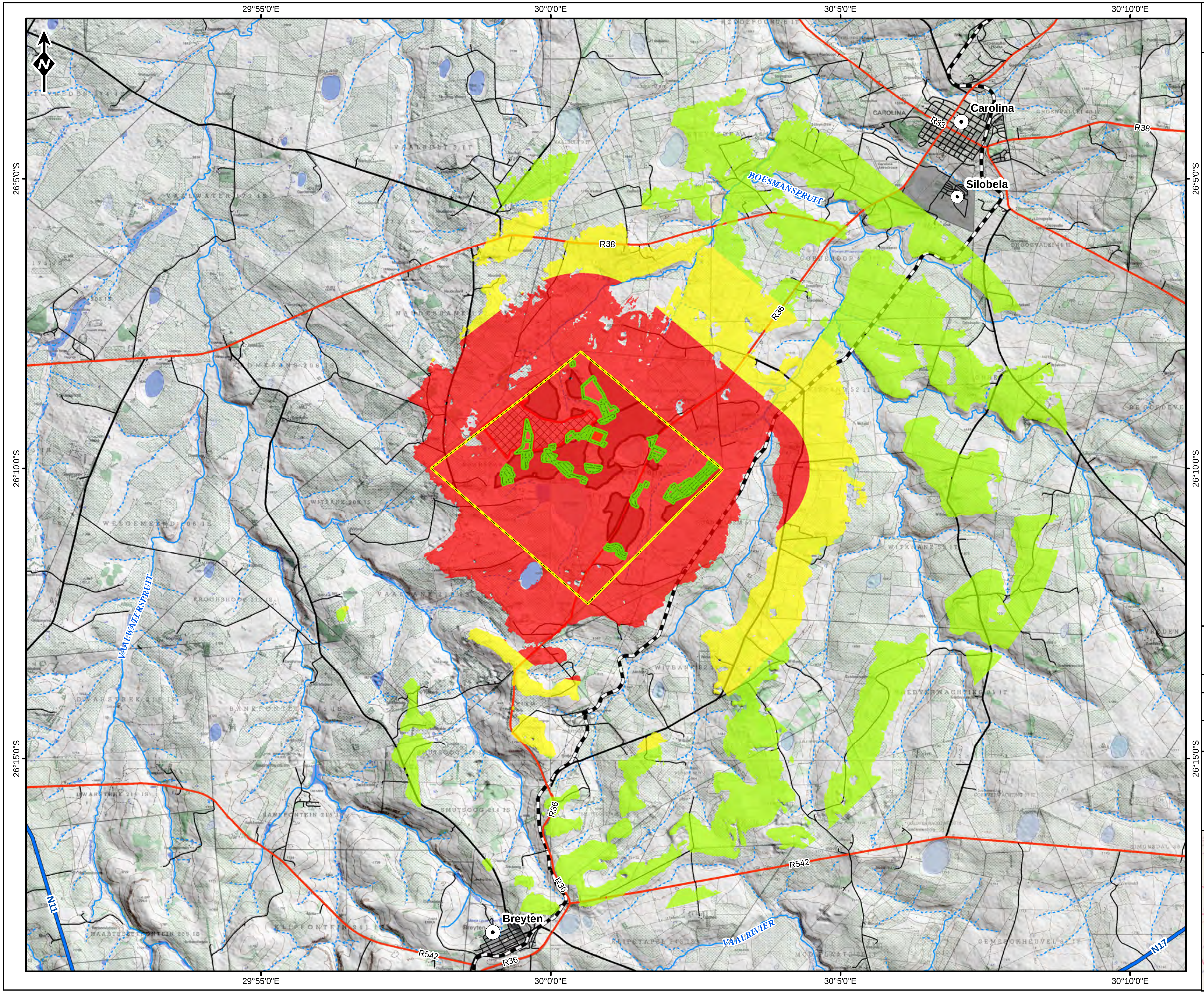

Kranspan MRA Project

Legend

- Towns/Cities

Road Network

- National Route
- Main Road
- Secondary Road
- Street
- Railway Line

Rivers and Streams

- Non-Perennial
- Perennial
- Modelled Infrastructure
- Proposed Kranspan MRA

Viewshed Results

- 74.92% Coverage of PZI 0 - 2.5 km
- 29.66% Coverage of PZI 2.5 - 5 km
- 21.19% Coverage of PZI 5 - 10 km

CUMULATIVE VIEWSHED

0 1 2 4 Kilometers

Reviewed: P. Furniss Environmental Scientist	Drawn by: A Brower GIS Consultant

Coordinate System: GCS WGS 1984
Datum: WGS 1984

ABS Africa Sustainability Advisors

Scale: 1:110 000

Version: Final

Date: 2019/06/12

APPENDIX 3: IMPACT RATINGS

SOCIO-ECONOMIC

Project Activity	Socio-Economic		Likelihood		Consequence			Significance Rating
All activities involving employment and procurement of goods and services	Phase of Project	All	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	**Positive** - Direct and indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Local employment	4	4	4	3	4	88
			Significance Post- Mitigation					
			4	5	5	3	4	108

Project Activity	Socio-Economic		Likelihood		Consequence			Significance Rating
All activities involving employment and procurement of goods and services	Phase of Project	All	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	**Positive** - Direct and indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Local economic development	3	4	4	3	4	77
			Significance Post- Mitigation					
			3	5	5	3	4	96

Project Activity	Socio-Economic		Likelihood		Consequence			Significance Rating
All activities involving employment and procurement of goods and services	Phase of Project	All	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	**Positive** - Direct and indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Training and development	5	4	3	3	5	99
			Significance Post- Mitigation					
			5	5	4	3	5	120

<table>
<tr><td>Project Activity</td><td colspan="2">Socio-Economic</td><td colspan="2">Likelihood</td><td colspan="3">Consequence</td><td rowspan="2">Significance Rating</td></tr>
<tr><td rowspan="6">All activities involving employment and procurement of goods and services</td><td>Phase of Project</td><td>All</td><td>Frequency of Activity</td><td>Frequency of Impact</td><td>Severity</td><td>Spatial Scope</td><td>Duration</td></tr>
<tr><td>Impact Classification</td><td>Negative - Direct and indirect</td><td colspan="6">Significance Pre-Mitigation</td></tr>
<tr><td rowspan="3">Resulting Impact from Activity</td><td rowspan="3">Influx of job seekers - demand on municipal services</td><td>3</td><td>5</td><td>3</td><td>3</td><td>3</td><td>72</td></tr>
<tr><td colspan="6">Significance Post- Mitigation</td></tr>
<tr><td>3</td><td>4</td><td>3</td><td>3</td><td>2</td><td>56</td></tr>
</table>

<table>
<tr><td>Project Activity</td><td colspan="2">Socio-Economic</td><td colspan="2">Likelihood</td><td colspan="3">Consequence</td><td rowspan="2">Significance Rating</td></tr>
<tr><td rowspan="6">All activities involving employment and procurement of goods and services</td><td>Phase of Project</td><td>All</td><td>Frequency of Activity</td><td>Frequency of Impact</td><td>Severity</td><td>Spatial Scope</td><td>Duration</td></tr>
<tr><td>Impact Classification</td><td>Negative - Direct and indirect</td><td colspan="6">Significance Pre-Mitigation</td></tr>
<tr><td rowspan="3">Resulting Impact from Activity</td><td rowspan="3">Influx of job seekers - disruption in community dynamics</td><td>3</td><td>5</td><td>4</td><td>3</td><td>3</td><td>80</td></tr>
<tr><td colspan="6">Significance Post- Mitigation</td></tr>
<tr><td>3</td><td>4</td><td>3</td><td>3</td><td>2</td><td>56</td></tr>
</table>

<table>
<tr><td>Project Activity</td><td colspan="2">Socio-economic</td><td colspan="2">Likelihood</td><td colspan="3">Consequence</td><td rowspan="2">Significance Rating</td></tr>
<tr><td rowspan="6">All mine-related activities</td><td>Phase of Project</td><td>All</td><td>Frequency of Activity</td><td>Frequency of Impact</td><td>Severity</td><td>Spatial Scope</td><td>Duration</td></tr>
<tr><td>Impact Classification</td><td>Negative - Direct</td><td colspan="6">Significance Pre-Mitigation</td></tr>
<tr><td rowspan="3">Resulting Impact from Activity</td><td rowspan="3">Mine health and safety</td><td>4</td><td>5</td><td>5</td><td>3</td><td>4</td><td>108</td></tr>
<tr><td colspan="6">Significance Post- Mitigation</td></tr>
<tr><td>3</td><td>3</td><td>5</td><td>3</td><td>4</td><td>72</td></tr>
</table>

Project Activity	Socio-Economic		Likelihood		Consequence			Significance Rating
All mine-related activities	Phase of Project	All	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	**Negative** - Direct	Significance Pre-Mitigation					
	Resulting Impact from Activity	Security risk	4	4	5	2	4	88
			Significance Post- Mitigation					
			2	3	5	2	4	55

Project Activity	Socio-Economic		Likelihood		Consequence			Significance Rating
All mining activities	Phase of Project	All	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	**Negative** - Direct and indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Loss of common property	4	5	1	3	5	81
			Significance Post- Mitigation					
			4	4	1	2	4	56

Project Activity	Socio-Economic		Likelihood		Consequence			Significance Rating
All mine-related activities	Phase of Project	Construction and Operational	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	**Positive** - Direct and indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Contribution of royalties, rates and taxes	3	4	3	3	4	70
			Significance Post- Mitigation					
			3	4	3	3	4	70

Project Activity	Socio-Economic		Likelihood		Consequence			Significance Rating
All mine-related activities	Phase of Project	All	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	**Negative** - Direct and indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Community health and safety	4	5	5	3	4	108
			Significance Post- Mitigation					
			2	2	5	3	4	48

Project Activity	Socio-Economic		Likelihood		Consequence			Significance Rating
All mine-related activities	Phase of Project	Decommissioning and Closure	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	**Negative** - Direct and indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Mine closure and associated effects on the local economy	1	5	5	3	5	78
			Significance Post- Mitigation					
			1	5	3	3	5	66

TRAFFIC AND ROAD SAFETY

Project Activity	Traffic and Road Safety		Likelihood		Consequence			
Movement of man and materials	Phase of project	Construction, Operational and Closure	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	**Negative** - Direct and Indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Heavy vehicles may cause damage to the road surface	5	4	4	4	5	117
			Significance Post-Mitigation					
			4	4	2	4	5	88
-								
Project Activity	Traffic and Road Safety		Likelihood		Consequence			
Movement of man and materials	Phase of project	Construction, Operational and Closure	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	**Negative** - Direct and Indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Need for additional lanes due to road capacity	4	1	1	4	4	45
			Significance Post-Mitigation					
			No mitigation required					
-								
Project Activity	Traffic and Road Safety		Likelihood		Consequence			
Movement of man and materials	Phase of project	Construction, Operational and Closure	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	**Negative** - Direct and Indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Vehicles making right-turn movements at intersections	4	4	4	3	4	88
			Significance Post-Mitigation					
			4	2	1	3	4	48
-								
Project Activity	Traffic and Road Safety		Likelihood		Consequence			Significance Rating

Movement of man and materials	Phase of project	Construction, Operational and Closure	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	**Negative** - Direct and Indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Loading and offloading of workers along roads at the mine access intersection may reduce road safety	4	5	4	2	4	90
			Significance Post-Mitigation					
			4	2	2	2	4	48

Project Activity	Traffic and Road Safety		Likelihood		Consequence			Significance Rating
Movement of man and materials	Phase of project	Construction, Operational and Closure	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	**Negative** - Direct and Indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Vehicles may reduce road safety due to reduced speed of the heavy vehicles entering fast flowing traffic	4	4	4	3	4	88
			Significance Post-Mitigation					
			4	2	1	3	4	48

APPENDIX 4: SURVEY RESULTS

ABS Africa
Sustainability Advisors

Vaalbank

SOCIAL INFORMATION QUESTIONNAIRE

The information to be gathered through this questionnaire is required to determine the socio-economic impacts associated with the proposed Kranspan Mining Project that forms part of an Environmental Impact Assessment Report. No private information will be disclosed.

(Nhlanhla Jele 0761267757) 250 people ± 50 Structures Isaac Nkosi

Question 1: Are you aware of the proposed mining on this area?

No

Question 2: What is the Farm's name and Portion number on which you reside?

~~Vaalbank~~ Witbank portion 0

Question 3: What kind of crops are grown on the farm?

~~Potatoes~~ Potatoes, beans, pumpkins, Maize

Question 4: Mark with X

	Race				Gender	
	Black	☒	**Coloured**	☐	**Female**	☐
	White	☐	**Indian**	☐	**Male**	☒

Question 5: What is your age?

39

Question 6: What language do you speak?

Home:

2nd:

3rd: IsiZulu, Swati & Ndebele

Question 7: Do you work on the same farm as the one you reside on? (If No please state on which farm you work)

No

Question 8: How many people live with you in the house? (please provide their race, age and gender for each)

-

Question 9: Do you grow any small-scale crops for personal use?

Yes

Question 10: Do you have any animals grazing on the farm? How many animals? And where are they grazing?

Cows
Pigs
Goats

Question 11: Are you reliant on any streams or waterbodies on the farm?

Only grazing animals use the dam

Question 12: Are you able to read and write?

Zulu, English & Afrikaans

Question 13: What level of education did you receive?

Grade 11

Question 14: What and where is your occupation?

Question 15: Type of housing?

Brick houses

Question 16: What is the source of energy? (electricity, gas, wood)

Electricity (No electricity on the opposite area)

Question 17: If you have children where do they go to school?

No

Any notes or concerns they have on the mining project.

- Not aware.

Thank you for your time.

Please do not hesitate to contact us should you have any queries.

Sincerely,

Chane Pretorius

For and on behalf of ABS Africa (Pty) Ltd.

ABS Africa
Sustainability Advisors

Kranspan

SOCIAL INFORMATION QUESTIONNAIRE

The information to be gathered through this questionnaire is required to determine the socio-economic impacts associated with the proposed Kranspan Mining Project that forms part of an Environmental Impact Assessment Report. No private information will be disclosed.

Question 1: Are you aware of the proposed mining on this area?

~~Kranspa~~ No

Question 2: What is the Farm's name and Portion number on which you reside?

Kranspan portion

Question 3: What kind of crops are grown on the farm?

Nothing

Question 4: Mark with X

Race

Black [X] **Coloured** [ ]
White [ ] **Indian** [ ]

Gender

Female [X]
Male [ ]

Question 5: What is your age?

Question 6: What language do you speak?

Home:

2nd:

3rd: Isizulu

Question 7: Do you work on the same farm as the one you reside on? (If No please state on which farm you work)

Question 8: How many people live with you in the house? (please provide their race, age and gender for each)

- 1

Question 9: Do you grow any small-scale crops for personal use?

None

Question 10: Do you have any animals grazing on the farm? How many animals? And where are they grazing?

None

Question 11: Are you reliant on any streams or waterbodies on the farm?

River

Question 12: Are you able to read and write?

~~None~~ No

Question 13: What level of education did you receive?

No

Question 14: What and where is your occupation?

Unemployed

Question 15: Type of housing?

Question 16: What is the source of energy? (electricity, gas, wood)

No electricity

Question 17: If you have children where do they go to school?

1

Any notes or concerns they have on the mining project.

- Blasting a concern.

Thank you for your time.

Please do not hesitate to contact us should you have any queries.

Sincerely,

Chane Pretorius

For and on behalf of ABS Africa (Pty) Ltd.

ABS Africa
Sustainability Advisors

Kranspan

SOCIAL INFORMATION QUESTIONNAIRE

The information to be gathered through this questionnaire is required to determine the socio-economic impacts associated with the proposed Kranspan Mining Project that forms part of an Environmental Impact Assessment Report. No private information will be disclosed.

Sibeko

Question 1: Are you aware of the proposed mining on this area?

Yes

Question 2: What is the Farm's name and Portion number on which you reside?

- kranspan portion 1

Question 3: What kind of crops are grown on the farm?

- Maize, Potato's, & beans

Question 4: Mark with X

	Race				Gender	
	Black	X	Coloured	☐	Female	☐
	White	☐	Indian	☐	Male	X

Question 5: What is your age?

1952 => 67

Question 6: What language do you speak?

Home: ←
2nd:
3rd: Isi Zulu

Question 7: Do you work on the same farm as the one you reside on? (If No please state on which farm you work)

Unemployed

Question 8: How many people live with you in the house? (please provide their race, age and gender for each)

- 2 Adults (Husband & Wife)
1 girl
1 boy

Question 9: Do you grow any small-scale crops for personal use?

Yes

Question 10: Do you have any animals grazing on the farm? How many animals? And where are they grazing?

15 Cows
5 New borns

Question 11: Are you reliant on any streams or waterbodies on the farm?

- Yes, small dam (Winter it dries out)

Question 12: Are you able to read and write?

No

Question 13: What level of education did you receive?

Never went to school, grew up in a farm

Question 14: What and where is your occupation?

Unemployed

Question 15: Type of housing?

Question 16: What is the source of energy? (electricity, gas, wood)

Electricity

Question 17: If you have children where do they go to school?

No

Any notes or concerns they have on the mining project.

- Doesn't like the idea of moving / being relocated
- Blasting is an issue

Thank you for your time.

Please do not hesitate to contact us should you have any queries.

Sincerely,

Chane Pretorius

For and on behalf of ABS Africa (Pty) Ltd.

ABS Africa
Sustainability Advisors

Kranspan

SOCIAL INFORMATION QUESTIONNAIRE

The information to be gathered through this questionnaire is required to determine the socio-economic impacts associated with the proposed Kranspan Mining Project that forms part of an Environmental Impact Assessment Report. No private information will be disclosed.

Nomvulo Nkabinde

Question 1: Are you aware of the proposed mining on this area?

Yes

Question 2: What is the Farm's name and Portion number on which you reside?

Kraspan - ~~aware~~ portion 1

Question 3: What kind of crops are grown on the farm?

Yes : Small scale, last grown last year

Question 4: Mark with X

Race

Black [X] **Coloured** [ ]

White [ ] **Indian** [ ]

Gender

Female [X]

Male [ ]

Question 5: What is your age?

43

Question 6: What language do you speak?

Home:

2nd:

3rd: IsiZulu

Question 7: Do you work on the same farm as the one you reside on? (If No please state on which farm you work)

~~N~~ Unemployed. Simelani just started working

Question 8: How many people live with you in the house? (please provide their race, age and gender for each)

- 7 people
- 3 male
- 4 Female

Question 9: Do you grow any small-scale crops for personal use?

Potato is grown

Question 10: Do you have any animals grazing on the farm? How many animals? And where are they grazing?

- Chickens (20)
- Cows (2)
- ~~Kt~~ Graze within the area

Question 11: Are you reliant on any streams or waterbodies on the farm?

There's a tank, small stream used incase tank doesn't work

Question 12: Are you able to read and write?

~~Red~~ Read & write IsiZulu

Question 13: What level of education did you receive?

Grade

Question 14: What and where is your occupation?

Unemployed

Question 15: Type of housing?

Question 16: What is the source of energy? (electricity, gas, wood)

Elect

Question 17: If you have children where do they go to school?

2 - Ezindongeni Primary (1 boy, 1 girl) 1 - VJ (Boy)

Any notes or concerns they have on the mining project.

- Blasting might be affecting house structures

Thank you for your time.

Please do not hesitate to contact us should you have any queries.

Sincerely,

Chane Pretorius

For and on behalf of ABS Africa (Pty) Ltd.

ABS Africa
Sustainability Advisors

Kranspan

SOCIAL INFORMATION QUESTIONNAIRE

The information to be gathered through this questionnaire is required to determine the socio-economic impacts associated with the proposed Kranspan Mining Project that forms part of an Environmental Impact Assessment Report. No private information will be disclosed.

Arrived 1967 Mfoekeng

Question 1: Are you aware of the proposed mining on this area?

No

Question 2: What is the Farm's name and Portion number on which you reside?

Kranspan portion 1

Question 3: What kind of crops are grown on the farm?

Nothing

Question 4: Mark with X

Race

Black [X] **Coloured** [ ]

White [ ] **Indian** [ ]

Gender

Female [ ]

Male [X]

Question 5: What is your age?

1927 = 92

Question 6: What language do you speak?

Home:

2nd:

3rd: Isizulu

Question 7: Do you work on the same farm as the one you reside on? (If No please state on which farm you work)

Unemployed

Question 8: How many people live with you in the house? (please provide their race, age and gender for each)

- One

Question 9: Do you grow any small-scale crops for personal use?

None

Question 10: Do you have any animals grazing on the farm? How many animals? And where are they grazing?

3 cows

-

Question 11: Are you reliant on any streams or waterbodies on the farm?

Yes (Small river they use but dries up in winter)

Question 12: Are you able to read and write?

No.

Question 13: What level of education did you receive?

No.

Question 14: What and where is your occupation?

____

Question 15: Type of housing?

____

Question 16: What is the source of energy? (electricity, gas, wood)

____

Question 17: If you have children where do they go to school?

____

Any notes or concerns they have on the mining project.

____

____

____

____

____

____

____

Thank you for your time.

Please do not hesitate to contact us should you have any queries.

Sincerely,

Chane Pretorius

For and on behalf of ABS Africa (Pty) Ltd.

