project Manager. Hydrology, Water Availability Assessment, Water Quality, Water resource Planning, Reporting, Project Management. Client: NCCL.
- Angola AEMR Area 5 Surface Water Study, Angola. (2014): Project Manager. Hydrology, Yield Analysis, Storm Water Management Plan, Water Balance, Reporting and Project Management. Client: Tenova Bateman.
- EnviroServ Water Facility Integrated Water Resources Study (2013). Project Manager. Hydrology, Water Balance, Salt Dilution Recommendations, Project Management. Client: EnviroServ.
- Surface Water Quantity and Quality Management Planning Study, King Shaka Airport, Durban, South Africa (2013-2016). Project Manager: Hydrology, SWMP, Water Quality Assessment, Bio-monitoring, Water Quality Monitoring Planning, Reporting, Project Management. Client: ACSA.
- Kangra Coal specialist input – hydrology. (2013). Project Manager. Hydrology, Storm Water Management Plan, Flood Lines, Water Quality Assessment, Water Balance, Monitoring Programme, Reporting and Project Management. Client: Kangra Coal.
- Angola AEMR Areas 2 and 3 Surface Water Study, Angola (2013). Project Manager. Hydrology, Yield Analysis, Storm Water Management Plan, Water Balance, Reporting and Project Management. Client: SMP.
- Kakanda-Luita Mine Project (2012). Project Manager. Hydrological modelling of mine areas to determine peak flows at various points, preparation of water balances for the respective mines and a flood line report. Client: ENRC Management South Africa (Pty) Ltd.
- Marikana Water Balance (2012). Hydrologist. An Excel-based process flow diagram and water balance was set up and verified for the mine. Client: Marikana Platinum Mine.
- Volspruit Platinum Mine Flood line calculations and berm design (2012). Project Manager. 1:50- and 1:100-year flood lines were calculated using Hec-RAS software for the watercourses running through the mine and flood protection berms were designed for these return periods. Client: Pan Palladium (Pty) Ltd.
- Marula Platinum Mine Flood Lines Project. (2012). Project Manager. 1:50- and 1:100-year flood lines were calculated using Hec-RAS software for the watercourses running through the mine and the risks associated with flooding identified. Client: Marula Platinum Mine.
- Marampa Iron Ore Flood Line Project (2012). Project Manager. 1:50- and 1:100-year flood lines were calculated using Hec-RAS software for the watercourses running through the mine and the risks associated with flooding identified. Client: Marula Platinum Mine.
- Two Rivers Platinum EIA specialist input – hydrology (2012). Project Manager. Hydrology, Storm Water Management Plan, Flood Lines, Water Quality Assessment, Risk Assessment, Water and Salt Balance, Monitoring Programme, Reporting and Project Management. Client: Two Rivers Platinum.
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- Mulepe Diamond Mine Project (2011). Project Manager. Flood Lines Calculation and reporting study. Client: De Beers Anglo Prospecting.
- Impala Tailings Dam Weirs (2011). Project Manager. PH and EC monitoring equipment were investigated and the best of these was recommended to the client. Client: Impala Platinum.
- New Clydesdale Coal Water Balance Study (2011). Project Manager. An Excel-based process flow diagram and water and salt balance was calculated for the mine. Client: Exxaro Coal.
- Nkomati Integrated Water and Waste Management Plan. (2012). Hydrologist. Client: African Rainbow Minerals Limited.
- Rus Ter Vaal Residential Development (2012). Project Manager. Water resources Availability Study, Water Balance and Project Management. Client: Arengo 6.
- Progressive Realisation of the IncoMaputo Agreement (PRIMA) Study. Tripartite Permanent Technical Committee (TPTC) between Mozambique, Swaziland and South Africa (2011). Developing and running a model to determine the water availability in the Maputo and Incomati catchments and their sub-catchments for a range of scenarios. Writing reports and giving presentations based on these findings at international meetings. Hydrologist. Client: PRIMA.
- Development of a Reconciliation Strategy for the Olifants River Water Supply System. (2011). Hydrologist. Client: DWA.
- Projected Impacts of Climate Change on water quality and quantity in the Mngeni Catchment (2011). Hydrologist. Client: The Water Research Commission.
- CSIR Regional Water infrastructure Project (2011). Hydrologist. Client: CSIR.
- uMgungundlovu Municipality Integrated Waste Management Plan (2010). Collection and analysis of solid waste collection, removal and disposal data for the 7 local municipalities making up uMgungundlovu District Municipality, and writing an integrated waste management plan for the area, based on this data. Client: uMgungundlovu District Municipality.
- Ugu District Municipality Disaster Management Plan. (2010). Hydrologist. Writing methodologies for air, soil and water pollution disaster mitigation and calculating preliminary timeframes and budgets for overall disaster management in the district. Client: Ugu District Municipality.
- eThekwini District Municipality Sandton Sanitation Project (2010). Hydrologist. Writing reports at various stages explaining what work has been done and what was still due to be done, on an area-by-area basis. Client: eThekwini District Municipality.
- SADC Climate Change Study. (2009). Hydrologist. Setting up the HEC-HMS modeling system to run various hydrological scenarios. Client: Pegasus.
- Bitou Stormwater and Flood Study. (2009). Hydrologist. Hydrological and hydraulic model development, flood hazard mapping and dam break analysis. Client: Bitou Local Municipality.
- SANRAL Bridge Study. (2009). Running the HDYP01 and HEC-HMS models and reporting on the findings. Client: Pegasus.

- EA Toddbrook Reservoir Rapid Impact Assessment. (2008). Hydrologist. Reports based on Toddbrook Reservoir were used in conjunction with a risk assessment modelling tool to produce a rapid impact assessment of the potential damage caused by a dam break at Toddbrook Reservoir. Client: The Environment Agency.
- SEW Ouse Cuckmere Control Lines. (2008). Flood control lines were produced using 1996 and 2005 simulation results and these were compared to identify how and why they differ. Client: South East Water.
- SEW NR09 Northern Region Development Options. (2007-2008). Hydrologist. The potential yield at these sites was assessed at various storage and pumping levels, and the sites were evaluated based on their potential yields and positions. Client: South East Water.
- West Sussex Strategic Flood Risk Assessment. (2006-2007). Hydrologist. Flood Risk mapping according to local climatic conditions, soils and populations, as well as surface water flood risk report writing. Client: The Environment Agency.
- Water Resources of South Africa, 2005 Study (2005). Hydrologist. The Water Research Commission. Setting up, simulating and calibrating water resources networks, including climatic, soils and vegetation data, and running scenarios for the whole of the Orange catchment, plus testing of the WRSM2005 model used for this exercise. Client: WRC.
- Assessment of Water Availability in the Olifants Catchments, South Africa. (2005). Hydrologist. Water resources Modelling. Client: SATAC.
- Development of a Reconciliation Strategy for the Amatole Bulk Water Supply Systems, South Africa. (2005). Hydrologist. Climate change and desalination studies made up a part of the project. Client: DWAF.
- Feasibility Study of Utilisation of the Low Level Storage at Vanderkloof Dam. (2005). Hydrologist. A feasibility study into utilisation of low level dam storage, accounting for the hydrological, economic, sociological, soils and environmental aspects thereof. Client: DWAF.

PUBLICATIONS AND PRESENTATIONS

Publications

- Engineering News – Crisis Proofing Water Preservation a SA Priority. January 2019. King, KN and A. Groves.
- SA Mining – Proactive, Long-Term Solutions for AMD Remain Critical. King, KN.
- Crown Publications – Women in STEM Share Career Advice. August 2018. King, KN, J Nhlapo, F A'Bear and H Manthose.
- Facing the Acid Mine Water Menace Squarely. African Mining. March 2018. King, KN.
- Sustainable Solutions Possible for AMD Treatment. Mining Weekly May 4 2018. King, KN.
- Shared Accountability Needed to Solve SA's Water Issues. News24. May 2017.
- Understanding Climate Effects. Mail and Guardian February 10-16 2017. King, KN, F Engelbrecht and J Weir.
- Water Management Crucial for Ensuring Economic Viability. Engineering News March 3 2017. King, KN and G Matthews.
- Effects of Land Use Changes on the Cape Flats. Environmental Sciences. King, KN and Janse van Rensburg, RT. 2016.