ABS Africa
Sustainability Advisors

21

Sydwiel ~~[illegible]~~ Kabindele sms - 0765248247

Social Information Questionnaire

CL

The information to be gathered through this questionnaire is required to determine the socio-economic impacts associated with the proposed Kranspan Mining Project that forms part of an Environmental Impact Assessment Report. No private information will be disclosed.

Question 1: Are you aware of the proposed mining on this area?

Yes

Question 2: What is the Farm's name and Portion number on which you reside?

kran span

Question 3: What kind of crops are grown on the farm?

none

Question 4: Mark with X

Race				Gender	
Black	X	Coloured	☐	Female	☐
White	☐	Indian	☐	Male	X

Question 5: What is your age?

29

Question 6: What language do you speak?

Home: isizulu

2nd: english

3rd:

Question 7: Do you work on the same farm as the one you reside on? (If No please state on which farm you work)

Question 8: How many people live with you in the house? (please provide their race, age and gender for each)

10 4 male

6 female

Question 9: Do you grow any small-scale crops for personal use?

No

Question 10: Do you have any animals grazing on the farm? How many animals? And where are they grazing?

1 cow

Question 11: Are you reliant on any streams or waterbodies on the farm?

spring + borehole with electric pump

Question 12: Are you able to read and write?

Yes

Question 13: What level of education did you receive?

Matric

Question 14: What and where is your occupation?

ADT operator

Question 15: Type of housing?

house

Question 16: What is the source of energy? (electricity, gas, wood)

Question 17: If you have children where do they go to school?

4

Any notes or concerns they have on the mining project.

Msobo Mines too close

Thank you for your time.

Please do not hesitate to contact us should you have any queries.

Sincerely,

Chane Pretorius

For and on behalf of ABS Africa (Pty) Ltd.

ABS Africa
Sustainability Advisors

SOCIAL INFORMATION QUESTIONNAIRE

The information to be gathered through this questionnaire is required to determine the socio-economic impacts associated with the proposed Kranspan Mining Project that forms part of an Environmental Impact Assessment Report. No private information will be disclosed.

Question 1: Are you aware of the proposed mining on this area?

No

Question 2: What is the Farm's name and Portion number on which you reside?

Kra 1

Question 3: What kind of crops are grown on the farm?

No

Question 4: Mark with X **Race** **Gender**

Black [X] **Coloured** [ ] **Female** [X]

White [ ] **Indian** [ ] **Male** [ ]

Question 5: What is your age?

—

Question 6: What language do you speak?

Home: isizulu

2nd:

3rd:

Question 7: Do you work on the same farm as the one you reside on? (If No please state on which farm you work)

no working pension

Question 8: How many people live with you in the house? (please provide their race, age and gender for each)

2

Question 9: Do you grow any small-scale crops for personal use?

None

Question 10: Do you have any animals grazing on the farm? How many animals? And where are they grazing?

/

Question 11: Are you reliant on any streams or waterbodies on the farm?

same

Question 12: Are you able to read and write?

No

Question 13: What level of education did you receive?

no school

Question 14: What and where is your occupation?

—

Question 15: Type of housing?

mud house

Question 16: What is the source of energy? (electricity, gas, wood)

Question 17: If you have children where do they go to school?

/

Any notes or concerns they have on the mining project.

/

Thank you for your time.

Please do not hesitate to contact us should you have any queries.

Sincerely,

Chane Pretorius

For and on behalf of ABS Africa (Pty) Ltd.

ABS Africa
Sustainability Advisors

Christina

SOCIAL INFORMATION QUESTIONNAIRE

The information to be gathered through this questionnaire is required to determine the socio-economic impacts associated with the proposed Kranspan Mining Project that forms part of an Environmental Impact Assessment Report. No private information will be disclosed.

Question 1: Are you aware of the proposed mining on this area?

Yes

Question 2: What is the Farm's name and Portion number on which you reside?

Vaalbank 212

Question 3: What kind of crops are grown on the farm?

Mielies + soya

Question 4: Mark with X

Race

Black [X] **Coloured** [ ]

White [ ] **Indian** [ ]

Gender

Female [X]

Male [ ]

Question 5: What is your age?

Question 6: What language do you speak?

Home: swazi

2nd: zulu

3rd: afrikaans

Question 7: Do you work on the same farm as the one you reside on? (If No please state on which farm you work)

Question 8: How many people live with you in the house? (please provide their race, age and gender for each)

Ct 4 21

23

45

2

Question 9: Do you grow any small-scale crops for personal use?

maize

Question 10: Do you have any animals grazing on the farm? How many animals? And where are they grazing?

40 beeste

Question 11: Are you reliant on any streams or waterbodies on the farm?

spring

Question 12: Are you able to read and write?

Ja

Question 13: What level of education did you receive?

grade 12

Question 14: What and where is your occupation?

Farmer

Question 15: Type of housing?

Baksten huis

Question 16: What is the source of energy? (electricity, gas, wood)

Question 17: If you have children where do they go to school?

1 child no school

Any notes or concerns they have on the mining project.

Blasting Trollop mine

Thank you for your time.

Please do not hesitate to contact us should you have any queries.

Sincerely,

Chane Pretorius

For and on behalf of ABS Africa (Pty) Ltd.

APPENDIX 5: REGISTERED LAND CLAIMS

info@abs-africa.com

+27 11 805 0061

www.abs-africa.com

ABS Africa

Sustainability Advisors

Earth Science Solutions

ILIMA COAL COMPANY (PTY) LIMITED

KRANSPAN COLLIERY

EMP Specialist Soils, Hydropedology, Land Capability & Pre Development Land Use Assessment

Compiled for

ABS Africa Sustainability Advisors

REPORT

May 2019

Sustaining the Environment

Stonecap Trading 14 (Pty) Ltd

23rd May 2019

ABS - Africa
Block C Suite 2,
Carlswald Close Office Park, Corner of New Road & Seventh Road,
Carlswald,
Midrand,
1685
South Africa

Attention: Mr. Paul Furness

Re: Kranspan Colliery
Baseline Specialist Soils and Land Capability Studies

Dear Paul/Chane,

In line with the ToR submitted Earth Science Solutions (Pty) Ltd was requested to provide a scope of work, methodology and budget estimate for the specialist baseline soils and land capability studies as part of the greater EA being undertaken for the Kranspan coal mining project.

Herewith attached please find our specialist report for the soils, hydropedology, capability and land use studies undertaken as part of the EIA for the Kranspan Mining Project.

Thanking you

Yours sincerely,
Earth Science Solutions (Pty) Ltd

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Declaration

This specialist report has been compiled in terms of Regulation 33.3 of the National Environmental Management Act 107/1998 (R. 385 of 2006), and forms part of the overall impact assessment, both as a standalone document and as supporting information to the overall impact assessment for the proposed development.

The Specialist Soils, Land Capability and Land Use Baseline Studies, where managed and signed off by Ian P.C. Jones (Pr. Sci Nat 400040/08) and Certified EAPASA, an Earth Scientist with 40 years of experience in the these specialist fields.

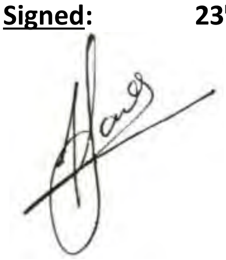
I declare that Earth Science Solutions (Pty) Ltd, is totally independent in this process, and has no vested interest in the project.

The objectives of the study were to:

- Provide a permanent record of the present soil resources in the area that are potentially going to be affected by the proposed development – Pre construction environment,
- Assess the nature of the site in relation to the overall environment and its present and proposed utilisation, and determine the capability of the land in terms of agricultural utilisation, and
- Provide a base plan from which long-term ecological and environmental decisions can be made, impacts of construction can be determined, and mitigation and rehabilitation management plans can be formulated.

The Taxonomic Soil Classification System and Chamber of Mines Land Capability Rating Systems in combination with the Canadian Land Inventory were used as the basis for the soils and land capability investigations respectively. These systems are recognized nationally.

Signed: **23rd May 2019**



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GLOSSARY OF TERMS

Alluvium: Refers to detrital deposits resulting from the operation of modern streams and rivers.

Base status: A qualitative expression of base saturation. See base saturation percentage.

Black turf: Soils included by this lay-term are the more structured and darker soils such as the Bonheim, Rensburg, Arcadia, Milkwood, Mayo, Sterkspruit, and Swartland soil forms.

Buffer capacity: The ability of soil to resist an induced change in pH.

Calcareous: Containing calcium carbonate.

Catena: A sequence of soils of similar age, derived from similar parent material, and occurring under similar macroclimatic conditions, but having different characteristics due to variation in relief and drainage.

Clast: An individual constituent, grain or fragment of a sediment or sedimentary rock produced by the physical disintegration of a larger rock mass.

Cohesion: The molecular force of attraction between similar substances. The capacity of sticking together. The cohesion of soil is that part of its shear strength which does not depend upon inter-particle friction. Attraction within a soil structural unit or through the whole soil in apedel soils.

Concretion: A nodule made up of concentric accretions.

Crumb: A soft, porous more or less rounded ped from one to five millimetres in diameter. See structure, soil.

Cutan: Cutans occur on the surfaces of peds or individual particles (sand grains, stones). They consist of material which is usually finer than, and that has an organisation different to the material that makes up the surface on which they occur. They originate through deposition, diffusion or stress. Synonymous with clayskin, clay film, argillan.

Denitrification: The biochemical reduction of nitrate or nitrite to gaseous nitrogen, either as molecular nitrogen or as an oxide of nitrogen.

Erosion: The group of processes whereby soil or rock material is loosened or dissolved and removed from any part of the earth's surface.

Fertilizer: An organic or inorganic material, natural or synthetic, which can supply one or more of the nutrient elements essential for the growth and reproduction of plants.

Fine sand: (1) A soil separate consisting of particles 0,25-0,1mm in diameter. (2) A soil texture class (see texture) with fine sand plus very fine sand (i.e. 0,25-0,05mm in diameter) more than 60% of the sand fraction.

Fine textured soils: Soils with a texture of sandy clay, silty clay or clay.

Hardpan: A massive material enriched with and strongly cemented by sesquioxides, chiefly iron oxides (known as ferricrete, diagnostic hard plinthite, ironpan, ngubane, ouklip, laterite hardpan), silica (silcrete, dorbank) or lime (diagnostic hardpan carbonate-horizon, calcrete). Ortstein hardpans are cemented by iron oxides and organic matter.

Land capability: The ability of land to meet the needs of one or more uses under defined conditions of management.

Land type: (1) A class of land with specified characteristics. (2) In South Africa it has been used as a map unit denoting land, mapable at 1:250,000 scale, over which there is a marked uniformity of climate, terrain form and soil pattern.

Land use: The use to which land is put.

Mottling: A mottled or variegated pattern of colours is common in many soil horizons. It may be the result of various processes *inter alia* hydromorphy, illuviation, biological activity, and rock weathering in freely drained conditions (i.e. saprolite). It is described by noting (i) the colour of the matrix and colour or colours of the principal mottles, and (ii) the pattern of the mottling.
The latter is given in terms of abundance (few, common 2 to 20% of the exposed surface, or many), size (fine, medium 5 to 15mm in diameter along the greatest dimension, or coarse), contrast (faint, distinct or prominent), form (circular, elongated-vesicular, or streaky) and the nature of the boundaries of the mottles (sharp, clear or diffuse); of these, abundance, size and contrast are the most important.

Nodule: Bodies of various shapes, sizes and colour that have been hardened to a greater or lesser extent by chemical compounds such as lime, sesquioxides, animal excreta and silica. These may be described in terms of kind (durinodes, gypsum, insect casts, ortstein, iron-manganese, lime, lime-silica, plinthite, salts), abundance (few, less than 20% by volume percentage; common, 20 – 50%; many, more than 50%), hardness (soft, hard meaning barely crushable between thumb and forefinger, indurated) and size (threadlike, fine, medium 2 – 5mm in diameter, coarse).

Overburden: A material which overlies another material difference in a specified respect, but mainly referred to in this document as materials overlying weathered rock

Ped: Individual natural soil aggregate (e.g. block, prism) as contrasted with a clod produced by artificial disturbance.

Pedocutanic, diagnostic B-horizon: The concept embraces B-horizons that have become enriched in clay, presumably by illuviation (an important pedogenic process which involves downward movement of fine materials by, and deposition from, water to give rise to cutanic character) and that have developed moderate or strong blocky structure. In the case of a red pedocutanic B-horizon, the transition to the overlying A-horizon is clear or abrupt.

Pedology: The branch of soil science that treats soils as natural phenomena, including their morphological, physical, chemical, mineralogical and biological properties, their genesis, their classification and their geographical distribution.

Slickensides: In soils, these are polished or grooved surfaces within the soil resulting from part of the soil mass sliding against adjacent material along a plane which defines the extent of the slickensides. They occur in clayey materials with a high smectite content.

Sodic soil: Soil with a low soluble salt content and a high exchangeable sodium percentage (usually EST > 15).

Swelling clay: Clay minerals such as the smectites that exhibit interlayer swelling when wetted, or clayey soils which, on account of the presence of swelling clay minerals, swell when wetted and shrink with cracking when dried. The latter are also known as heaving soils.

Texture, soil: The relative proportions of the various size separates in the soil as described by the classes of soil texture shown in the soil texture chart (see diagram on next page). The pure sand, sand, loamy sand, sandy loam and sandy clay loam classes are further subdivided (see diagram) according to the relative percentages of the coarse, medium and fine sand subseparates.

Vertic, diagnostic A-horizon: A-horizons that have both, a high clay content and a predominance of smectitic clay minerals possess the capacity to shrink and swell markedly in response to moisture changes. Such expansive materials have a characteristic appearance: structure is strongly developed, ped faces are shiny, and consistence is highly plastic when moist and sticky when wet.

EXECUTIVE SUMMARY

The Kranspan Coal Mining Project (the project) is situated approximately 15km to the south west of the town of Carolina in Mpumalanga, South Africa.

The Project covers a significant portion of the overall mining right area, with both underground and open cast mining planned to extract the resource.

The majority of the land is owned by the proponent (Refer to Figure 1.1 – locality Plan) with portions of the western and south western extent owned by a neighbouring land owner.

The development covers an area of land that falls within the Greater Inkomati – Usuthu Water Management Area.

The hydrology of the study area is significant in understanding the complex of soils and the hydropedology that occur within study area, the major pan feature and associated wetlands having a strong lithological and hydropedological control.

The geomorphology and hydropedology of this site have a significant influence on the ecosystem services and utilisation potential of the area, the sensitivity of some of these sites regarded as important to the long term sustainability of the natural environment. This said, there has been a significant amount of development within the general area, and on the study area in particular, with the majority (>75%) of the land surface having been impacted by commercial farming.

These impacts render the study area brown fields in character, a factor that has been considered in the cumulative effects of ongoing development in the area.

The baseline conditions for the mining project is that of commercial farming where the soils and land capability have been effected by ploughing and tilling of the soils for many years, with commercial grazing on many of the more sensitive wetland areas. And sites that are not conducive to commercial cultivation. This disturbance will play a role in the cumulative impacts that any future development might have, with the interactions of landform, climate, topography, aspect and geology producing a complex inter-relationship that is basic to the soil forming processes and resultant soil characteristics having been influenced and altered by the present land use.

The impacts of the planned opencast and underground mining and the associated processing (crushing, screening and possible washing of the coal) on the soils and land capability and the tabling of appropriate management and mitigation strategies to minimise the impacts is important if the long term sustainability of this area is to be realised.

An initial site assessment was undertaken in early 2018, with additional exploration having been undertaken to better establish the resource boundaries and grades. This information has been used as the basis for the detailed assessment going forward.

The terms of the reference given to ESS, details the proposed mining plan which includes the opencast mining of a shallow seam within 25m of surface using the roll over method of mining (Truck and Shovel), the underground mining using bord and pillar methods and the development of a washing plant and waste disposal facility.

The long-term plan for the mining venture is to maximise its life thereby ensuring optimal coal reserve utilisation.

With the background information available, it is incumbent on the developer to obtain a full understanding of the impacts that this overall project could have on the environment. It was imperative that a full understanding of the baseline conditions and environmental aspects of the site that is to be disturbed and affected was obtained and recorded prior to the implementation of any mining or related activities taking place.

Apart from the more obvious environmental studies (Fauna and Flora, Surface Water etc.) that need to be undertaken prior to the implementation of any new development, it has become increasingly apparent that the soils need to be investigated in detail if a comprehensive base line of information is to be available for future reference.

In compliance with the NEMA and MPDRA, a comprehensive pedological investigation at various scales (depending on the degree of disturbance to be implemented), coupled with an interpretation, and understanding of the land capability for the area to be disturbed has been undertaken.

The pedological assessment revealed a strong correlation between the underlying lithologies and weathering of the in-situ materials, and the accumulation of depositional materials within the lower lying areas as colluvial deposits, the result of movement of materials downslope. The result of these geomorphological interactions has resulted in a complex of soil forms and families, with a general trend from moderately shallow to deep sandy loams and silty clay loams associated with the Ecca sediments and a small area of structured and more clay rich materials derived from the intrusive volcanics that have intruded the sedimentary sequence.

The depth of soil associated with the hydromorphic soils noted and mapped outside of the pan structures and their associated transition zone returned well drained soils on a deeply weathered saprolitic sub base.

There are significantly large and highly sensitive areas of wet based and wetland soils associated with the seep zones and hydromorphic environments upslope and around the numerous pan structures. However, many of the wet based soils are greater than 500mm to the diagnostic features needed for wetland classification, or are underlain by a hard plinthic horizon that classifies as a relic landform and shows little to no redox morphology. These sites are classified for the most part as Glencoe or Dresden form soils, and are not considered wetland soils.

The accumulation of colluvial materials in the transition zone are reflected in the sandy clays and clay loams that vary in depth, water holding capabilities and drainage characteristics, with the development of inhibiting iron rich layers, shallow outcrop in the weathering profile, and some deep soft plinthic horizons.

The seep zones are the direct result of the well-developed and extensive sandstone layer within the sedimentary lithologies that characterise the Ecca Formation in this area, a feature that results in soil water being held within the soil profile and the development of an iron rich horizon in a perched position within the topography. The lack of low chroma colours within the sandy loam horizons is indicative of high evaporation and low levels of leaching.

In contrast to the sandy loams and silty clay loams that characterise the majority of the area, an area of more structured (moderate blocky to pedocutanic) red and orange red sandy clay and clay loams are mapped in association with a dolerite intrusive. The majority of these soil forms are mapped off the coal reserves in the south and south west of the site.

Successful rehabilitation of the sensitive and more structured soils will require significant management input if a sustainable vegetative cover is to be re-established and the project is to obtain a standalone status at closure.

Significant economic gain can be achieved by getting the stripping and storage of utilisable materials correct as part of the overall mine planning, with successful rehabilitation and ease of closure being achieved more readily if the materials are available and a conceptual plan is in place.

The outcomes for the soil and hydropedological studies for the mining project are summarised as follows:

The major soil types encountered comprise moderately deep to deep fine grained sandy loams and sandy clay loams, dominated by Clovelly, Hutton and deep Glencoe and Avalon Forms for the most part, with some shallower soils associated with the ridge slopes and elevated hills. These soils are contrasted by significantly large but well defined wetlands and pan structures.

The land capabilities range from moderately large areas with good arable and agricultural potential, to moderate to poor and very poor quality grazing lands that are generally associated with shallow wet based and wetland environments, or shallow rocky soils, that returned low economic potential and land capability ratings of wilderness/conservation land capability

The strong correlation between soil depth, soil structure and the capability of the land is evident across the study area, with the shallow and sensitive soils being confined to low intensity grazing and wilderness/conservation activities, and the deeper and less sensitive soils being utilized for better quality (higher density) grazing and cultivation of annual crops.

Physical Characteristics

- Topsoil clay percentages range from as low as 10% on the sandy and silty loams, to more than 18% depending on the host/parent geology from which they are derived, and their position in the topography (Crest Slopes versus colluvial and/or alluvial bottom slope deposits);
- Subsoil clays that range from 15% to greater than 35%,
- Moderate to high in-situ permeability rates (0.90m/day to 2.10m/day) on the sandy clay loams and structured clay rich (plinthic) form soils respectively,
- Moderate to good intake (infiltration) rates (8mm/m to 12mm/m, depending on the type of clay present,
- Moderate to good (60 to 120mm/m) water holding capacities, and
- Moderate to poor agricultural potential (nutrient status).

The physical characteristics are highly influenced by the parent materials from which the soils are derived, and to a lesser extent by their position in the topography.

The structure of the soils varies from single grained or apedel for the most part, with minor areas of weak crumby to blocky structure on the clay loams and gleycutanic materials respectively.

Chemical Characteristics

The chemistry of the soils is typical of the sedimentary lithologies that make up the major part of the study area, with some distinctive differences associated with the relatively much younger intrusive/volcanic lithologies that occur within and cross cutting the bedded/layered sedimentary lithologies.

The soils are characteristically:

- Variable in pH with more alkali pH values for the sedimentary derived soils, of between 5,25 and 7.5, and slightly more acidic to neutral pH on the intrusive derived soils of between 6.5 and 7.5;
- A generally good supply of calcium and magnesium in a ratio of 3:1;
- Under subscribed with potassium and phosphorous and in places zinc, and
- Low to very low organic carbon matter content (0.045 – 0.45 C%)

Overall, and as a generalised statement, these soils require significant amounts of nutrient input if they are to be used for commercial farming ventures on a full rotation system. Grazing of livestock on the natural pastures requires good management and larger areas of land to sustainably accommodate grazing.

The proposed activities include open cast roll over truck and shovel mining and crushing and screening of the raw product. There is potential for the washing of the coal.

The land capability of the open cast mining areas and the surface infrastructure associated with these activities will be altered from moderate to poor potential arable land and moderate to low intensity grazing to that of “mining land and wilderness/conservation” status for the life of the mining operation.

The land use for all areas that are proposed to be affected by surface activities will be temporarily changed from commercial cropping and livestock grazing to mining land use.

1. INTRODUCTION AND TERMS OF REFERENCE

Ilima Coal Company commissioned ABS Africa (Pty) Ltd to undertake the environmental authorisation application in association with the mining right application for the Kranspan deposit. ABS in tern commissioned Earth Science Solutions (Pty) Ltd. to undertake the specialist Soils (Pedological) and Land Capability baseline studies, Impact Assessment and Mitigation Management Planning for the areas that are to be disturbed by the planned colliery.

The initial site evaluation was undertaken during April 2018, the Scoping Study of the area of concern having been compiled by ESS (Pty) Ltd as part of the exploration phase of the project. Subsequent investigations and studies around the mine planning have culminated in the detailed specialist investigations being commissioned as part of the formal application for a mining right.

The project involved the undertaking of a comprehensive reconnaissance pedological survey and land capability study as part of the greater environmental assessment, the studies being undertaken so as to satisfying the requirements of the National Environmental Management Act (NEMA) as well as the Mineral and Petroleum Resource Development Act (MRPDA). To this end, a number of soil parameters were mapped, recorded and interpreted.

A total area of approximately 850ha has been investigated in the course of the soils and land capability studies undertaken.

This document deals with the Soils and Land Capability assessments for the overall area that is planned for opencast and/or underground mining and the development of the required surface infrastructure inclusive of the haulage ways, access roads, soil and soft overburden stockpiles, RoM Stockpiles and beneficiation of the resource.

To this end, a number of soil parameters were mapped and classified using the standard *Taxonomic Soil Classification System, a system designed for South Africa (Mac Vicar et al, 2nd edition* 1991**)** and the Chamber of Mines Land Classification System of rating.

The objectives of the study were to:

- Provide a permanent record of the present soil resources in the areas that are potentially going to be affected by the proposed developments;
- Assess the nature of the sites in relation to the overall environment and its present and proposed utilisation, to determine the capability of the land in terms of agricultural utilization, and
- To provide a base plan from which long-term ecological and environmental decisions can be made based on the impacts of construction and operation, and from which meaningful and site specific management and mitigation/rehabilitation plans can be formulated.

Historically the area has been utilised for intensive commercial cultivation of annual crops and grazing of livestock with a significant amount of coal mining in close proximity (less than five (5km) kilometres. The site is considered a "brownfields" environment with significant impacts associated with the intensive farming activities.

The land proposed for the mining operation and the beneficiation facilities is existing farmland that has been zoned as such and is already extensively disturbed by these activities.

Mining and the development of support infrastructure is a feature of the landscape in the vicinity, and mining as an activity in the Middelburg area has been accepted as a way of life for generations and has successfully coexisted with farming to date.

However, with the ever-increasing competition for land, it has become imperative that the full scientific facts for any particular site are known, and the effects on the land by the existing user and those that are being proposed by the proponent must be evaluated, prior to the new activity being implemented (NEMA).

This document describes the in-field methods used to classify and describe the *in-situ* soils, using a well-documented rating system to classify and rank the land capability based on the soils assessment, regional geomorphology (climate information, geology, ground roughness and terrain/topographic variables), along with all/any records of the pre mining/construction land use. These facts will form part of the cumulative effects/impacts and baseline to the proposed planning.

This information will be invaluable in determining the END LAND USE and rehabilitation plans for the closure phase of the developments.

The findings of this investigation are based on a pedological survey involving a number of specialists in differing fields of expertise and the interpretation of the resulting data.

This study was aimed at describing the physical and chemical properties of the soils that are to be disturbed, to identify the soil forms, characterise the pedological status of the areas that are to be utilized for development, and to determine the effect that the proposed mining will have on the land capability and sustainability of the area.

This includes an evaluation of the hydropedology, recording of the change in the effective rooting depths, nutrient status, the potential erodibility, and the soil utilisation potential. In addition, the investigation required that the impacts be assessed, and mitigation methods recommended where possible, and the status of the proposed mining area understood.

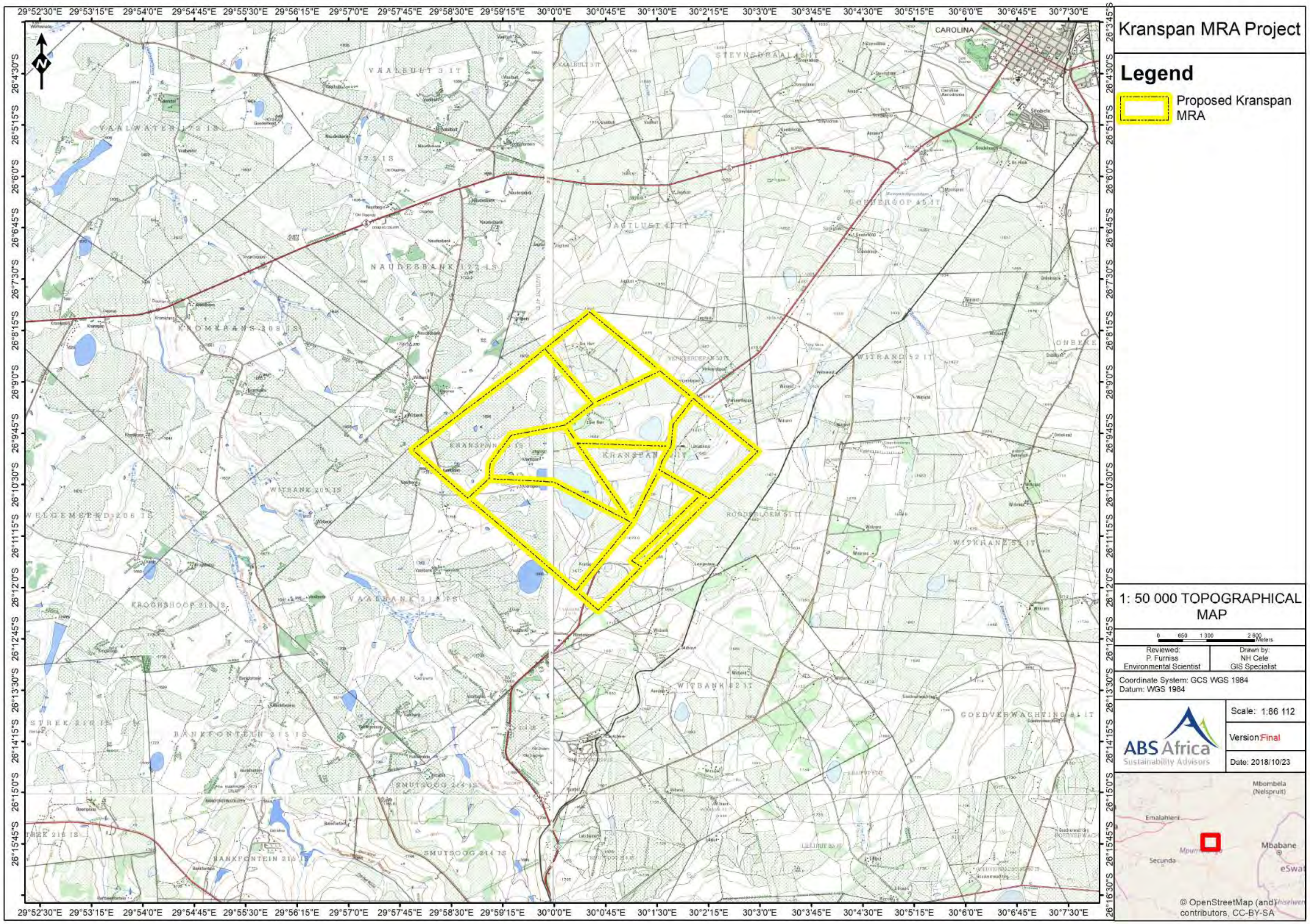


Figure 1a **General Locality Plan**

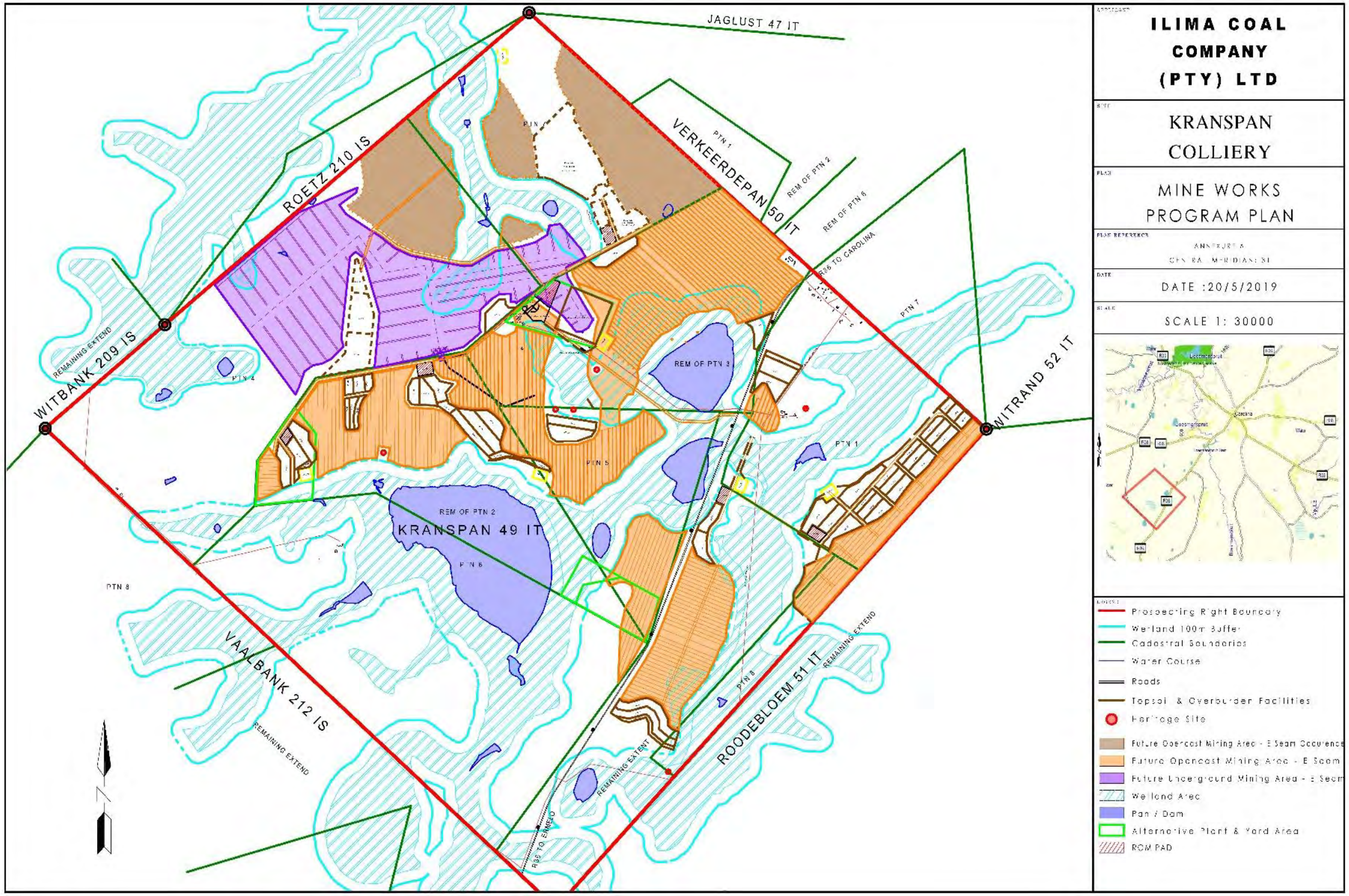


Figure 1b – Mine Plan

2. DESCRIPTION OF THE PRE-MINING/CONSTRUCTION ENVIRONMENT

2.1 Soils

2.1.1 Data Collection

Review of Published Reports and Maps

The area proposed for development is in close proximity to a number of existing mining ventures, and forms part of the greater coal mining regions of the eastern highveld coal fields of South Africa. Extensive geological and geotechnical information is available for this area and a substantial amount of existing socio economic and environmental work has been undertaken by a number of independent consultants in the authorisation of mining projects.

The geology and geochemistry of the sedimentary formations that make up the major portion of the materials that are to be affected by mining or infrastructure development are well known and understood and sufficient good scientific information is available that can be used to better understand the issues and impacts of coal mining on the soil and land capability resource as well as being of use in the development of sound management and mitigation structures that will minimise the effects of the activities to a manageable and sustainable level.

With the economic viability of the resource understood, and with a realistic mine plan on the table, it remains only for the socio economic and environmental aspects of the site to be assessed and the impacts understood.

The general characteristics of the soils of this area are well understood. However, the subtle changes and localised characteristics associated with the specific site are important to the baseline of information that is required if sustainability of rehabilitation and closure are to be achieved, and if a realistic management plan for the soils and land capability are to be implemented during the operational and closure phase.

These detailed specialist investigations will add to the baseline information required as part of the planning, operational and rehabilitation phases that are proposed.

In achieving the ToR, ESS have used any exploration data, drilling logs where available, and the local knowledge from the land owners to better understand the basic characteristics of the soils and the lay of the land, to obtain information about the parent geology that has contributed to the pedogenisis and hydropedology of the site and to extrapolate chemical and physical attributes to the soil classification.

The Land Type Mapping of S.A. (1:250000 scale), the Geological Map of S.A. and local knowledge of the soils and land capability where made available to the study. However, no existing detailed mapping was available for either the soils or the general geomorphology of the site.

The Department of Agriculture has voiced its concerns regarding the impact of mining activities on the agricultural potential of the soils in South Africa in general, and they require that a detailed assessment is carried out prior to any change in land use being considered.

The Land Type Maps are the only information that could be supplied by this department. However, additional inputs from the land owners and farmers in the region were very helpful in better understanding the physical and chemical components of the soils and the true utilization potential of the soils. As stated previously, the farmers are concerned that the carrying capacity of the soils (both livestock farming as well as commercial grain production) are over supplied and are verging on the non-profitable in today's terms.

The maps available during scoping were of a small scale, and have been compiled using basic aerial photographic interpretation of the area with limited field interpretation. They are a good first approximation, and in combination with the geological maps (1:250,000) were useful as a baseline from which to work.

Of significance to the study is the underlying geology, with a moderately complex suite of rocks that make up the geological sequence. In its simplicity, the major portion of the area studied is underlain by the Ecca sediments that have been intruded by a complex of iron and magnesium rich dykes and sills of differing ages and orientation.

It is these complexes of lithologies combined with the topography that produce the complex of differing soil polygons noted across the study site.

Field Work

The soil classification/characterisation and mapping has delineated the broad soil patterns for the total mining right area. The survey was undertaken during January 2019.

In addition to the grid point observations, a representative selection of the soil Forms mapped was sampled to determine the chemistry and physical attributes of the soils. The soil mapping was undertaken on a 1:10,000 scale (Refer to Figure 2.1.1 – Soil Polygon Mapping).

A total area of approximately 880ha was covered in the course of this study.

The majority of observations used to classify the soils were made using a hand operated Bucket Auger and Dutch (clay) augers with any and all natural exposures (road cuttings, drill sumps etc.) being used to obtain a better understanding of the in-situ characteristics of the soils.

In all cases, the observation points were excavated to a depth of 1,500mm or until refusal was obtained. Immediately after completing the classification of the profiles, the excavations (Pits and Auger Holes) were backfilled for safety reasons.

Standard mapping procedures and field equipment were used throughout the survey. Initially, geological map of scale 1:250,000 and top cadastral maps at a scale of 1:50,000 were used to provide an overview of the area, while Ortho photographs at a scale of 1:10,000 being used as the base map for the soil survey.

The pedological study was aimed at investigating/logging and classifying the soil profiles. Terrain information, topography and any other infield data of significance was also recorded, with the objective of identifying and classifying the area in terms of:

- The soil types to be disturbed/rehabilitated;
- The soil physical and chemical properties;
- The soil depth;
- The erodibility of the soils;
- Pre-construction soil utilisation potential.

Soil Profile Identification and Description Procedure

The identification and classification of soil profiles were carried out using the *Taxonomic Soil Classification System (Mac Vicar et al, 2nd edition 1991*)

The Taxonomic Soil Classification System is in essence a very simple system that employs two main categories or levels of classes, an upper level or general level containing Soil Forms, and a lower, more specific level containing Soil Families. Each of the soil Forms in the classification is a class at the upper level, defined by a unique vertical sequence of diagnostic horizons and materials. All Forms are subdivided into two or more families, which have in common the properties of the Form, but are differentiated within the Form on the basis of their defined properties.

In this way, standardised soil identification and communication is allowed by use of the names and numbers given to both Form and Family.

The procedure adopted in field when classifying the soil profiles is as follows:

i. Demarcate master horizons (Refer to Figure 5.3.1)
ii. Identify applicable diagnostic horizons by visually noting the physical properties such as:
   - Depth (below surface)
   - Texture (Grain size, roundness etc.)
   - Structure (Controlling clay types)
   - Mottling (Alterations due to continued exposure to wetness)
   - Visible pores (Spacing and packing of peds)
   - Concretions (cohesion of minerals and/or peds)
   - Compaction (from surface)

iii. Determine from i) and ii) the appropriate Soil Form
iv. Establishing provisionally the most likely Soil Family

Sampling of representative areas of each of the Soil Forms were carried out and submitted for analysis.

Factors that were considered in the laboratory included:

- Determination of the pH
- Exchangeable bases
- C.E.C. (cation exchange capacity)
- Texture (% clay)
- Nutrient status and
- Any potential pollutants

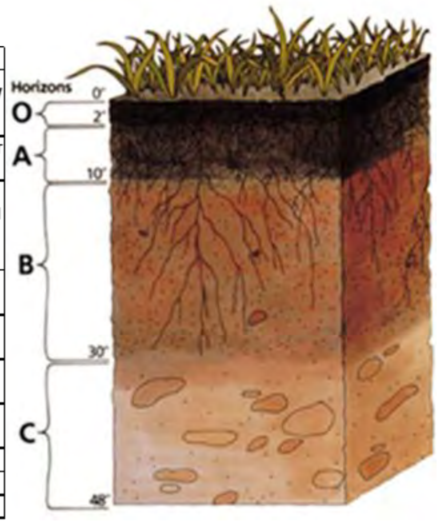
The methods employed in the determination of the above variables are:

- The Spectro Atomic Analyser for the determination of the basic elements
- The titration method for the determination of Organic Carbon contents, and
- The use of a density meter for the determination of the clay contents.

Analytical results are given for the extractable quantities available from the soil, the results having been obtained from the actual soil sample.

Table 2.1- Typical Arrangement of Master Horizons in Soil Profile

		Arrangement of master horizons					Comments on Layers
SOLUM	(Zone in which the soil forming processes are maximally expressed)	O - Organic	C - Regic Sands (C), Stratified Alluvium (C), Man - Made Soil Deposits (C).	A	Humic,Vertic, Melanic, Orthic	G	Loose leaves and organic debris, largely undecomposed
							Organic debris, partially decomposed or matted
				B	Red Apedel, Yellow-brown Apedel, Soft Plinthic, Hard Plinthic, Prismacutanic, Pedocutanic, Lithocutanic, Neocutanic, Neocarbonate, Podzol, Podzol with placic pan		Dark coloured due to admixture of humified organic matter with the mineral fraction
							Light coloured mineral horizon
							Transitional to B but more like A than B
			C		Dorbank, Soft Carbonate horizon, Hard Carbonate Horizon, Saprolite, Unconsolidated materials without signs of wetness, Unconsolidated materials with signs of wetness, Unspecified materials with signs of wetness		Transitional to A but more like B than A
							Maximum expression of B-horizon character
							Transitional to C
							Unconsolidated material
			R - Hard Rock				Hard rock



2.1.2 Description

Soil Forms Identified

The soils in the region are some of the better and more productive soils albeit that a significant quantity of additives are required to achieve an economic return on commercial crop production, the variation in soil depth and texture the main variables effecting the return on investment.

The major soils encountered/mapped include:

The Hutton (Hu), Clovelly (Cv), Griffin (Gf), Pinedene (Pn), Glencoe (Gc), Avalon (Av), Westleigh (We), Kroonstad (Kd), Katspruit (Ka), Glenrosa (Gs), Dresden (Dr) and Mispah (Ms) Form soils

The dominant soils mapped are described in terms of their pedological classification (Taxonomic System), the capability of the land being rated in terms of the overall geomorphology of the site (soils, climate, geology and topography).

<u>Hutton (Hu)/Clovelly (Cv) and Glencoe (Gc)</u>

The Hutton, Clovelly and deeper Glencoe Form soils comprise predominantly sandy loams and sandy clay loams, varying from fine to very fine, single grained to apedel structure, with pale red brown to yellow red colours in the top soils, and dark orange reds and dark red colours in the sub soil horizons. Clay contents vary from less than 10% in the top soils (where the soils are derived from the sandstone parent materials), to between 12% and 30% for the topsoil associated with the more clay rich shale's and mudstones. Subsoil clay percentages range from 28% to 42% depending on the parent material from which they ate derived, and the position of the soils mapped in the topography.

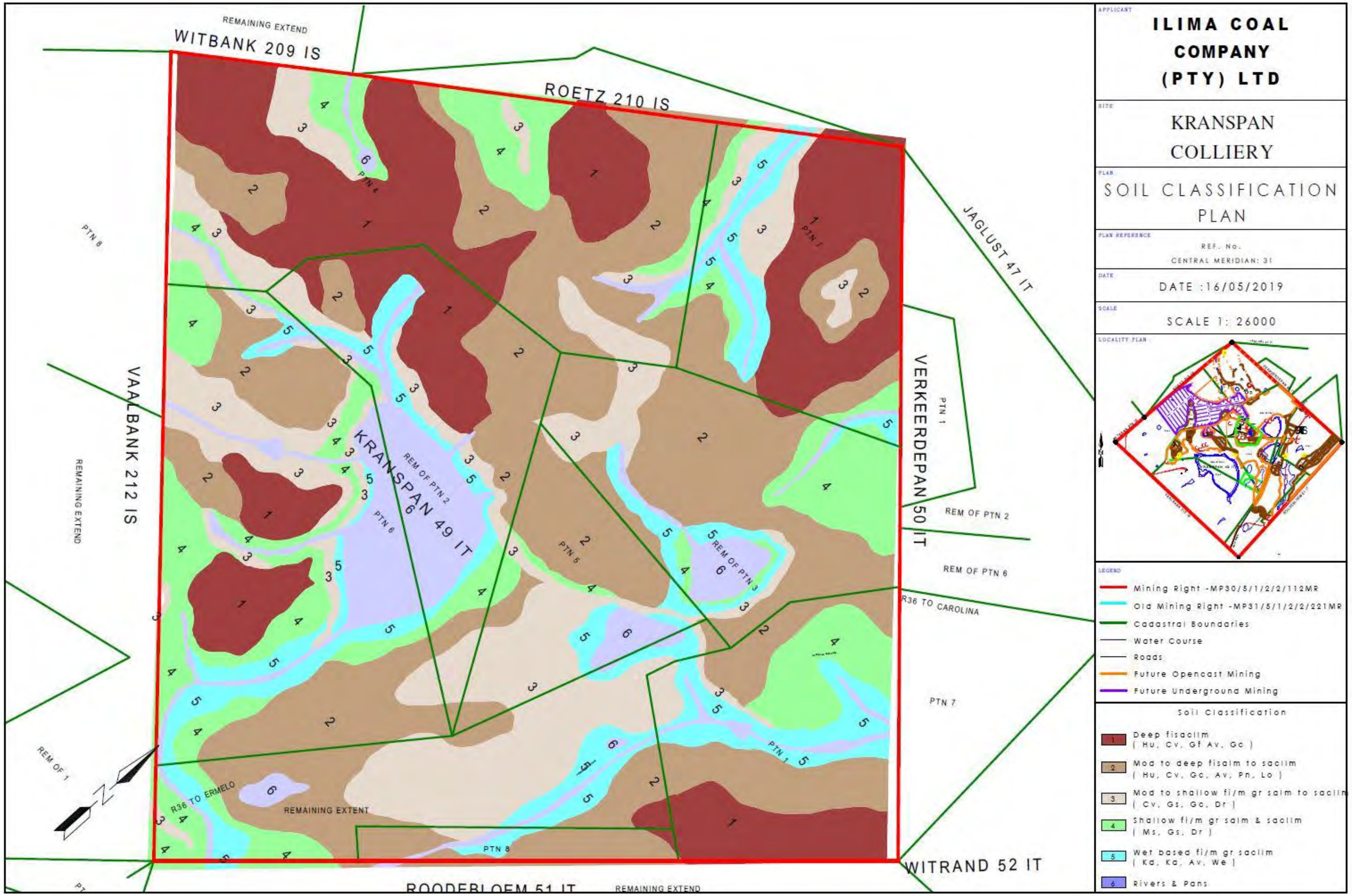


Figure 2.1.1b Dominant Soils - Distribution Map

In almost all cases mapped, the soils are classified as having a dystrophic leaching status and are generally luvic in character. For the most part, these soils occupy the upper and upper mid slopes and are generally found upslope of the hydromorphic Form soils.

Effective rooting depths vary from 400mm to 1,200mm, with some deeper rooting depths associated with the weathered sandstone lithologies on the ridge and midslope positions.

Pinedene (Pn), Bloemdal (Bd), Avalon (Av) and Bainsvlei (Bv)

The Pinedene, Bloemdal, Avalon and Bainsvlei Forms mapped fall into the hydromorphic category. These soils are generally found associated with, and down slope of the Clovelly and Hutton Form soils. Chemically, their characteristics are similar, comprising a moderate to low nutrient status, with deficiencies of potassium and sodium, low organic carbon values, and a range of pH values.

A small area of these soils mapped will be impacted by the mining activities as well as by the Polcon Dam, and potentially the office facilities.

By definition, these soils vary in the degrees of wetness at the base of their profile, i.e. the soils are influenced by a rising and falling water table, hence the mottling within the lower portion of the profile.

Depths of utilisable agricultural soil (to top of mottled horizon) vary from 600mm to 1,200mm, and in places as deep as 1,500mm.

Westleigh (We), Kroonstad (Kd), Longlands (Lo) and Katspruit (Ka)

The Westleigh, Kroonstad and Katspruit Forms mapped, have been grouped based on their similarities. They are all shallow hydromorphic, varying in the degree of wetness, and the strength of gleying with depth. In all cases, they are at least one degree wetter, and are associated with wetlands and/or moist grasslands areas.

Chemically, these soil forms are very similar, returning moderate to poor levels of most nutrients (Al, P and N materialisation capacity). Consequently the salts (K and Zn) return as higher levels, resulting in a greater potential for salinity/sodicity problems (moderate to severe).

Physically these soils returned higher clay contents (>38%) with resultant high water holding capacities and they are generally less well drained. The intake rates range from medium to poor with drainage and erosion hazards deemed to be the major problems to be managed on these soils.

Structurally the Katspruit and Kroonstad Forms are difficult to work, and they are generally shallower (400-800mm) with a “wet foot”, while the Westleigh Form (300mm-1200mm) are found associated with wetlands.

Better than average management of both erosion as well as compaction will be needed to retain the usability of these soils during the rehabilitation process. There will be no disturbance of these soil forms by the proposed project.

Glenrosa (Gs) Mispah (Ms) and Dresden (Dr)

The Glenrosa soil form returned effective rooting depths of between 100 and 400mm. The major constraint envisaged with these soils will be tillage, sub surface hindrance and erosion. The restrictive layer associated with these soils is a hard lithocutanic layer in the form of weathered parent material, or rock. The effective soil depth is restricted, resulting in reduced soils volumes, and as a result, depletion in the water holding capacity as well as nutrient availability.

Physical characteristics of these soils include moderate to low clay percentages (10 to 18%), moderate to good internal drainage and low water holding capabilities. These are of the poorer land capability units mapped.

2.1.3 Soil Chemical and Physical Characteristics

A representative suite of samples (composite) from the differing soil forms/types were taken and sent for analyses for both chemical as well as physical constituents (Refer to Table 2.1.3). A select number of samples were submitted, each sample containing a number of sub samples from a particular soil polygon/type which is representative of the area in question, thus forming a composite sample, which in turn is representative of the soil polygon rather than just the point sampled.

2.1.3.1 Soil Chemical Characteristics

Sampling of the soils for nutrient status was confined where possible to areas of uncultivated land. However, some of the grazing lands might well have been fertilized in the past, and the results, in these cases might not be truly representative of the soils in their natural state.

The soils derived from the sediments (Ecca Group) are characterised for the most part as sandy loam to sandy clay loam texture, while those associated with the more basic intrusive dykes and silts (limited in extent) returned more clay rich soils that are higher in iron and magnesium.

The analytical results returned light to moderate textured soils with a pH (KCl) of between 5.25 and 7.0, base status ranging from 3.9 to 19.6me%, and nutrient levels reflecting acceptable levels of Calcium and Magnesium, but deficiencies in the reserves of potassium, zinc and potash.
In general, the Ca:Mg ratios are of a range compatible with average growth regimes for most agricultural dryland crops on the deep well drained soils.

The more structured soils returned values indicative of the higher reserves of calcium, magnesium, and iron and in most cases observed sodium. They are inherently low in potassium reserves, and returned lower than acceptable levels of zinc and potash for economically acceptable agricultural growth.

The nutrient status (as returned from the limited sampling undertaken) indicates a need for fertiliser applications of “K”, “P” and “Zn” (Refer to Table 2.4.3 – Analytical Results).

It should be noted that, additions of K, P and Zn in the form of commercial fertilisers are potential pollutants to the riverine, wetland and groundwater environment if added in excess. This should be avoided, and additions of nutrients, if required must be applied in small quantities at regular intervals.

Table 2.1.3 Soil - Analytical Results

Sample No.	KP1	KP2	KP3	KP4	KP5	KP6	KP7	KP8	KP9	KP10
Soil Form	Kd	Hu	We	Pn	Cv	Hu	Cv/Gf	Av	Dr	Gc
Constituents mg/kg										
pH	5.8	5.8	6.2	6.2	6	6.6	5.2	7.1	6.3	5.5
"S" Value	31	5.2	5.8	14.8	11.2	11	3.8	12.1	5.2	4.1
Ca Ratio	62	58	65	65	59	65	66	72	70	66
Mg Ratio	34	12	10	32	16	22	22	30	28	22
K Ratio	7	12	12	1	18	4	5	7	0.6	5
Na Ratio	1.1	0.2	0.2	1.6	0.2	0.5	0.3	0.8	1.4	0.1
P	17	80	82	6	111	10	11	14	5	10
Zn	1.4	1.6	1.6	1.1	7.2	1.5	1.4	1.6	1	1.1
Sand	18	42	44	46	45	52	45	45	58	50
Silt	22	34	35	46	39	30	43	35	34	38
Clay	60	24	21	8	16	18	12	20	8	12

Sample No.	KP11	KP12	KP13	KP14	KP15	KP16	KP17	KP18	KP19	Kp20
Soil Form	Gc	Lo	Av	Pn	HU/Gf	Gc	Av	Kd	Rg	Pn
Constituents mg/kg										
pH	6.5	6.9	5.8	6.2	6.4	5.6	6.2	6.2	5.2	6.2
"S" Value	5.6	22.4	11.6	10.2	22.8	22.1	8.9	22	33	18.2
Ca Ratio	72	54	58	72	68	66	70	49	62	65
Mg Ratio	33	33	20	26	34	30	24	28	34	33
K Ratio	0.7	10	22	4	4	1	4	8	9	2
Na Ratio	1.8	0.4	0.4	0.3	0.4	0.2	0.3	0.3	0.8	1.5
P	5	18	111	22	12	8	22	15	20	6
Zn	0.9	1.7	7	2	2	1	2	1.4	1.1	1.1
Sand	48	21	44	36	42	34	42	21	16	62
Silt	40	24	34	46	26	38	36	27	26	30
Clay	12	55	22	18	32	28	22	52	58	8

2.1.3.2 Soil acidity/alkalinity

In general, it is accepted that the pH of a soil has a direct influence on plant growth. This may occur in a number of different ways, which include:

- The direct effect of the hydrogen ion concentration on nutrient uptake;
- Indirectly through the effect on major trace nutrient availability; and by
- Mobilising toxic ions such as aluminium and manganese, which restrict plant growth.

A pH range of between 6 and 7 most readily promotes the availability of plant nutrients to the plant. However, pH values below 3 or above 9, will seriously affect, and reduce the nutrient uptake by a plant.

The dominant soils mapped in this area are neutral to slightly acid (5.25 to 7.60), generally within the accepted range for good nutrient mobility.

However, some of the soils derived from intrusive material will tend to be more alkaline than indicated by these results due to the potential buffering capacity of the moderately high levels of calcium carbonate. This may affect the pH of the soils to some extent. It is unlikely however, that they will be dramatically impaired.

2.1.3.3 Soil Salinity/Sodicity

In addition, to the acidity/alkalinity of a soil, the salinity and/or sodicity are of importance in a soils potential to sustain growth.

Highly saline soils will result in the reduction of plant growth caused by the diversion of plant energy from normal physiological processes, to those involved in the acquisition of water under highly stressed conditions. Salinity levels of <60mS/m will have no effect on plant growth. From 60 – 120mS/m salt sensitive plants are affected, and above 120mS/m growth of all plants is severely affected.

In addition, soil salinity may directly influence the effects of particular ions on soil properties. The sodium adsorption ratio (SAR) is an indication of the effect of sodium on the soils. At high levels of exchangeable sodium certain clay minerals, when saturated with sodium, swell. The effects of shrink and swell enhances the erosion potential (chemical erosion) on these soils.

With the swelling and dispersion of a sodic soil, pore spaces become blocked and infiltration rates and permeability are greatly reduced. The critical SAR for poorly drained (grey coloured) soils is 6, for slowly draining (gleycutanic soils) clays it is 10 and for well drained, (red and yellow) soils and recent sands, 15.

Generally, the soils mapped are non-saline in character, but could become susceptible to an increase in salinity if their water regime is not well managed, particularly on the more clay rich materials.

2.1.3.4 Soil Fertility

The soils mapped in this area returned at best only moderate concentrations of the nutrients required for good plant growth, with Zn, P and K generally lower than the optimum required, and the soil depths are inhibiting due to the extreme soil structure.

However, areas of soil with an acceptable level of plant nutrition where mapped on soils that are not generally considered to be of an arable rating. These results can possibly be ascribed to either a natural anomaly in nutrient levels within the soil profile sampled, or to residual levels of fertiliser within the soil due to farming activities in the area.

Calcium levels are considered high. This would normally have the capacity to restrict magnesium uptake. However, as the ratio between calcium and magnesium is approximately 3:1 a magnesium deficiency in the soils is unlikely.

There are no indications of any toxic elements that are likely to limit natural plant growth in the soils mapped within the study area.

Fairly standard fertiliser treatments will be needed for optimum agricultural production of crops on areas that have previously been planted, with exceptionally good water management being of paramount importance on both dryland as well as irrigated lands.

2.1.3.5 Nutrient Storage and Cation Exchange Capacity (CEC)

The potential for a soil to retain and supply nutrients can be assessed by measuring the "cation exchange capacity" (CEC) of the soils.

The low organic carbon content is balanced to some extent by the clay content which naturally provides exchange sites and which serve as nutrient stores. These conditions will result in a moderate retention and supply of nutrients for plant growth.

Low CEC values are an indication of soils lacking organic matter and clay minerals. Typically a soil rich in humus will have a CEC of 300 me/100g (>30 me/%), while a soil low in organic matter and clay may have a CEC of 1-5 me/100g (<5 me/%).

Generally, the CEC values for the soils mapped in the area are moderate to low, the clay contents assisting the poor organic matter content.

2.1.3.6 Soil organic matter

The organic matter content of the soils is low to moderate, with values ranging from 0.2-0.8%. "Normal" soils have an organic matter content of 1-2%. Within the range of 0-4%, soil erodibility tends to decrease as organic matter increases.

2.1.3.7 Soil Physical Characteristics

Overall, the deeper and better drained soils (Hutton, Clovelly and Avalon), are light textured, sandy loams to sandy clay loams, implying that they can, during a mining process, be worked at a wide range of moisture contents without structural damage, and are moderately easily rehabilitated. Compaction of the upper "A" horizon is likely to occur if machinery is used during the summer months over unprotected ground. Compaction of these soils and their erodibility are factors to be considered during rehabilitation.

A large portion of the proposed mining area and its related infrastructure is planned to occur over these soil types, and given their sandy clay loam nature, they will need to be well managed during the stockpiling stage.

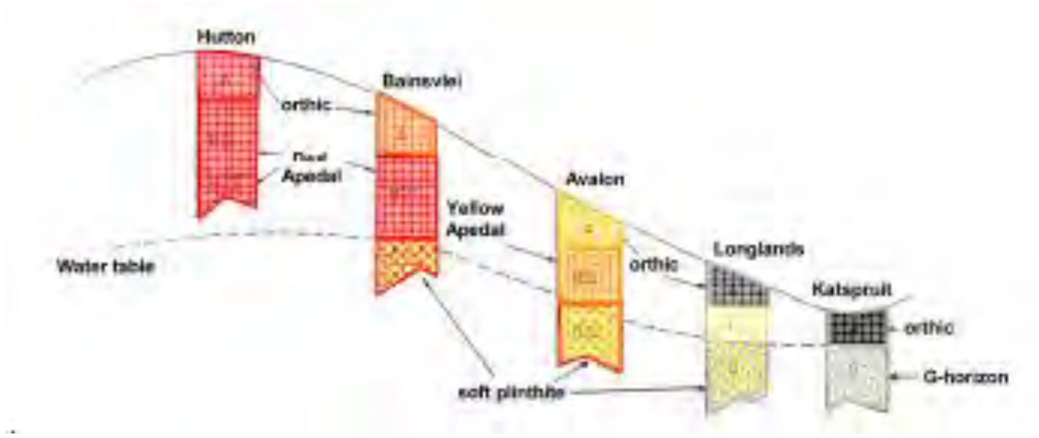
The wet and more structured soils associated with the colluvial flood plains will need to be handled separately from the dry well drained soils of the mid and upper slopes. These soils are prone to forming large, hard, structured soil clods that are difficult to work, and are not conducive to easy rehabilitation.

A proportion of the overall area to be affected by the planned mining operations is underlain by soils with a more sensitive nature to trafficability, compaction and erosion.

The soil forming mechanisms at work in this area are dominated by the usual wind, water and temperature, resulting in the formation of moderately deep in-situ soils on the mid and upper slopes. However the lower mid and lower slope positions are dominated by erosion platforms and recent accumulations of transported materials from upslope which overly moderately deep saprolitic layers and/or hard rock geology.

The end result is a complex of differing soil forms within a relatively small spatial area. Figure 2.1.3.7 is a diagrammatic cross section of the typical soil catena for this area.

Figure 2.1.3.7 – Typical Catena



2.1.3.8 Soil Erodibility

Erodibility is defined as the vulnerability or susceptibility of a soil to erosion. It is a function of both the physical characteristics of that soil and the treatment of the soil.

The erosion potential of a soil is expressed by an erodibility factor (K), which is determined from soil texture, permeability, organic matter content and soil structure. The soil Erodibility Nomography of Wischmeier et al (1971) was used to calculate the K value.

Erosion problems may be experienced when the index of erosion is greater than 0.2.

Erodibility ratings are:

Resistant	K factor = <0.15
Moderate:	K factor = 0.15 – 0.35
Erodible:	K factor = 0.35 – 0.45
Highly erodible:	K factor = >0.45

The erosion indices for the dominant soil forms on the study site are classified as having a moderate to high erodibility rating, albeit that this is tempered by the relative flatness of the site. This is largely ascribed to the moderate to low clay, and low organic carbon content of the A horizons of many of the soils.

Extremely good management of these soils will be needed throughout the mining operation, as well as during rehabilitation.

2.1.4 Dry Land Production Potential

The dryland production potential of the shallow soils and the more structured Soil Forms, are poor.

The deeper, apedel form soils are easier to cultivate and have a better propensity to both drainage as well as the holding of moisture within the soil that is available to the plant. However their productivity is hampered by the generally poor nutrient pool.

2.1.6 Soil Utilization Potential

In general, the soils that are planned to be disturbed and that will require rehabilitation are moderately deep (500mm – 1,200mm) to deep, well-drained and although susceptible to erosion, are tempered by the relatively flat to undulating topography. Compaction will need to be managed.

The wet and structured soils will be more difficult to work, both from a traffic-ability, workability, and rehabilitation point of view, and, although relatively small areas of these soils are planned to be impacted, they will require good management.

Compaction must be considered carefully as the working of the gleyed soils when wet will be detrimental and compaction will occur. The structure of the soil affects their workability, and provision will need to be made for the timing of the rehabilitation works to be undertaken if these soils are to be worked sustainably.

The utilisation of the moist grasslands and wetlands as grazing lands and in some cases for the cultivation of crops is a common practice that has occurred in this area. This practise generally/often results in the degradation and in places destruction of the soil functionality.

The agricultural potential of these hydromorphic soils for commercial farming is at best low/poor.

Added impacts to these soils will require that they are managed separately from the dry soils, and replaced as close as possible to their original space.

These soils are considered to have a wilderness status and should be restricted to low intensity grazing of wildlife at best. The carrying capacity for the majority of these soils is relatively low (two to three animals per hectare and 3 tonnes/ha respectively), due predominantly to their inherent lack of nutrient status and need for inputs of fertilizer and organics.

Cultivation practices in the area require that substantial inputs of additives are considered for an economic return. Local reports indicate the need for substantial inputs of fertilizer and lime as part of the farming enterprise.

Approximately 75% of the surveyed area has been disturbed by commercial agriculture with more than 95% of the area proposed for mining or its associated activities having been farmed at one point in time or another to either commercial cropping and/or livestock grazing.

To date the site has been used primarily for maize and soya bean production and the grazing of livestock. The reported tonnes of maize from the area (including inputs) range from 3 tonnes to 6 tonnes of maize per hectare of land (general reports in the area), an average for cultivated and managed lands on the Highveld soils.

2.2 Hydropedology

2.2.1 Hydropedology (HP) Considerations

The assessment of the wetland status is important and necessary to the understanding of the potential type of reservoir for soil water storage available within a specific landscape. It is equally important if not more important to understand the dynamics of soil water movement and the source of the wetland moisture, as this will better inform the site sensitivities and impact assessment of any development that is being planned.

The science of hydropedology is the linking of soil morphology with hydrological processes (Article *in* Water Wheel - J.J. Van Tol, June 2017).

Soil physical properties, such as the hydraulic conductivity and porosity, have an important impact on the occurrence and rates of hydrological processes. In turn, hydrological processes play an important role on the formation of soil morphological properties such as colour, mottles, macropores and carbonate accumulations.

Mapping and the interpretation of these soil morphological properties can thus be used to conceptualise and characterise hydrological processes, including water flow paths, storage mechanisms and the connectivity between different flow paths. Most of these hydrological mechanisms and processes are very difficult to observe in the field because they are dynamic in nature with strong temporal and spatial variation. Nevertheless, soil morphological properties are not dynamic in nature and their spatial variation is not random – making soil properties the ideal vehicle for predicting and conceptualising hydrological processes.

One of the major contributions of hydropedology is the ability to conceptualise hydrological processes spatially i.e. not only one dimensional mechanisms, but a more holistic understanding of the hydrological functioning of landscapes (catchments or hillslopes).

Hydropedological information is used in process based landscape water resource management. This includes, for example:

- Configuration and parameterisation of distributed hydrological models;
- Effective wetland delineation, protection and rehabilitation;
- Understanding and controlling the fate of pollution in the subsurface;
- Determining the impact of land use change (e.g. open pit mining) on water resources and
- Characterising groundwater/surface-water interactions, including the important mechanism of low-flow generation.

In general, hydropedological information assists with effective water resource management, as required by the National Water Act through improved understanding and characterisation of hydrological processes. (Article *in* Water Wheel - May 2017).

The hydropedological behaviour of different soils can differ significantly.

- The red and poorly leached soils with high chroma colours associated with the top soil and sub soils are typically associated with freely drained soils. Vertical flow into, through and out of the profile are the dominant hydrological pathway.

These soils are termed ***recharge soils***, as they are likely to recharge groundwater, or lower lying positions in the regolith, via the bedrock.

- In the case of the soils with a restricted horizon at their base, the saprolite, bedrock or hard plinthic layer interferes with the vertical infiltration and lateral flow is likely to be dominant. These soils are termed ***interflow soils***. Lateral flow occurs due to differences in the conductivity of horizons. The lower chroma colours of the soil horizons is further support that lateral flow being dominant, the mottles (red, yellow and grey colours) in the 'sp' horizon the result of a fluctuating water table.
- Low chroma grey colours in the lower B and C horizon and the dark colours in the topsoil horizon are indications that this profile is saturated for long periods of time. The semi saturated to saturated nature of these soils, especially during peak rainy seasons, will result in overland flow (or surface runoff) downslope. These soils are termed ***responsive soils*** due to their rapid response to rain events.

The study or approach to assessing the complex discipline of hydropedology (an understanding that pedology is the description and classification of soil on the basis of morphology, which is the result of soil and landscape hydrology, both physical and chemical processes) (Lin 2012) and the assessment of a site in terms of its soil water association has been simplified and described very nicely by Van Der Waals J. H.

Four levels of investigation are considered depending on the detail required in the assessment being undertaken (J H van der Waal):

- A level 1 assessment entails the collection and generation of all applicable remote sensing, topographic and land type parameters and the production of a base plan. This will provide a broad overview of dominant hydropedological parameters of a site.
- A level 2 assessment makes use of the data generated during the Level 1 assessment and will include a reconnaissance soil and site survey to verify the information gathered during the Level 1 assessment.
- A level 3 assessment builds on the Level 1 and 2 assessments and entails a detailed soil survey with sampling and analysis of representative soils. The parameters to be analysed include soil physical, chemical and mineralogical parameters that assist in confirming the morphological parameters identified during the field survey.
- A level 4 assessment makes use of the data generated during the previous three levels and will include the installation of adequate monitoring equipment and measurement of soil and landscape hydrological parameters.

For most wetland delineation exercises a Level 2 or Level 3 assessment should be adequate.

2.2.2 Hydropedological findings

As part of the baseline assessment the area delineated for development was mapped to determine the topographic land forms and natural water ways, the extent of the possible wetlands and any artificial modifiers that are evident. These features were delineated using a combination of aerial survey and Google Earth Imagery.

The desktop study was followed by a more detailed site survey (part of the pedological assessment study) in which the soils and geomorphology of the area were mapped.

The soils were classified using the Taxonomic Soil Classification System developed for South Africa. In addition, a number of infiltration tests were carried out across the soil catena to determine the soil permeability and water flow characteristics in more detail. In addition, note was made of the land use and any historical impacts that might have been caused to the area. These observations were correlated and referenced to the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) findings already reported as part of the ecological and wetland delineation studies), taking cognisance of the vegetation indicators as reported in the baseline ecological assessment.

The overall geomorphology and pedology have been discussed briefly earlier in this document. The topography combined with the horizontally layered nature of the sedimentary geology that underlie the site result in a land form of alternating hard and less hard strata that has resulted in confined wetland zones that are controlled by the drainage lines. Relic land forms are a resultant feature that control the hydropedology of the site. The presence of Pan Structures in upper and crest slope positions in the land scape are testament to perched surface water (rainfall and surface inflow) being contained on top of the highly impermeable hard plinthite.
The soil catena typical of this area is represented by:

- Crest slopes comprising red and red brown fine to medium grained red to red brown apedal mesotrophic soils (moderate leaching status), with high chroma colours that are generally free draining for all but the sites where the soils are underlain by hard pan (relic) ferricrete horizons, where the soil infiltration is inhibited and forced to flow laterally;

  Vertical flow into, through and out of the profile are the dominant hydrological pathways (***recharge soils)***, and are likely recharging the local groundwater aquifers or bedrock;
- On the lower slopes the soils returned restricted horizons at their base, the saprolite, bedrock or hard plinthic layer restricting the vertical infiltration resulting in lateral flow or ***interflow soils***. Lateral flow occurs due to differences in the conductivity of horizons. The lower chroma colours of the soil horizons is further support that lateral flow is the dominant system, with mottles (red, yellow and grey colours) in the 'sp' horizon the result of a fluctuating water table.
- Low chroma grey colours in the lower B and C horizon and the dark colours in the topsoil horizon are indications that this profile is saturated for long periods of time. These soils were mapped along the lower slopes and drainage lines, the semi saturated to saturated nature of these soils resulting in overland flow (or surface runoff) downslope. These soils are termed ***responsive soils*** due to their rapid response to rain events.

The results of the geomorphological (soils, geology, climate, topography and ground roughness analysis) and hydropedological studies conclude that the topographic controls, horizontal bedding of the underlying lithologies (sediments) and the sub-tropical climate result in a moderately typical soil catena for the terrain and parent materials from which the soils are derived.

The moderately deep to deep sandy loam to loamy soils that colonise the crest and midslopes comprise well developed recharge soils, while the lower midslopes returned more restrictive saprolite and plinthic horizons at depth that result for the most part in lateral flow (interflow) conditions.

The wetlands comprise shallow rooted and semi saturated to saturated clay rich gleycutanic and plinthite horizons (responsive soils) that returned predominantly overland flow during rain events and return flows to the streams and riverine environment during the drier periods.

2.2.3 Risk/Impact Potential

Whilst the impact of open cast mining itself does not cause direct damage to wetland habitat where management and mitigation are implemented correctly, the consequences of poor management can in some cases be significant.

The potential for surface impacts are generally associated with the ingress of dirty water into the wetland environments where mining occurs upslope of the wetlands, while sedimentation and the potential for contamination is real.

Well managed, well designed and well implemented rehabilitation is critical to the sustainability of any project, with wetland management paramount where these features occur within the zone of influence.

Unconsolidated soils and unprotected materials will erode and move downslope into the valley bottoms as a natural event. Unprotected soils and soft sediments will, during the construction, operation and life of mine become a risk if not managed and mitigated.
If contamination of the wetland environment happens, the impact on water quality will become problematic with time.

The purpose of this impact assessment was to focus on the potential impacts of the proposed mining on the wetland sites delineated.

2.2.4 Impact/Risk Assessment

The aim of the Impact Assessment is to assess and define the sites of concern, and where possible to manage and mitigate (avoid) damage or loss of ecosystems and services that they provide. Where this is not possible, a plan needs to be considered and put in place to reduce the impacts (DEA, 2013) to a sustainable level. Table 2.2a details the mitigation hierarchy that should be followed when managing any development that might impact on an area.

Open Cast Mining is planned to take place to a maximum depth of 40m below surface and the impact will be restricted to the planned area that has taken cognisance of the wetland delineation. The taking of water from the ground, the storage and use of dirty water, dust suppression, mining within 100m of a wetland and the storage of water in a PCD are all part of the IWUL that is to be applied for.

Based on the mining plan proposed, and the management plan that has been proposed, the impact significance rating is considered to be moderate to low.

Table 2.2a: Mitigation Hierarchy

Avoid or Prevent	Refers to considering options in project location, sitting, scale, layout, technology and phasing to avoid impacts on biodiversity, associated ecosystem services and people. This is the best option, but is not always possible. Where environmental and social factors give rise to unacceptable negative impacts, mining should not take place. In such cases, it is unlikely to be possible or appropriate to rely on the other steps in the mitigation.
Minimise	Refers to considering alternatives in the project location, sitting, scale, layout, technology and phasing that would minimise impacts on biodiversity, associated ecosystem services. In cases where there are environmental constraints, every effort should be made to minimise impacts.
Rehabilitate	Refers to rehabilitation of areas where impacts are unavoidable and measures are provided to return impacted areas to near natural state or an agreed land use after mine closure. Rehabilitation may, however, fall short of replicating the diversity and complexity of natural systems.
Offset	Refers to measures over and above rehabilitation to compensate for the residual negative impacts on biodiversity after every effort has been made to minimise and then rehabilitate the impacts. Biodiversity offsets can provide a mechanism to compensate for significant residual impacts on biodiversity.

The activities that could potentially have an impact on the site and wetland environments within the zone of influence include:

- Construction of offices, a site workshop and security Site Clearance
- Storage of fuel, lubricant and explosives
- Development and use of haul and access roads.
- Establishment of boxcut.
- Generation and temporary storage of waste (hazardous and general)
- Construction of ROM stockpile and stockpile loading area
- Construction of Pollution Control Dam (PCD)
- Construction of pipelines for transport of water
- Abstraction and dewatering of underground water
- Transport of coal
- Rehabilitation of Project area

2.2.5 Impact Assessment – Significance Rating

The preservation of wetlands is a legal requirement and regarded as essential to the mine plan. The outcomes of the site assessment and PES/EIS ratings, categorise the wetlands as C for the most part, a rating that implies a system with moderately unaffected qualities.
Degradation of these systems must be avoided at all costs and has been included as part of the management plan for mining.

None of the proposed surface infrastructure will be constructed on within or on wet based soils that classify as wetland soils, and as a result, no direct loss of wetland soil is expected. There will be no river crossings and all dirty water will be contained and managed within a lined/engineered PCD.

In terms of the impact assessment protocol the mining has been assessed in terms of the construction phase, the operational phase and decommissioning and closure phases, while consideration of the duration, extent intensity and probability have all been measured for each of the different phases.

Based on the outcomes and rating system used, the construction phase is considered to have a significance rating (SR) of low if the management and mitigation measures are implemented. Without mitigation the SR was calculated as minor to negligible negative

During the operational phase the significance rating is rated as minor in the unmitigated state and negligible in the managed state with mitigation measures in place.

The findings of this study concluded that:

- There are no indications of wetland “soil” features (Soil chroma is too high, no signs of redoximorphic/mottling) within the top 500mm of the observation profiles excavated within the areas of proposed open cast mining.
- The dominant soils noted on the upper midslopes and ridge slope comprise moderate to deep Hutton, Clovelly, Griffin, Avalon and Glencoe form soils, with a depth to a saprolite interface, hard rock or plinthite (soft and hard respectively) of greater than 500mm, with shallow Glencoe and Dresden form soils found associated with a hard plinthite (relic land form) that has formed on top of the semi impermeable and substantive sandstone sub outcrop.
- The geology (resistant sandstone layer that is prominent in the area) has facilitated the formation of a hard plinthite layer and the development of a highly impermeable “relic” landform or layer in elevated topographic positions. The lack of redoximorphic features mapped in these profiles negates the idea that these environments classify as wetlands;
- However, in the lower slope positions and riverine environments the dominant soil forms comprise transition zone wetland forms of varying depth that grade downslope into shallow wet based soils. These are predominantly shallow plinthite or gleyed materials with distinctive hydromorphic and redoximorphic characteristics.
- Indications of wetlands were mapped along the prominent valley bottom streams and riverine environment, with a significant transition zone of wet based soils (not always shallow enough to classify as wetlands) within the valley bottom. There is a well-defined boundary along the sandstone outcrop that characterises the area. These valley bottom wetlands are characterised by shallow Avalon, Westleigh, Kroonstad, Katspruit and Rensburg form soils and areas of deeper Avalon forms within the transition zone. These wetland zones have been restricted and kept outside of the 100m buffer and will not be impacted by the mining operation or its associated activities. There will be active management and mitigation measures implemented to keep all dirty water out of the sensitive and/or legally controlled zones, while all clean water will be actively diverted back into the wetland environment under controlled and engineered conditions so that erosion is reduced and siltation is prevented;

2.3 Pre-Mining Land Capability

2.3.1 Data Collection

The land capability of the study area was classified into four classes (wetland/transitional zone, arable land, grazing land and wilderness) according to the Chamber of Mines Guidelines (1991). The criteria for this classification are set out in the table below.

The "land capability classification" as described above was used to classify the land units identified during the pedological survey.

Table 2.3 - Criteria for Pre-Mining Land Capability (Chamber of Mines 1991)

Criteria for Wetland Land with organic soils or supporting hygrophilous vegetation where soil and vegetation processes are water determined. Criteria for Arable land Land, which does not qualify as a wetland. The soil is readily permeable to a depth of 750mm. The soil has a pH value of between 4.0 and 8.4. The soil has a low salinity and SAR. The soil has less than 10% (by volume) rocks or pedocrete fragments larger than 100mm in the upper 750mm. Has a slope (in %) and erodibility factor (K) such that their product is <2.0. Occurs under a climate of crop yields that are at least equal to the current national average for these crops. Criteria for Grazing land Land, which does not qualify as wetland or arable land. Has soil, or soil-like material, permeable to roots of native plants, that is more than 250mm thick and contains less than 50% by volume of rocks or pedocrete fragments larger than 100mm. 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. Criteria for Wilderness land Land, which does not qualify as wetland, arable land or grazing land.

2.3.2 Description

The "Capability" of the land is a function of not only the soils and their relative depth and structure/texture, but also the geomorphological aspects of the area. The topographic slope, aspect and altitude combined with the climate and ground roughness (rockiness and percentage outcrop) all need to be considered when classifying the ability of the land.

In this rating system, the ability of the land to sustain agriculture is a consideration that is noted, the economic potential of the site being measured in terms of its ability to be farmed. At closure, the area will need to be rehabilitated and the baseline information presented here will be invaluable in making sound sustainable decisions that are economically viable to determine the End land Use that can be measured against the baseline.

Figure 2.3.2 illustrates the distribution of land capability classes for the area assessed.

2.3.2.1 Arable

The land capable of sustaining arable crop production comprises the deep well drained, red (Hutton) and yellow-brown (Clovelly) soils that generally occur on the midslope and upper midslope positions. The study area has significant areas that rate as having a moderate arable land capability potential, albeit that the nutrient stores are low.

2.3.2.2 Grazing

The majority of the study area classifies as low intensity grazing land in its natural state. These areas comprise the moderate to deep well drained soils and more shallow dry sandy loams. The soils are generally darker in colour, and are not always free draining to a depth of 750mm, but are capable of sustaining palatable plant species on a sustainable basis especially since only the subsoil's (at a depth of 500mm) are periodically saturated, and there are no restrictions to rooting in the upper horizons.

2.3.2.3 Wilderness

The areas that classify as either conservation or wilderness land are found associated with shallow rocky soils and some of the transition zone sites upslope of the wetlands.

2.3.2.4 Wet Based Soils

The wet based soils (highly sensitive sites) are defined in terms of the wetland delineation guidelines, which use both soil topography as well as botanic criteria to define the domain limits.

These areas are associated with hydromorphic soils, but do not have any plant life that is associated with aquatic processes. The soils are generally dark grey to black in the topsoil horizons, are high in transported clays and show signs of mottling on gleyed backgrounds in the sub soils (600mm to 1,200mm).

The planned mining areas should not impact on any functioning wetland soils.

The distribution of the land capability classes for the mining area is illustrated in Figure 2.2.2.

2.3.2.5 Transitional Zone

The transitional zone is defined as the area between the wetland zone or hydromorphic soil zone and the dry soils. This zone is periodically wetted by rising soil water and is often influenced by seepage water that moves sub-horizontally within the upper vadose zone. Classically, this zone shows weak mottling at depth (>50cm.b.g.l).

These soils are typically found upslope of the wetlands proper and define an area of sensitivity that is conducive to dryland vegetation but has hydromorphic characteristics in the soil at depth.

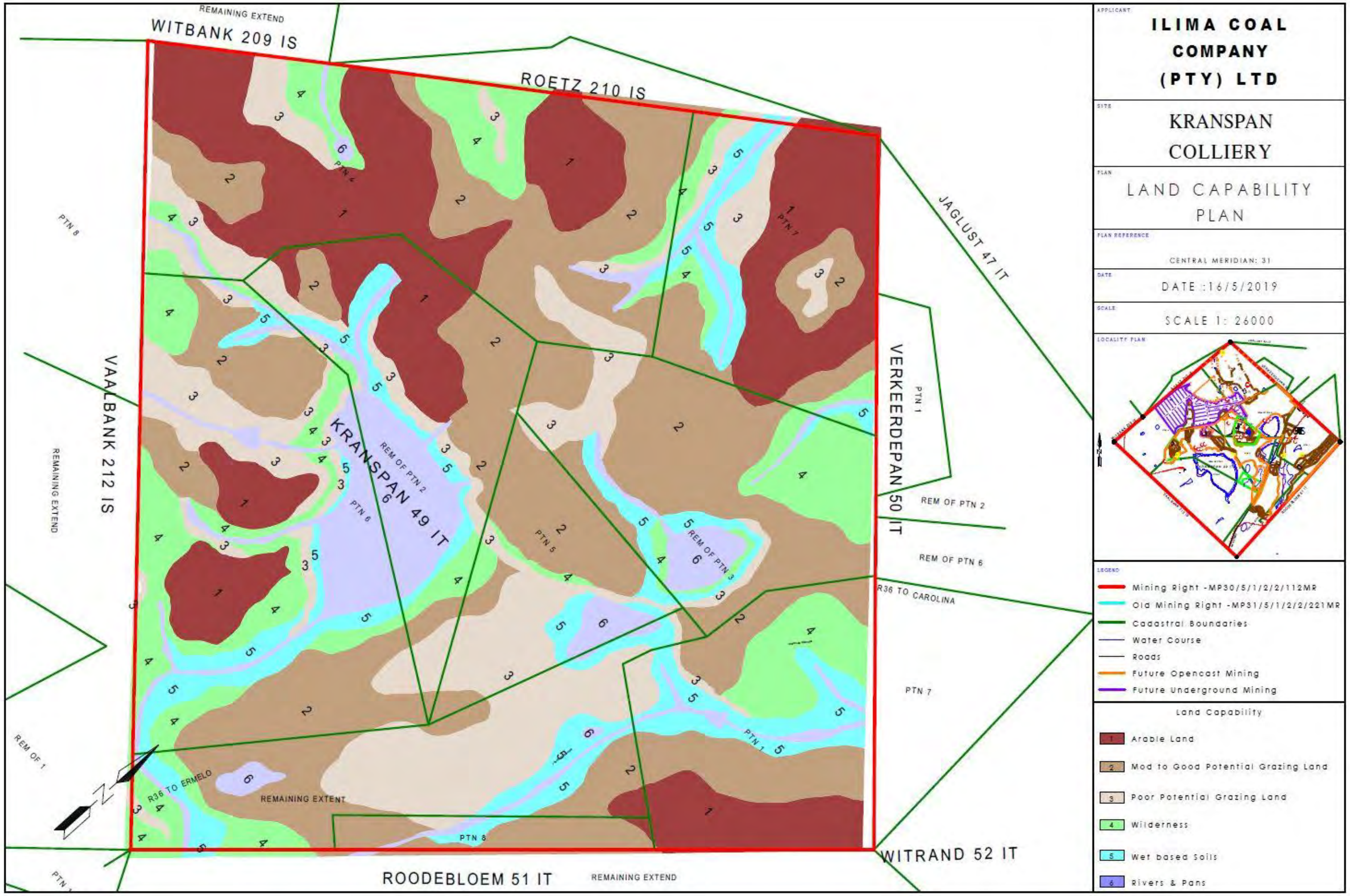


Figure 2.3.2 Land Capability Plan

2.4 Current Land Use

The current land use study has been confined to the mining right area and not only the sites that will be directly affected by the open cast mining and its associated activities.

The study has been based on the LiDAR and Google Earth aerial imagery made available, and the interpretation of pictorial changes across the landscape. These changes were field checked and land use types noted during the field assessment undertaken for the soils and land capability assessment.

Field observations confirmed that the imagery used is quite recent 2017-2018, and the land uses note are for the most part accurate.

The land use has not changed significantly in the past two decades with commercial farming of cereals and livestock the primary current and historic land uses. Figure 2.4 reflects the major land uses in the area, with cultivated land distinguished from grazing lands/grasslands. For the majority of the area under consideration even the grasslands have been impacted by the commercial grazing of livestock, the percentage of area under natural and unaffected veld grasses being exceptionally small.

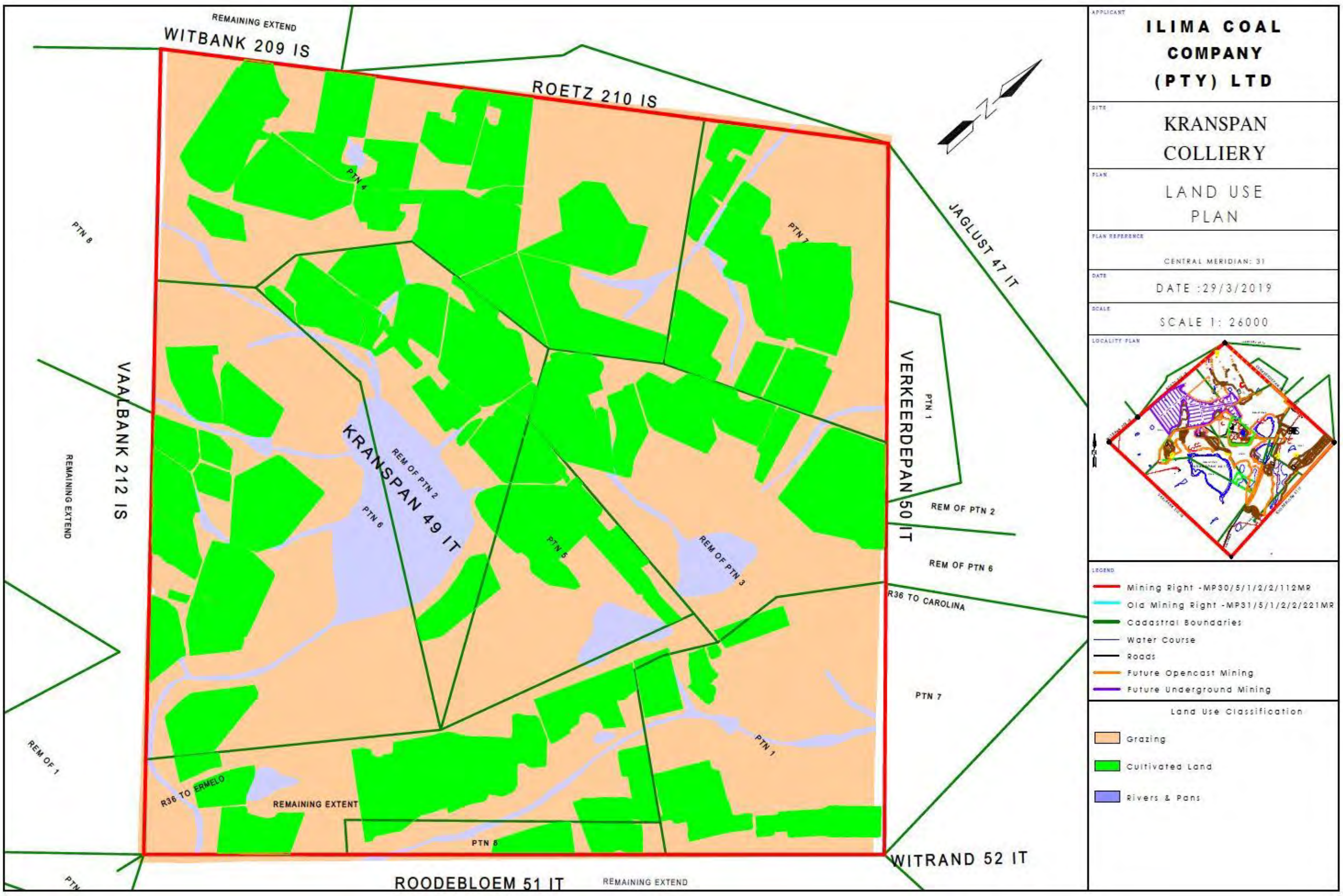


Figure 2.4 Current Land Use Plan

3 Environmental Impact Assessment

The system for the rating and ranking of impact follows the guidelines as tabled by the department and a system developed by the consultant. The detailed outcomes are specified in the tables below.

The Impact Significance is rated as a combination of the "consequence and the likelihood" of the event happening, the consequence being calculated as the sum of the Duration of the expected impact and the likely frequency of the activity, while the Likelihood is calculated as the sum of the potential severity of the activity, the spatial scope of the potential impact and the duration of the impact.

Table 3a – Criteria for Impact Assessment

EPOCH ANALOGY	SEVERITY OF IMPACT	RATING
	Insignificant / non-harmful	1
	Small / potentially harmful	2
	Significant / slightly harmful	3
	Great / harmful	4
	Disastrous / extremely harmful	5
	SPATIAL SCOPE OF IMPACT (Extent)	**RATING**
Within Site	Activity specific	1
Activity/ Site Boundary	Area specific	2
Incl adjacant area	Whole project site / local area	3
Province	Regional	4
Countrywide/ International	National	5
	DURATION OF IMPACT	**RATING**
	One day to one month	1
	One month to one year	2
	One year to ten years	3
	Life of operation	4
	Post closure / permanent	5
	FREQUENCY OF ACTIVITY / DURATION OF ASPECT	**RATING**
	Annually or less / low	1
	6 monthly / temporary	2
	Monthly / infrequent	3
	Weekly / life of operation / regularly / likely	4
	Daily / permanent / high	5
	FREQUENCY OF IMPACT	**RATING**
	Almost never / almost impossible	1
	Very seldom / highly unlikely	2
	Infrequent / unlikely / seldom	3
	Often / regularly / likely / possible	4
	Daily / highly likely / definitely	5

CONSEQUENCE (Severity, Spatial Scope, Duration)

LIKELIHOOD (Frequency of Activity, Frequency of Impact)

Table 3b – Significance Matrix

CONSEQUENCE (Severity + Spatial Scope + Duration)															
LIKELIHOOD (Frequency of activity + Frequency of impact)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

Table 3c – Positive and Negative Mitigation

Significance Rating	Value	Negative Impact Management Recommendation	Positive Impact Management Recommendation
VERY HIGH	126-150	Improve current management	Maintain current management
HIGH	101-125	Improve current management	Maintain current management
MEDIUM-HIGH	76-100	Improve current management	Maintain current management
LOW-MEDIUM	51-75	Maintain current management	Improve current management
LOW	26-50	Maintain current management	Improve current management
VERY LOW	0-25	Maintain current management	Improve current management

As part of better understanding the impacts that any development might have on the environment, the specialist studies need to consider the site sensitivity, the soils and hydropedology of being but two of the ecosystem services that will be affected and for which mitigation will be required. Figure 3 reflects the Site Sensitivities for the Kranspan Site based on the soils and hydropedology outcomes.

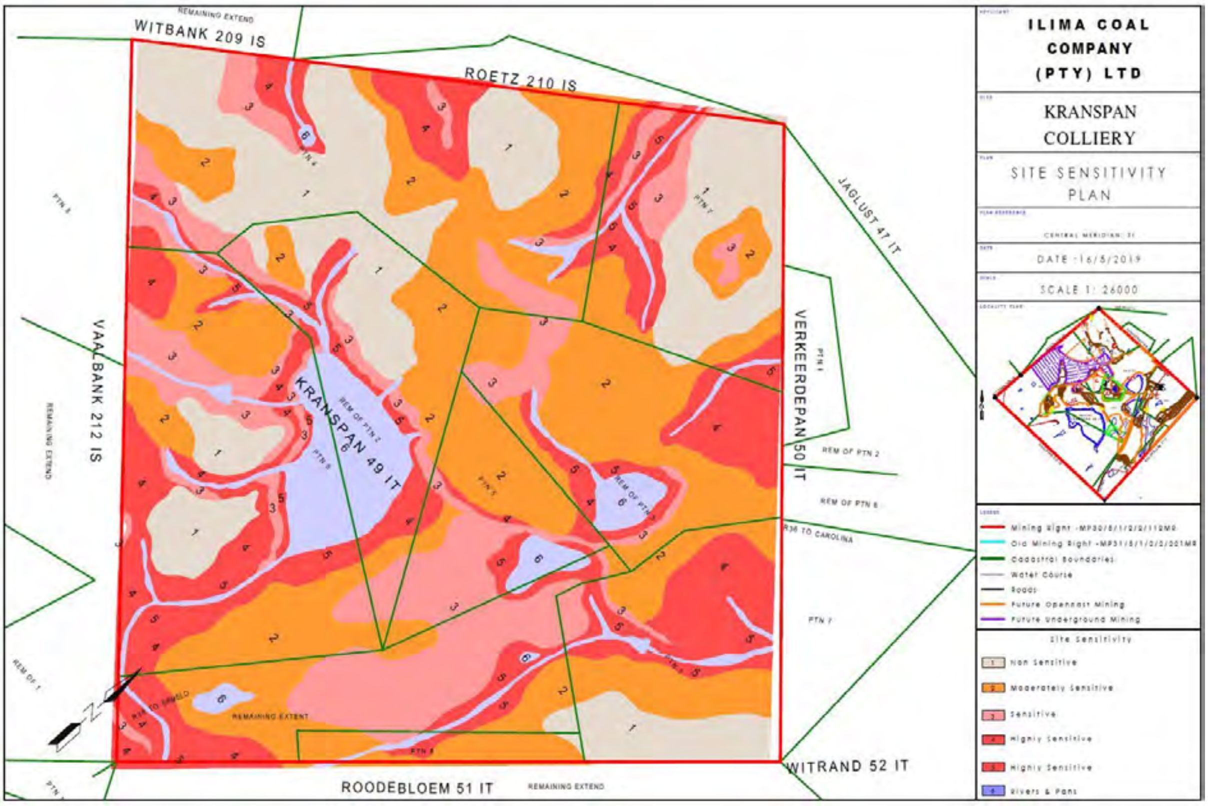


Figure 3 **Site Sensitivity Plan**

3.1 Impact Assessment

3.1.1 Construction Phase

Issue: Loss of Utilisable Soil Resource due to – Erosion, Contamination and/or Compaction during construction

Due to the relative differences between the complex of soil forms that make up the study area, the extremes of texture, structure and hydromorphy, and the in-situ materials that show distinctive pedogenisis and which are better sorted and show distinctive soil formation, the impacts will be different and mitigation measures will be varied.

Construction for Project

Stripping of utilisable soil, preparation (levelling and compaction) of lay-down areas and pad footprint for stockpiling of utilisable soil and berms, opening up of foundations, mining voids (Box Cut and Adits), stockpiling of utilisable soil and soft overburden, and slope stability where required. Haulage via dumper trucks and construction of access roads.

Control of dust and loss of materials to wind and water erosion, and protection of materials from contamination (chemical, hydrocarbons and sewage)

The construction phase will impact on all of the proposed mining and developmental activities, inclusive of:

- The construction/preparation of the footprint for the overall lay down of the materials stockpiles (Removal of vegetation and topsoil's) around the boxcut development as well as the haulage ways and the footprint to the underground adit and all associated mine infrastructure;
- The construction of the starter walls for the storm water/pollution control dams;
- Construction of access roads;
- Stockpiling of the soils and overburden (softs and cover material) from construction footprints;
- Design and construction of dirty water control dams, channels and berms (storm water control facilities) to cater for all dirty water and diversion of clean water around the facilities;
- Design and construction of the washing plant, site offices, workshops, change house etc. and
- Clearing and removal of vegetation and the stockpiling of the topsoil prior to the lay down of soft overburden materials from the boxcut development to the underground adit excavations

In addition, the soils will need to be stockpiled in different locations throughout the construction and operational phases, with the materials stripped from the areas of infrastructure development and mining being best stockpiled as close as possible to these features in the form of berms upslope of the facilities, the soils from the adit entrance (decline adits) being stored as low level dumps and/or berms close to but upslope of the voids to which they are planned to be used at closure.

Description of Impacts

The loss of the soil resource to the overall environment due to the impact on the soils stripped during the opening up of the boxcut to the open cast mining and/or adit entrance to the underground mining areas, the construction of the footprint pads and laydown areas for the soil storage, opening up of the haulage ways and removal of soils and the disturbance of the soils associated with the construction area to be used for the support infrastructure (Workshops, Offices etc).

These activities and actions will definitely be High (H) in the medium term_(life of mine) (M) and restricted to the immediate mining area (L). The overall loss of the soil resource to the environment if un-mitigated will result in a High (H) Significant Rating.

All of the workings and proposed structures associated with the mining development are outside of the waterways and or moist grassland environment and are for the most part associated with the moderately shallow to deep soils of the sedimentary host rock and only small areas of upper transitional zone soil forms (deep wet based soils) have been included where required. The variation in soil sensitivity is marked, with the dry friable sandy loams and silty loams being far easier to manage.

The impact of removing the topsoil's and upper portion of the subsoil horizon (Utilisable soil – 500mm) will destroy any surface capping that might be in place, will remove all vegetative cover, and will expose the subsoil's to wind and water affects and induce possible erosion and compaction if not well managed and protected.

The moderate to highly sensitive soils (friable soils) will be susceptible to erosion and compaction once disturbed, and will be difficult to utilize and manage if left unprotected.

It must be emphasised, that the failure to manage the soils will result in the total loss of this resource, with a resultant high significance.

Mitigation/Management Actions

With management, the loss of this primary resource can be reduced and mitigated to a level that is more acceptable.

The impacts on the soils may be mitigated with a number of management procedures, including:

- Effective soil stripping during the dryer and less windy months when the soils are less susceptible to erosion and compaction. This will assist the stockpiling and vegetative cover to propagate before the following wet season;
- Effective cladding of any stockpiles, dumps, berms and/or by-product facilities and the minimising of the height of all stockpiles wherever possible will help to reduce wind erosion and the loss of materials;
- Soil replacement to all areas (temporary) that are not required for the operational phase, and the preparation of a seed bed to facilitate the re-vegetation program for these areas will limit potential erodibility during the operational phase and into the rehabilitation and closure phases.
- Soil amelioration (cultivation) to enhance the growing capability of the stockpiled soils so that they can be used for rehabilitation at closure and to maintain the soils viability during storage.

- Backfilling of the boxcut with soft overburden, discards and the creation through compaction of a **barrier layer** at the soil backfill interface using the relatively more impermeable clay rich subsoil (Non utilisable soils) and soft overburden. These actions are recommended as the ferricrete layer and any hard impermeable sedimentary layers will have been destroyed and will not be available to re-create this barrier;
- Replacement of the growing medium (Utilisable soil) in the correct order and as close as possible to its original position in the topography will help to maintain the soil pedogenisis and utilization potential relative to the ecology and biological constraints;
- Soil replacement and the preparation of a seed bed to facilitate the re-vegetation program and to limit potential erodibility during the rehabilitation process.

Care will need to be taken to keep any wet based soils separated from the dry soils, and to keep all stockpiled soils that are in storage vegetated and protected from contamination and erosion.

These soils will be stripped as “Utilisable Soil” the topsoil and upper portion of the subsoil’s (B2/1 Horizon) stored in a position that will be convenient for the final rehabilitation of the facilities during the operational and closure phases – reduce distances to be hauled and negate the need for double handling.

Only if these materials are available can rehabilitation possibly be executed successfully and cost effectively. It is suggested that an average “Utilisable Soil Depth” (USD) of 500mm be stockpiled where present/available.

Residual Impact

The above management procedures will probably reduce the significance of the impacts to Medium in the long term.

Table 3.1 – Impact Significance rating – Construction Phase

Project Activity		Soils	Likelihood		Consequence			Significance Rating
All construction phase activities	Phase of Project	Construction Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Loss of Soil Utilisation - Removal from System	4	5	5	3	4	108
			Significance Post-Mitigation					
			4	4	3	1	4	64
Project Activity		Soils	Likelihood		Consequence			Significance Rating
All construction phase activities	Phase of Project	Construction Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Loss of soil Utilisation - Erosion & Compaction	4	4	3	2	4	72
			Significance Post-Mitigation					
			4	3	3	1	4	56
Project Activity		Soils	Likelihood		Consequence			Significance Rating
All construction phase activities	Phase of Project	Construction Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Loss of soil Utilisation - Product & Hydrocarbon Spills	4	4	4	3	4	88
			Significance Post-Mitigation					
			4	3	3	1	4	56

3.1.2 Operational Phase

Issue: **Loss of Soil Usability**

Operation of Project – Cumulative

Loss of soil utilization - On-going soil stripping for extensions to open cast mining, the maintenance of the stockpiles of soil and material, the possible contamination by dirty water interaction, dust and/or hydrocarbon spillage, covering of the soils by infrastructure, by-product stockpiles, storage facilities and dumps, compaction by vehicle movement, and erosion and loss of materials due to wind and water interaction with unprotected soils.

Description of Impacts

During the operational phase, all of the construction activities for the infrastructure and major by-product storage structures will have been completed and the haulage way, RoM storage area of product the deposition of any by-product will have begun along with the on-going and continuous mining operation.

The loss of the soil utilization and the covering of materials for extended periods of time will lead to the compaction and sterilization of the materials for future use. This will definitely result in a High (H) negative impact that will last for the duration of the mining venture within the mining area. The consequence is moderate (M) with an overall significance of High.

The movement/haulage of product, the use of access roads and the on-going additions of by-product to the stockpiles and storage facilities will all impact on the size of area to be impacted, and ultimately on the area of soil affected.

Spillage from vehicles and the handling of coal, possibly leakage or spillage of hydrocarbons and leakage of dirty water from the water management system etc. will negatively impact the in-situ materials, while unmanaged dirty water will erode and contaminate the soils that it comes into contact with.

Un-managed soil stockpiles and soil that is left uncovered and not vegetated will be lost to water and wind erosion, and will be prone to compaction if left unprotected.

The preservation of any restrictive layers or capping to the soil will be lost along with its protective properties wherever the soils have been stripped, and it will be difficult or impossible to re-produce or re-create these features during the rehabilitation phase.

All of these soils will be impacted upon to differing degrees, and will have been stockpiled for future use during the rehabilitation phase and at closure.

The significance of the impact on these soils during the operational phase will differ both in intensity and duration, with the soils associated with the infrastructure remaining in a stockpile for the full life of the mining and processing operations, with the adit declines and ventilation shafts remaining open for the life of mining of any particular section.

It is inevitable however, that the soils utilization potential will be lost during the operational phase, and possibly for ever if they are not well managed and a mitigation plan is not implemented.

Mitigation/Management Action

The impacts on the stockpiled and stored soils may be mitigated with management procedures including:

- Minimisation of overall/total area of impact;
- Timorous replacement of the soils so as to minimise the area of disturbance;
- Effective vegetative and soil cover and protection from wind (dust) and dirty water contamination;
- Adequate protection from erosion (wind and water);
- Servicing of all vehicles and equipment on a regular basis and in well-constructed and bunded areas, well-constructed and maintained oil traps and dirty water collection systems;
- Cleaning of all roadways and haulage ways, drains and storm water control facilities;
- Containment and management of spillage;

Soil replacement and the preparation of a seed bed to facilitate and accelerate the re-vegetation program and to limit potential erosion, and
Soil amelioration to enhance the growth capability of the soils and sustain the soils ability to retain oxygen and nutrients, thus sustaining vegetative material during the storage stage;

Of consequence during the operational phase will be the minimising of the area that is being impacted by the mining operation and its related support structures and operations, and maintenance of the integrity of the soils. This will require that the soils are kept free of contamination (dust and dirty water), and stabilized and protected from erosion and compaction. The action of wind on dust generated and the loss of materials downwind will need to be considered, while contamination of the soils used on the roads and workshop areas will need to be managed.

However, if the soils are stripped to a "utilisable" depth, and replaced as close as possible to their original position in the topography, the chances of nature being able to restore the systems present prior to disturbance will be better and greater/higher.

Residual Impact

In the long term, the above mitigation measures will probably reduce the impact on the utilisable soil reserves to a **Medium** impact.

Table 3.2 – Impact Significance Rating – Operational Phase

Project Activity		Soils	Likelihood		Consequence			
Ineffective Housekeeping and Management of Stockpiles and Exposed Soils	Phase of Project	Operational	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Loss of Soil Utilisation - Open cast Mining	4	5	5	3	4	108
			Significance Post-Mitigation					
			4	4	3	2	4	72
Project Activity		Soils	Likelihood		Consequence			
Ineffective Housekeeping and Management of Stockpiles and Exposed Soils	Phase of Project	Operational	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Contamination due to Product and Hydrocarbon Spillage	4	4	4	3	4	88
			Significance Post-Mitigation					
			3	3	3	2	2	42
Project Activity		Soils	Likelihood		Consequence			
Ineffective Housekeeping and Management of Stockpiles and Exposed Soils	Phase of Project	Operational	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Loss of soil Utilisation due to Permanent Infrastructure - Dumps, stockpiles etc.	5	5	5	2	5	120
			Significance Post-Mitigation					
			5	4	3	2	3	72

Project Activity		Soils	Likelihood		Consequence			
Continued Activities Including Mining and Transportation	Phase of Project	Operational	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Erosion and Compaction - wind, water and vehicle movement	4	5	3	3	3	81
			Significance Post-Mitigation					
			4	3	3	2	3	56

3.1.3 Decommissioning & Closure Phase

Issue: Net loss of soil potential due to change in materials (Physical and Chemical) and loss of nutrient base.

Decommissioning and Closure – Cumulative Loss of the soils original nutrient store by leaching, erosion and de-oxygenation while stockpiled. Impact of vehicle movement, dust contamination and erosion during soil replacement and demolishing of infrastructure, slope stabilization and re-vegetation of disturbed areas. Possible contamination by dirty water interaction (use of mine water for irrigation of re-vegetation), dust and/or hydrocarbon spillage from construction vehicles. Positive impacts of reduction in areas of disturbance and return of soil utilization potential, uncovering of areas of storage and rehabilitation of compacted materials.

Description of Impact

The impact will remain the net loss of the soil resource if no intervention or mitigating strategy is implemented. The impact will be high, negative and permanent over the area of disturbance, with a relatively high consequence and resultant high significance. Un-managed closure will result in a long term depletion of soil utilization potential.

Management/Mitigation Actions

Ongoing rehabilitation during the decommissioning phase of the project will probably bring about a net long-term positive impact on the soils.
The initial impact will be high and negative due to the necessity for vehicle movement while rehabilitating the open voids, moving of softs and soils, the demolishing of storm water controls, dams etc and the demolishing of buildings and infrastructure. Dust will be generated and soil will be contaminated and eroded.

The positive impacts of rehabilitating an area are the reduction in the area previously disturbed, the amelioration of the affected soils and oxygenation of the growing medium, the stabilizing of slopes and revegetation of areas decommissioned with a reduction in areas previously subjected to wind or water erosion.

Residual Impacts

On mine closure the long-term negative impact on the soils will probably be of medium to low significance if the management plan set out in the Environmental Management Plan of this report is effectively implemented to reinstate current soil conditions. The success of re-creating an inhibiting or compacted layer to the disturbed areas will require significant management inputs and corrective engineering to the environment and rehabilitation.

Chemical amelioration of the soils will possibly have a low but positive impact on the nutrient status (only) of the soils in the medium term.

Table 3.3 – Impact Significance Rating – Decommissioning Phase

Project Activity		Soils	Likelihood		Consequence			
Continued Activities Including Concurrent Rehabilitation and Closure	Phase of Project	Decommissioning & Closure	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Cumulative Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Loss of soil Nutrient Pool	4	5	4	3	4	99
			Significance Post-Mitigation					
			4	3	3	2	3	56
Project Activity		Soils	Likelihood		Consequence			
Continued Activities Including Concurrent Rehabilitation and Closure	Phase of Project	Decommissioning & Closure	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Cumulative Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Compaction from vehicle movement during material replacement	4	5	3	3	4	90
			Significance Post-Mitigation					
			4	3	3	2	3	56
Project Activity		Soils	Likelihood		Consequence			
Continued Activities Including Concurrent Rehabilitation and Closure	Phase of Project	Decommissioning & Closure	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Cumulative Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Contamination by dirty water and hydrocarbon spills	4	4	4	2	3	72
			Significance Post-Mitigation					
			4	3	3	1	3	49
Project Activity		Soils	Likelihood		Consequence			
Continued Activities including Concurrent Rehabilitation and Closure	Phase of Project	Decommissioning & Closure	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Positive - Cumulative Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Reduction in area of impact and return of soil utilisation potential	2	3	3	3	3	45
			Significance Post-Mitigation					
			4	3	3	2	3	56

4. ENVIRONMENTAL MANAGEMENT PLAN

Based on the studies undertaken, it has been possible to assess the impacts that mining and beneficiation could potentially have on the soils and their resultant utilization potential, and has aided in a better understanding of the possible management and mitigation measures that could help in minimising the impacts during the rehabilitation process, decommissioning and at closure.

The management and mitigation measures proposed have been tabled for the different stages of the project and, based on the soil forms that will be impacted or affected and the resultant utilization change, with an environmental management plan (EMP) suggested for each of the stages of mining.

The plan caters for the construction, operation and decommissioning stages of the project, and gives recommendations on the stripping and handling of the soils during the construction and operational phases, with recommendations given for the rehabilitation and ultimate closure of the facility as part of the "End Use" planning. It is imperative that a full and detailed EMP is implemented if the economics of mine closure are to be understood, and the relative positioning and timings of materials handling are to be aligned with the mining plan.

All materials and all associated soils that are not going to be mined, but which might be impacted by the process or support infrastructure, will be impacted, and will require that the utilisable soil (Top 500mm) is stripped and stored for possible utilization for rehabilitation at closure

4.1 Construction Phase

Soil Stripping and Handling

In considering any management plan for soils it is imperative that the soil physical and chemical composition are known as these will be exceptionally important in obtaining a utilisable material at decommissioning and/or during rehabilitation. The method of stockpiling and general handling of the soil will vary depending on the composition.

The sandy and silty loams that form the topsoil's, along with the upper portion of the subsoil's (B2/1 Horizon) within which the majority of the nutrient store occurs **(Utilisable Soil)** will need be stripped and stockpiled for use at closure.

The concept of stripping and storage of all "utilisable" soil is tabled as a minimum requirement and as part of the overall Soil Utilization Guidelines.

In terms of the "Minimum Requirements", usable soil is defined here as ALL soil above an agreed subterranean cut-off depth defined by the project soil scientist and will vary for different types of soil encountered in a project area. It does not differentiate between topsoil (orthic horizon) and other subsoil horizons.

Soil stripping requirements are set to enable the mining company to achieve post mining land capabilities stipulated by the management plan and are based on pre-mining land capability assessment for the area in question. Pre-mining grazing land capability is the norm that is aimed for in most situations post mining. However, in this sensitive environment, although a low intensity grazing land status is tabled as the minimum requirement, it is likely that moderate grazing could be achieved with the possibility of low yielding crop production if the rehabilitation plan is well managed and implemented.

Table 4.1 – Construction Phase – Soil Conservation Plan

Phase	Step	Factors to Consider	Comments
Construction	Delineation of areas to be stripped		Stripping will only occur where soils are to be disturbed by activities that are described in the design report, and where a clearly defined end rehabilitation use for the stripped soil has been identified.
	Reference to biodiversity action plan		It is recommened that all vegetation is stripped and stored as part of the utilizable soil. However, the requirements for moving and preserving fauna and flora according to the biodiversity action plan should be consulted.
	Stripping and Handling of soils	Handling	Soils will be handled in dry weather conditions so as to cause as little compaction as possible. Utilizable soil (Topsoil and upper portion of subsoil B2/1) must be handled and stockpiled separately from the lower "B" horizon and all softs (decomposed rock).
		Stripping	The "Utilizable" soil will be stripped to a depth of 500mm or until hard rock is encountered. These soils will be stockpiled together with any vegetation cover present (only large bushes to be removed prior to stripping). The total stripped depth should be 500mm, where possible.
	Delineation of Stockpiling areas	Location	Stockpiling areas will be identified in close proximity to the source of the soil to limit handling and to promote reuse of soils in the correct areas.
		Designation of Areas	Soils stockpiles will be demarcated, and clearly marked to identify both the soil type and the intended area of rehabilitation.

The following requirements (**all be they generic**) should be adhered to wherever possible:

- Over areas of OPEN CAST PITS or openings of a boxcut workings *strip all usable soil* as defined (500mm). Stockpile alluvial soils should be stockpiled separately from the colluvial (shallower) materials, which in turn should be stored separately from the overburden.

  At *rehabilitation* replace soil to appropriate soil depths, and cover areas to achieve an appropriate topographic aspect and achieve a free draining landscape as close as possible to the pre-mining land capability rating.
- Over area of STRUCTURES (Offices, Workshops, Haul Roads) AND SOFT OVERBURDEN STOCKPILES *strip the top 300 mm* of usable soil over all affected areas including terraces and *strip remaining usable soil* where founding conditions require further soil removal. Store the soil in stockpiles of not more than 1.5 m around infrastructure area for closure rehabilitation purposes. Stockpile hydromorphic soils separately from the dry materials. *For rehabilitation* strip all gravel and other material places to form terraces and recycle as construction material or place in open pit. Remove foundations to a maximum depth of 1m. Replace soil to appropriate soil depths, and over areas and in appropriate topographic position to achieve pre-mining land capability and land form.
- Over area of CONSTRUCTION OF BY-PRODUCT/TAILINGS/SLURRY STORAGE FACILITIES AND HARD OVERBURDEN STOCKPILES *strip usable soil* to a *depth of 750 mm* in areas of *arable soils* and *between 300mm and 500mm* in areas of *soils with grazing land capability.* Stockpile hydromorphic soils separately from the dry and friable materials. *For rehabilitation* strip all gravel and other material places to form terraces and recycle as construction material or place in open pit. Remove foundations to a maximum depth of 1m. Replace soil to appropriate soil depths, and over areas and in appropriate topographic position to achieve pre-mining land capability.
- Over area of ACCESS ROADS, LAY-DOWN PADS AND CONVEYOR SERVITUDES *strip the top 150 mm* of usable soil over all affected areas and stockpile in longitudinal stockpile within the mining lease area.

In general, the depth of the topsoil's material for the site is between 300mm and 450mm. However, due to the shallow soil depths on the more rocky slopes, and the need to rehabilitate these areas with sufficient materials to induce growth at closure, it is recommended that a minimum of 500mm is stripped from the mining and associated infrastructure areas (Sites with impacts to below the B2/1 level, or foundations that extend into the saprolitic zone (weathered rock)), and 300mm from all roads (Access and Haulage Ways) and founding pads for the soil stockpiles and all dump footprints.

The positioning of any/all storage facilities will need to be assessed on the basis of the cost of double handling, distances to the point of rehabilitation need, and the potential for use of the materials as storm water management facilities (berms). Suggestions include the use of materials in positions upslope of the mining infrastructure and open cast mining facilities as clean water diversion berms, and/or as stockpiles close to, but outside of the final voids that are to be created by the mining operations.

Soils removed from area that require deep foundations, lay-down pads for by-product facilities and the processing facility, dam footprints, all access roads and haulage ways and their associated support infrastructure must be stockpiled as close as possible to the facilities as is possible without the topsoil's becoming contaminated or impacted by the operations.

The vegetated soils should be stripped and stockpiled without the vegetation having been cleared/stripped off wherever practical, while any grassland/natural veld that have been disturbed should be fertilized with super phosphate prior to being stripped (wherever practical).

This will ensure that the fertilizer is well mixed into the soil during the stripping operation and will aid in the quick cover to the stockpiles and reduce the amount of fertilizer required during the rehabilitation program. All utilization of the land for any other purpose will need to stop before mining begins.

The lower portions of the subsoil's (>500mm) and the soft overburden material (where removed) can be stored as separate stockpiles close to the areas where they will be required for backfilling and final rehabilitation.

The base to all of the proposed structures to be constructed should be founded on stabilized materials, the soils having been stripped to below the topsoil contact (200mm to 300mm) and or to 500mm as the depth of utilisable soil.

It is proposed that prior to soil stripping, an appropriate (to be determined by local experts) fertilizer (super phosphate) should be added to the sandy loams and silty clay loams at a rate of about 200 kg/ha if they have not previously been fertilized. This will help to enhance the seed pool and encourage growth within the stored materials.

The stripping and handling of these sensitive materials during the construction phase or while opening up of the open cast mining sections is highlighted, because the correct removal, storage and reinstatement of the materials will have a significant effect on the costs and the final success or failure of the rehabilitation plan at closure.

Of importance to the success and long term sustainability of rehabilitating these sensitive environments will be the replacement of the materials in their correct topographic position, and the ability of the rehabilitation team to re-create a layer within the final profile that will inhibit vertical infiltration of water.
Long term and forward planning for the utilization of the materials to their best advantage and the understanding of the final "End Land Use" will need to be well understood if the optimum utilization

of the materials is to be achieved. Please refer to the recommendations of materials replacement under the decommissioning and closure plan section.

The consequences of not achieving these goals will need to be assessed and quantified in terms of the long term ecological impacts, and will require the input of the specialist ecologists, hydrogeologists and engineers in formulating the management plan.

4.2 Operational Phase

Soil Stockpiling and Storage

Based on the findings of the baseline studies the sensitivity of the soil materials has been evaluated and site specific recommendations are made that are relevant to the unique conditions that pertain to this highveld environment.

Table 4.2– Operational Phase – Soil Conservation Plan

Phase	Step	Factors to Consider	Comments
Operation	Stockpile management	Vegetation establishment and erosion control	Rapid growth of vegetation on the Soil Stockpiles will be promoted (e.g. by means of watering or fertilisation). The purpose of this exercise will be to protect the soils and combat erosion by water and wind.
		Storm Water Control	Stockpiles will be established with storm water diversion berms to prevent run off erosion.
		Stockpile Height and Slope Stability	Soil stockpile heights will be restricted where possible to <1.5m so as to avoid compaction and damage to the soil seed pool. Where stockpiles higher than 1.5m cannot be avoided, these will be benched to a maximum height of 15m. Each bench should ideally be 1.5m high and 2m wide. For storage periods greater than 3 years, vegetative cover is essential, and should be encouraged using fertilization and induced seeding with water. The stockpile side slopes should be stabilized at a slope of 1 in 6. This will promote vegetation growth and reduce run-off related erosion.
		Waste	No waste material will be placed on the soil stockpiles.
		Vehicles	Equipment movement on to of the soil stockpiles will be limited to avoid topsoil compaction and subsequent damage to the soils and seedbank.

It is proposed that the construction of any berms needed and soil storage stockpiles are undertaken in a series of 1,5m lifts if the storage facilities are to be greater than 1,5m high. For soils that are to be stored for any length of time (greater than three years) it is recommended that all utilisable soil should be stockpiled, while the heavier subsoil's and ferricrete materials should be stored as separate stockpiles. Storing the soil in this manner will maximize the beneficial properties of each material, and render them available for use at closure in the best position. Separation of these layers at the time of utilizing these soils is a matter for management, as the mixing and dilution of the soil properties is not recommended.

The utilisable soil stockpiled must be adequately vegetated as soon after emplacement on the storage pads as possible and maintained throughout the life of mining.

It is imperative, where possible, that the slopes of the stockpile berm facility are constructed to 1:6 or shallower.
This will minimize the chances of erosion of the soils and will enhance the growth of vegetation. However, prior to the establishment of vegetation, it is recommended that erosion control measures,

such as the planting of Vetiver Grass hedges, or the construction of benches and cut-off drains be included in the stockpile/berm design.

These actions will limit the potential for uncontrolled run-off and the subsequent erosion of the unconsolidated soils, while the vegetation is establishing itself, and throughout the life of the mining operation.

Vetiver is a recognised and certified natural grass specie in South Africa, and after many years of trials and testing has been given a positive record of decision as a non-invasive material that can be used as a hedging grass in the development of erosion control. The advantages to the use of Vetiver Grass, is documented in the attached brochure (Refer Appendix 2 - The Vetiver Network International - www.vetiver.org).

Erosion and compaction of the disturbed soils and the management of the stored or stockpiled materials are the main issues that will need to be managed on these sensitive soil forms. This is due to the sensitivity of the soils to mechanical disturbances during/after the removal of surface vegetation and the difficulties in replacing the disturbed materials.

Working with or on the differing soil materials (all of which occur within the areas that are to be disturbed) will require better than average management and careful planning if rehabilitation is to be successful. Care in removal and stockpiling or storage of the "Utilisable" soils, and protection of materials which are derived from the "hardpan ferricrete" layer is imperative to the success of sustainable rehabilitation in these areas. The sensitivity of the soils is a factor to be considered during the rehabilitation process (Refer to section on Soil Handling and Removal – Construction Phase (4.1) and Mitigation and Management Measures – Decommissioning and Closure Section (4.3))

4.3 Decommissioning and Closure

Soil Replacement and Land Preparation

During the decommissioning and closure phase of any mining project there will a number of actions being undertaken or completed. The removal of all infrastructure and the demolishing of concrete slabs, the backfilling of any and all open voids and the compaction of the barrier layer, and the topdressing of the disturbed and backfilled areas with utilisable soil ready for re-vegetation are all considered part of a successful closure operation.

The order of replacement, fertilization and stabilization of the backfilled materials and final cover materials (soil and vegetation) are all important to the success of the decommissioning plan and final closure.

There will be a positive impact on the environment in general and on the soils in particular as the area of disturbance is reduced, and the soils are returned to a state that can support low to moderate intensity grazing (Natural conditions).

Table 4.3 – Decommissioning and Closure Phase – Soil Conservation Plan

Phase	Step	Factors to Consider	Comments
Decommissioning & Closure	Rehabilitation of Disturbed land & Restoration of Soil Utilization	Placement of Soils	Stockpiled soil will be used to rehabilitate disturbed sites either ongoing as disturbed areas become available for rehabilitation and/or at closure. The utilizable soil (500mm) removed during the construction phase or while opening up of decline adit entrance, shall be redistributed in a manner that achieves an approximate uniform stable thickness consistent with the approved postmining land use (Low intensity grazing), and will attain a free draining surface profile. A minimum layer of 300mm of soil will be replaced.
		Fertilization	A representative sampling of the stripped soils will be analysed to determine the nutrient status of the utilizable materials. As a minimum the following elements will be tested for: EC, CEC, pH, Ca, Mg, K, Na, P, Zn, Clay% and Organic Carbon. These elements provide the basis for determining the fertility of soil. based on the analysis, fertilisers will be applied if necessary.
		Erosion Control	Erosion control measures will be implemented to ensure that the soil is not washed away and that erosion gulleys do not develop prior to vegetation establishment.
	Pollution of Soils	In-situ Remediation	If soil (whether stockpiled or in its undisturbed natural state) is polluted, the first management priority is to treat the pollution by means of in situ bioremediation. The acceptability of this option must be verified by an appropriate soils expert and by DWAF, on a case by case basis, before it is implemented.
		Off site disposal of soils.	If in situ treatment is not possible or acceptable then the polluted soil must be classified according to the Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste (DWAF 1998) and disposed at an appropriate, permitted, off-site waste facility.

Fertilizers and Soil Amendments

For any successful soil amelioration and resultant successful vegetative cover, it is necessary to distinguish between the initial application of fertilizers or soil amendments and maintenance dressings. Basal or initial applications are required to correct disorders that might be present in the in-situ material and raise the fertility status of the soil to a suitable level prior to seeding. The initial application of fertilizer and lime to the disturbed soils is necessary to establish a healthy plant cover as soon as possible. This will prevent erosion. Maintenance dressings are applied for the purpose of keeping up nutrient levels. These applications will be undertaken only if required, and only after additional sample analysis has been undertaken.

Fertilizer requirements reported herein are based on the sampling of the soils at the time of the baseline survey and will definitely alter during the storage stage.

The quantities of additives required at any given time during the storage phase or after rehabilitation has been established will potentially change due to physical and chemical processes. The fertilizer requirements should thus be re-evaluated at the time of rehabilitation.

It is recommended that a qualified person (agronomist or plant ecologist) be employed to establish the possible need or not for lime, organic matter and fertilizer requirements that will be applied, prior to the starting of the rehabilitation process.

The soils mapped are generally deficient in zinc, phosphorus, and potassium. It is recommended that a standard commercial fertilizer be added to the soil before re-vegetation. The fertilizer should be added to the soil in a slow release granular form at a rate of approximately 200 kg/ha. It will be necessary to re-evaluate the nutrient status of the soils at regular intervals to determine the possibility of needing additional fertilizer applications. In addition, it is important that only small amounts of fertilizer are added on a more frequent basis, rather than adding large quantities in one application.
The following maintenance is recommended:

- The area must be fenced, and all animals kept off the area until the vegetation is self-sustaining;
- Newly seeded/planted areas must be protected against compaction and erosion;
- Traffic should be limited were possible while the vegetation is establishing itself;
- Plants should be watered and weeded as required on a regular and managed basis;
- Check for pests and diseases at least once every two weeks and treat if necessary;
- Replace unhealthy or dead plant material;
- Fertilise, hydro seeded and grassed areas with 200 kg/ha ammonium sulphate 4-6 weeks after germination, and
- Repair any damage caused by erosion;

Soil Sampling

During the rehabilitation exercise preliminary soil sampling should be carried out to determine the fertilizer requirements more accurately. Additional soil sampling should also be carried out annually until the levels of nutrients, specifically magnesium, phosphorus and potassium, are at the required level (approximately 20 and 120 mg/kg respectively). Once the desired nutritional status has been achieved, it is recommended that the interval between sampling be increased. An annual environmental audit should be undertaken. If growth problems develop, ad hoc, sampling should be carried out to determine the problem.

Sampling should always be carried out at the same time of the year and at least six weeks after the last application of fertilizer.

All of the soil samples should be analysed for the following parameters:

- pH (H_2O);
- Electrical conductivity;
- Calcium mg/kg;
- Magnesium mg/kg;
- Potassium mg/kg;
- Sodium mg/kg;
- Cation exchange capacity;
- Phosphorus (Bray I);
- Zinc mg/kg;
- Clay% and;
- Organic matter content (C %)

5 ENVIRONMENTAL MONITORING PLAN

5.1 MONITORING PHILOSOPHY AND REQUIREMENTS

5.1.1 Monitoring Philosophy

The observation and recording of environmental data are costly exercises and therefore the philosophy and reasoning behind an environmental monitoring system should always be sound. The benefits of sound environmental monitoring are not only legal compliance, but also certain business benefits such as the improvement of operational efficiency, the improvement of risk management, the reduction of liabilities, the avoidance of adverse publicity and ultimately the improvement of business performance.

Current Environmental Legislation in South Africa requires mining and industry to comply with the philosophy of Integrated Environmental Management. The applicable legislation includes inter alia the Constitution, the National Environmental Management Act, the Environment Conservation Act, the Minerals and Petroleum Resources Development Act, and the National Water Act, to name but a few of the more prominent acts.

Some of the general principles of Integrated Environmental Management include meaningful participation with Interested and Affected Parties, due consideration of alternatives that includes the “no go option”, and understanding that activities will not be approved if there is scientific uncertainty.

The abovementioned legislation is furthermore applied subject to a number of emerging Environmental Law Norms, including norms such as sustainable development, a human right to a decent environment, legal standing, inter-generational equity, the public trust doctrine, the precautionary principle, the preventive principle, the polluter pays principle, local level governance and the norm of common but differentiated responsibility.

Some of these norms have a profound influence on the way in which mining and industry need to perform their environmental management. In this regard, the precautionary principle, which states that “where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.” This norm introduces and elevates scientific quantification of impacts, and the associated risks to human health and the environment, to a status of representing a fundamental requirement in Environmental Management.

This implies that from a technical perspective, all environmental systems must be understood to their full consequence, to allow for accurate, quantitative impact and risk assessment, on which to base decisions related to the management of these systems. In simple laymen terms, this means that the different biophysical components of the environment must be measured and monitored, to supply quantitative decision making information of high certainty, on which to base the management of the environment.

However, effective integrated environmental management does not only require a fundamental understanding of the environmental components and the activities and processes which could impact on the environment, but more important, the transient development of the impacts associated with these processes, need to be understood to such a degree that their future development and response to management, remedial and/or rehabilitation measures, can be predicted.

Environmental Monitoring therefore forms the cornerstone of Integrated Environmental Management.

Environmental Management policies in South Africa advocate the Risk Based (Averse) Approach, subject to the implementation of the Best Practical Environmental Option (BPEO), using the management hierarchy of Source-Pathway-Receptor. The Source-Pathway-Receptor hierarchy requires an in-depth understanding of the origin of all pollutants, the pathway these pollutants could follow into the environment and the ultimate fate of these pollutants. The overarching Risk Profile relates to the protection of Human Health and the Environment. BPEO is a minimum requirement in terms of South African Environmental Management Policy and forms the basis of all source control measures to be implemented.

On a practical level, compliance with all the above legislation, environmental law norms, guidelines and policies, requires environmental monitoring systems which must ensure the generation, interpretation and reporting of information of high scientific integrity.

The monitoring of the soil environment has not been legislated in terms of South African Law, but as an integral part of the "pathway" that any pollutant or contaminant is likely to follow, it is often an area where the contaminant is detected in the early stages of a problem, and often, due to its variability and ability to inhibit flow rates is part of the protection mechanism that can be used in mitigating impacts. The soils can also of course be part of the source of contamination.

Monitoring of the water in the environment are legislated and, although the nature of the material being sampled and analysed is different, the principles and methodology are similar. Formal technical guidelines for Environmental Monitoring are currently being developed locally.

Internationally there are norms that have been tabled for certain metal content and hydrocarbon limits to soils, and SA have adopted a similar approach to the understanding of soil quality, with research being undertaken on a need to know basis. This is often not satisfactory, and a retrospective philosophy that is often costly.

In addition, it is not only important to understand the presence of contamination in the vadose zone and soil profile, but it is necessary to understand the quality of a soil if it is to be used as a growing medium. The nutrient content of a soil is important to the success of failure of many a rehabilitation project.

The results of soil analysis should be assessed to determine areas of success and identify any activities that require corrective or preventative action and improvement.

In this particular case (Soil and Land Capability), it is the intention of this monitoring plan to raise awareness regarding the possibility of problems within the soil profile (be it due to inputs of material from the mining activities that are a potential source of contamination, or the observation of nutrient levels), that can be mitigated.

By monitoring and observing the development (trends) of change within a soil profile, the corrective action to remedy the situation is highlighted early.

Data should be collected systematically, from appropriate sources at a frequency consistent with the environmental objectives and targets, taking cognizance of the significance of the environmental aspects.

The environmental management plan specifies the baseline conditions that are to be achieved as part of the rehabilitation planning, and gives input into the procedures for the dealing of contaminated soils.

At the outset, and as part of the baseline information gathered, soil chemistry was measured for the pre-mining environment. This must be used as the basis for any change that becomes apparent during the activity.

The demarcating of specific points for monitoring are not recommended as composite samples were originally taken at the time of baseline investigation. Sampling of specific points during the life cycle of the mining venture will need to be decided on a need to understand basis, with the rehabilitated areas being sampled for nutrient levels when required, and any areas of concern regarding contamination will need to be determined and a specific grid decided for each individual situation.

As with any monitoring and data capture, protocols need to be developed for the specifics of the area and the material being sampled. In the case of soils, it is important that aspects such as sampling technique, sampling equipment, sampling frequency, sample preservation, analysing technique, and variables to be analysed for, should be formalized and documented.

The frequency of monitoring/sampling should at all times be a combined function of the sampling objectives and the expected variability in the parameter(s) to be monitored. In the case of soils the changes and variation in quality are generally a function of input or removal due to a known action or process and the measuring of change will be determined on a need to know basis. This is specifically true for the rehabilitation of an area, or when a spill has occurred. Thus, the frequency of sampling will be determined by the circumstance.

The success of any monitoring program depends inter alia on the selection of appropriate sampling techniques and equipment to satisfy all monitoring objectives. Broadly speaking these objectives should support regulatory requirements, certain operational decision making requirements and corrective action evaluation. Incorrect or poorly selected sampling techniques will render all of the preceding effort (such as evaluation of site conditions, optimization of sampling frequency and selection of variables to be analysed for) futile.

Great care should at all times be taken in the field to prevent mishaps or contamination. In the case of soil monitoring, the equipment used will depend on the depth at which the sample is to be taken and the quantity of material that is needed. If only the nutrient content of a soil is needed as part of the rehabilitation planning, then relatively small quantities of soil are needed, while the understanding of a soils physical attributes and its engineering properties or possible containment of a contaminant will often require that a much bigger sample is taken a varying depths through the profile.

Aspects such as timing, techniques, and the capture of the information will vary with the different reasons for undertaking the sampling. Please refer to Section 4 – Management Planning for details on sampling periods and determinants that are recommended.

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LIST OF ABBREVIATION TERMS

JBU	**:**	JB Umwelttechnik
IWWMP	**:**	Integrated Water and Waste Management Plan
MAR	**:**	Mean Annual Rainfall
PCD	**:**	Pollution Control Dam
DTM	**:**	Digital Terrain Modelling
NGL	**:**	Natural Ground Level
SWMP	**:**	Storm Water Management Plan

1. INTRODUCTION

In 2018 JB Umwelttechnik (Pty) Ltd. was appointed by Ilima Coal Company (Pty) Ltd., to compile a Storm Water Management Plan for the KRANSPAN coal mine, South-West of Carolina in the Mpumalanga province. The Site comprises an area of approximately 111ha. See Fig. 1 for the site location. This area comprises mostly of agricultural land and farming infrastructure. . The area falls in the X11B sub-catchment.

The kranspan mine will consist of opencast mining and surface works:

2. SITE LOCATION

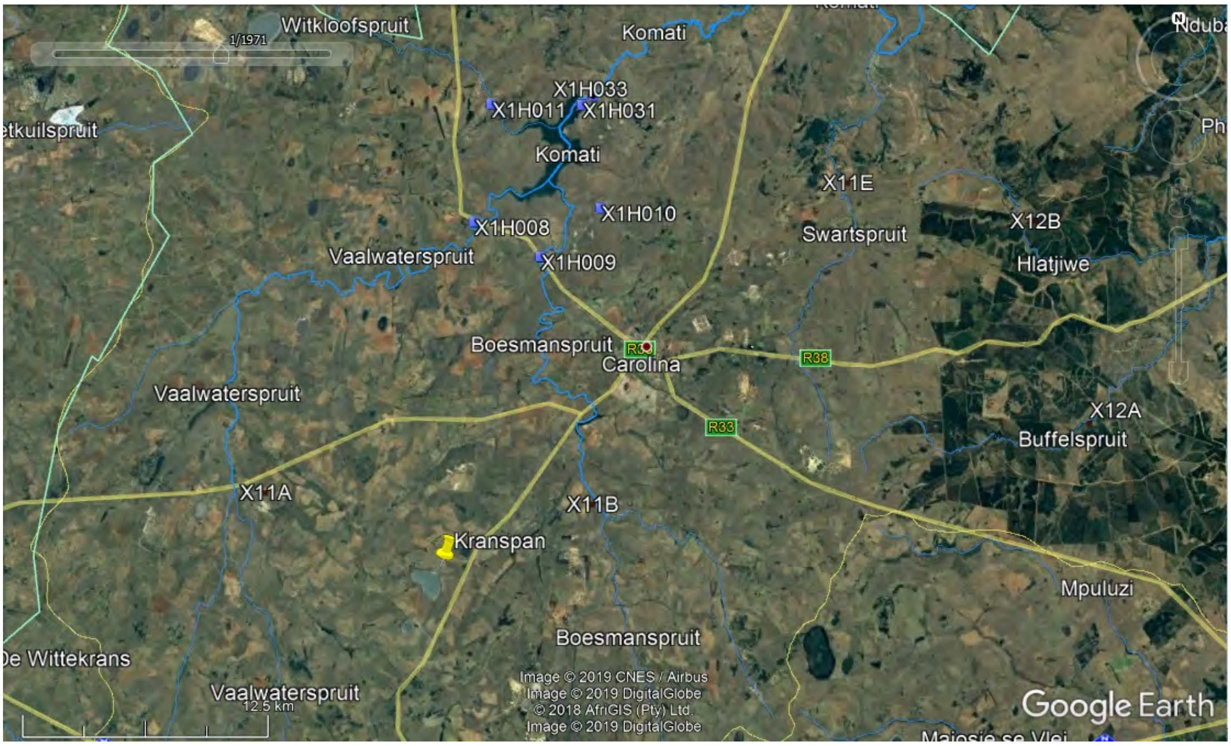

Figure 1: Site Location

3. WATER MANAGEMENT AREA AND CATCHMENTS

The catchment area is into various dirty sub catchment areas that corresponds to the proposed mining blocks. Each sub-catchment will be handled as a stand-alone system. The areas are divided as follow:

Figure 2: Dirty water areas

4. DESIGN METHOLDOLOGY

Watson (1981) states that run-off calculation techniques used in South Africa are inadequate and often based on unverified catchment and rainfall data. The use of various models should be used to derive the most probable values and to ensure that gross errors in estimation are eliminated. The ILLUDAS and RATIONAL methods were selected to derive run-off for the purpose of this study. The background to each method and the calculation methodologies are briefly explained below.

Since its inception in 1851, the Rational Method has become one of the world's most widely used methods for determining peak flows from small catchments. The basis of the relationship is the conservation of mass and the premise that the flow rate is directly proportional to the size of the contributing area and rainfall intensity. Rainfall intensity is a function of the return period. Peak flow is obtained by the following relationship:

$$Q=\frac{CIA}{3.6}$$

$$\frac{CIA}{3.6}$$

where:

Q = peak flow (m3/s);

C = run-off coefficient;

I = average rainfall intensity over catchment (mm/hour);

A = effective area of catchment (km2); and

3.6 = conversion factor.

Despite the Rational Method's shortcomings and widespread criticism, it provides realistic results, especially in combination with other run-off estimation models. The method is based on the following assumptions:

- The rate of rainfall is constant throughout the storm and uniform over the entire catchment
- Catchment imperviousness remains constant for the duration of the storm
- The contributing impervious area is uniform over the entire catchment

Assumption 1 can underestimate, as can assumption 3; however assumption 2 tends to overestimate. In most cases, these inaccuracies tend to cancel each other out producing a reasonably accurate result and a good first design approximation, in most situations and for smaller catchments (<150 hectares), the method can be used for full design.

Although The ILLUDAS method is not as sensitive as the Rational Method to user input and an entire hydrograph can be calculated for flood routing purposes. Peak flows, derived with the ILlUDAS method, were thus selected to check canal sizes for the dirty water areas at the Kranspan Coal Mine site.

Generally it was found that the peak outflow rates at the outfall locations for the dirty water catchments were similar using both the ILLUDAS and Rational methods. The time of concentration, i.e. time taken to achieve peak flow, varied between the two design methods.

5. STORM WATER MANAGEMENT PLAN

The KRANSPAN Mine has been designed as a "zero discharge Facility". This means that provisions have been made to divert storm water falling in areas where non-coal related activities are taking place away from the operational area and collecting storm water from dirty areas in the proposed pollution control dams on each of the defined mining areas. (PCD's)

The clean water diversion berms will be sized for a 1:100 year storm. This water is discharged directly into the environment as it is not contaminated by carbonaceous material from the site. For the purpose of this report, all the sizes have been designed to accommodate a 1:100 year storm as directed by Department of water affairs.

No retention ponds are required for the discharge from this areas as these diversions will not have an effect on the current flood hydrology curves. Energy dissipaters will be constructed in the outlet structures of the canals.

The dirty water collection drains will be designed for a 1:50 year storm. The dirty water will be collected in the PCD's on the eastern and southern end of the site, where it will either evaporate or be used as service water (Dust suppression). The PCD's together have a capacity of approximately 1 450 000m^3. The PCD's have been designed to fall within the limit of 50 000m^3 capacity and 5m high dam wall. In order to ensure that the dams can contain a 1:50 year storm, a portion of each of the PCD capacity will be used for Service water and normal rainfall collection. All haul roads that can contain carbonaceous material will be bermed of to ensure no contamination of surrounding clean areas.

6. CLEAR WATER DRAINAGE SIZING

Clean water catchment area falls beyond the scope of this report as it will have no influence on the Dirty water footprint, and have thus been left out of the scope.

7. POLLUTION CONTROL DAM

The capacities of the pollution control dams have been sized to contain a 1:50 year storm event from a run-off area of 46ha. Although this area is smaller than the total respective mining areas, the whole area will not be stripped at any one time as the "roll – over" mining method will ensure simultaneous rehabilitation behind the mining face. The dams will be lined with 1500 micron HDPE as well as a suitable clay lining to prevent any groundwater contamination (type C barrier). The projected lifespan of the lining is longer than the expected life of the facility (LOM: 6 years). The dams will be constructed to have an 800mm freeboard as directed in DWS best practice guidelines.

The dams will be designed to be accessible for maintenance purposes, but access controlled for safety.

The canals will be designed to allow for a 30% silt load to ensure proper operation and serviceability.

Specifications for each of the dams are as follow:

Dirty water runoff area 1 (A1 Open cast mining):

Area	=	1.11km² (0.46km² actual)
Longest water course	=	1198m (800m actual)
Level difference	=	24m
Slope	=	0.03m/m

Table 1: Dirty water runoff area: A1 Open cast mining

Description	Value
Area	0.46km²
Longest Water Course	0.8km
Level Difference	24m
Slope	0.03m/m
Return period	1:50
Cover	0.3
Seasonal rainfall	Summer
Average Annual Rainfall	750mm
Tc (Overland)	0.703
Slope Coefficient	0.03
Permeability Coefficient	0.16
Cover Coefficient	0.245
Runoff Coefficient “C”	0.361
Peak flow 1:50	4.85m³/sec

Dirty water runoff area 1 (B1 Open cast mining):

Area	=	1.46km² (0.46km² actual)
Longest water course	=	1198m (800m actual)
Level difference	=	44m (24m actual)
Slope	=	0.03m/m

Table 2: Dirty water runoff area: B1 Open cast mining

Description	Value
Area	0.46km²
Longest Water Course	0.8km
Level Difference	24m
Slope	0.03m/m
Return period	1:50
Cover	0.3
Seasonal rainfall	Summer
Average Annual Rainfall	750mm
Tc (Overland)	0.703
Slope Coefficient	0.03
Permeability Coefficient	0.16
Cover Coefficient	0.245
Runoff Coefficient “C”	0.361
Peak flow 1:50	4.85m³/sec

Dirty water runoff area 1 (C1 Open cast mining):

Area = 5.23 km^2 (0.46km^2 actual)

Longest water course = 1198m (800m actual)

Level difference = 44m (23m actual)

Slope = 0.03m/m

Table 3: Dirty water runoff area: C1 Open cast mining

Description	Value
Area	0.46km^2
Longest Water Course	0.8km
Level Difference	24m
Slope	0.03m/m
Return period	1:50
Cover	0.3
Seasonal rainfall	Summer
Average Annual Rainfall	750mm
Tc (Overland)	0.703
Slope Coefficient	0.03
Permeability Coefficient	0.16
Cover Coefficient	0.245
Runoff Coefficient “C”	0.361
Peak flow 1:50	4.85m^3/sec

Dirty water runoff area 1 (EX1 Surface works):

Area	=	0.08 km^2 (0.08km^2 actual)
Longest water course	=	412m (412m actual)
Level difference	=	12m (12m actual)
Slope	=	0.03m/m

Table 4: Dirty water runoff area: EX1 Surface works

Description	Value
Area	0.08km^2
Longest Water Course	04
Level Difference	12m
Slope	0.03m/m
Return period	1:50
Cover	0.3
Seasonal rainfall	Summer
Average Annual Rainfall	750mm
Tc (Overland)	0.703
Slope Coefficient	0.03
Permeability Coefficient	0.16
Cover Coefficient	0.245
Runoff Coefficient “C”	0.361
Peak flow 1:50	4.92m^3/sec

Dirty water runoff area 1 (D1 Open cast mining):

Area	=	5.23 km^2 (0.46km^2 actual)
Longest water course	=	1198m (800m actual)
Level difference	=	44m (23m actual)
Slope	=	0.03m/m

Table 5: Dirty water runoff area: C1 Open cast mining

Description	Value
Area	0.46km^2
Longest Water Course	0.8km
Level Difference	24m
Slope	0.03m/m
Return period	1:50
Cover	0.3
Seasonal rainfall	Summer
Average Annual Rainfall	750mm
Tc (Overland)	0.703
Slope Coefficient	0.03
Permeability Coefficient	0.16
Cover Coefficient	0.245
Runoff Coefficient “C”	0.361
Peak flow 1:50	4.75m^3/sec

Dirty water runoff area 1 (E1 Open cast mining):

Area	=	1.473 km^2 (0.46km^2 actual)
Longest water course	=	1500m (800m actual)
Level difference	=	45m (24m actual)
Slope	=	0.03m/m

Table 6: Dirty water runoff area: E1 Open cast mining

Description	Value
Area	0.46km^2
Longest Water Course	0.8km
Level Difference	24m
Slope	0.03m/m
Return period	1:50
Cover	0.3
Seasonal rainfall	Summer
Average Annual Rainfall	750mm
Tc (Overland)	0.703
Slope Coefficient	0.03
Permeability Coefficient	0.16
Cover Coefficient	0.245
Runoff Coefficient “C”	0.361
Peak flow 1:50	4.85m^3/sec

8. OPEN CANAL DESIGN

The surface operations area (1) will drain via overland flow into an open canal system that will drain to the PCD's. These canals have been sized to accommodate a 1:50 year storm.

Table 7: Open Canal Design

Description	Value
Bed width	0.1.1m
LSH Side Slope	2.5m/m
RHS Side Slope	2.5m/m
Depth	0.53m
Grade	0.03m/m
Manning "n" value	0.015
Flow capacity	7.5m³/s

The canals will be designed to allow for a 30% silt load to ensure proper operation and serviceability.

9. PUMPSTATION

Due to the short LOM predicted for each of the areas, it was decided to omit dry-well pump stations and transfer water from the dam by means of floating pump systems. This pumping systems will be manually operated in order to enable the use of the water in the PCD's for dust suppression and other operational water.

10. CONCLUSION AND RECOMMENDATIONS

The storm water management plan ensures a fit-for-purpose design of all storm water management infrastructure that will be able to contain a storm of 1:50 year magnitude. The proposed infrastructure also minimizes the negative effect on the environment should a larger storm occur.

The dams and drain sizes in this project will be sized optimally with some minor