- Storm Water Management Involving the 'First Flush' Principle. Environmental Management November/December 2015. King, KN and E Naidoo.
- Exploring Water Resources Sustainability in a Trans-Boundary Context. Water and Sanitation Africa. May/June 2012. King, KN and Dr K Winter. 2012.
- Study Shows Not all Answers in Science. Published in the January/February 2006 Water Wheel. Volume 5. No.1. WRC, Pretoria, South Africa. King, KN. 2006.
- The analysis of 74 years of rainfall recorded by the Irwins on two farms south of Potchefstroom. SD Lynch, JT Zulu, KN King, DM Knoesen. WaterSA Vol.27 (4) 2001: 559-564. 2001.

Presentations

- Development of Alternative Soil Risk Assessment Methods. Golder Technical Excellence Conference (GTEC) April 2022. San Diego, California. King, KN.
- Yanfolila Gold Mine Open Pit Slope Depressurisation. ICARD IMWA 2018. CSIR International Conference Centre in Pretoria. September 2018. Lottreaux, G, King, KN and J McStay.
- Effects of Land Use Changes on the Cape Flats. The Combined Congress**.** 18-21 January 2016. University of the Free State, Bloemfontein. King, KN and Janse van Rensburg, RT
- A Combined Water Quality–Water Quantity Assessment for King Shaka International Airport. WISA Biennial Conference – Durban ICC – May 2016 – Paper Accepted August 2015. King, KN and Pickering, C
- Soil and Mine Water Assessment for Proposed Community Agricultural Projects. The Combined Congress. 20-23 January 2014. Rhodes University, Grahamstown. King, KN and Wuite, M. 2014
- Assessment of Water Resources Sustainability in a Trans-Boundary Context. WISA Youth Conference. July 2013. King, KN and Dr. K Winter. 2013
- Approaches to Sustainability Assessment in Trans-Boundary Basins. The International Conference on Water Security, Risk and Society. Oxford University, England. 16-18 April, 2012. King, KN. 2012
- Exploring Water Resources Sustainability in a Trans-Boundary Context. 15th South African National Hydrology Symposium (SANCIAHS), 2011. King, KN. And K. Winter. 2011
- Characteristics of Gravity Waves presentation at the Faculty of Science and Agriculture Post-Graduate Research Symposium, UKZN. 20th September, 2005. Durban, Howard College. 2005
- SANCIAHS (South African National Hydrological Symposia). 12th set of Proceedings – Pietermaritzburg, 2001. Floods and Droughts. Lynch, SD, Knoesen, DM and King, KN. 2001

APPENDIX

B SITE NOTES

Point: 1

Soil Form: Clovelly

Slope: <1%

Topsoil Depth: 30cm

Subsoil Depth: 0cm (cultivated)

Image:

Point: 2

Soil Form: Clovelly

Slope: <2%

Topsoil Depth: 15cm

Subsoil Depth: 15cm

Image:

Point: 3

Soil Form: Clovelly

Slope: <1%

Topsoil Depth: 30cm

Subsoil Depth: 0cm (cultivated)

Image:

Point: 4

Soil Form: Clovelly

Slope: <3%

Topsoil Depth: 30cm

Subsoil Depth: 0cm (cultivated)

Image:

Point: 5

Soil Form: Clovelly

Slope: <4%

Topsoil Depth: 30cm

Subsoil Depth: 0cm (cultivated)

Image:

Point: 6

Soil Form: Clovelly

Slope: <4%

Topsoil Depth: 30cm

Subsoil Depth: 0cm (cultivated)

Image:

Point: 7

Soil Form: Clovelly

Slope: <3%

Topsoil Depth: 15cm

Subsoil Depth: 15cm

Image:

Point: 8

Soil Form: Clovelly

Slope: 7%

Topsoil Depth: 15cm

Subsoil Depth: 30cm

Image:

Point: 9

Soil Form: Clovelly

Slope:

Topsoil Depth: 10cm

Subsoil Depth: 20cm

Image:

Point: 10

Soil Form: Mispah

Slope: <4%

Topsoil Depth: 2cm

Subsoil Depth: 0cm

Images:

Point: 11

Soil Form: Clovelly

Slope: <1%

Topsoil Depth: 10cm

Subsoil Depth: 15cm

Image:

Point: 12

Soil Form: Clovelly

Slope:

Topsoil Depth: 10cm

Subsoil Depth: 15cm

Image:

Point: 13

Soil Form: Clovelly

Slope: <1%

Topsoil Depth:15cm

Subsoil Depth:35cm

Image:

Point: 14

Soil Form: Clovelly

Slope: <1%

Topsoil Depth: 15cm

Subsoil Depth: 35cm

Image:

Point: 15

Soil Form: Mispah

Slope: <2%

Topsoil Depth:2cm

Subsoil Depth:0cm

Images:

Point: 16

Soil Form: Mispah

Slope: <3%

Topsoil Depth: 2cm

Subsoil Depth: 0cm

Images:

Point: 17

Soil Form: Clovelly

Slope: <3%

Topsoil Depth: 10cm

Subsoil Depth: 30cm

Image:

Point: 18

Soil Form: Clovelly

Slope: <2%

Topsoil Depth: 15cm

Subsoil Depth: 20cm

Image:

Point: 19

Soil Form: Clovelly

Slope: <4%

Topsoil Depth: 15cm

Subsoil Depth:30cm

Image:

Point: 19

Soil Form: Clovelly

Slope: <5%

Topsoil Depth: 10cm

Subsoil Depth: 25cm

Image:

Point: 20

Soil Form: Clovelly

Slope: <4%

Topsoil Depth: 10cm

Subsoil Depth: 25cm

Image:

Point: 21

Soil Form: Clovelly

Slope: <3%

Topsoil Depth: 10cm

Subsoil Depth: 25cm

Image:

Point: 22

Soil Form: Clovelly

Slope: <3%

Topsoil Depth: 15cm

Subsoil Depth: 25cm

Image:

Point: 23

Soil Form: Clovelly

Slope: <2%

Topsoil Depth: 15cm

Subsoil Depth: 30cm

Image:

Point: 24

Soil Form: Clovelly

Slope: <4%

Topsoil Depth: 20cm

Subsoil Depth: 30cm

Image:

Point: 25

Soil Form: Clovelly

Slope: <2%

Topsoil Depth: 10cm

Subsoil Depth: 30cm

Image:

Point: 26

Soil Form: Clovelly

Slope: <3%

Topsoil Depth: 10cm

Subsoil Depth: 20cm

Image:

Point: 27

Soil Form: Clovelly

Slope: <3%

Topsoil Depth: 10cm

Subsoil Depth: 40cm

Image:

Point: 28

Soil Form: Clovelly

Slope: <3%

Topsoil Depth: 5cm

Subsoil Depth: 20cm

Image:

Point: 29

Soil Form: Clovelly

Slope: <3%

Topsoil Depth: 10cm

Subsoil Depth: 40cm

Image:

Point: 30

Soil Form: Clovelly

Slope: <5%

Topsoil Depth: 10cm

Subsoil Depth: 35cm

Image:

Point: 31

Soil Form: Clovelly

Slope: <5%

Topsoil Depth: 20cm

Subsoil Depth: 30cm

Image:

Point: 32

Soil Form: Mispah

Slope: <5%

Topsoil Depth: 2cm

Subsoil Depth: 0cm

Image:

Point: 33

Soil Form: Mispah

Slope: <3%

Topsoil Depth: 2cm

Subsoil Depth: 0cm

Images: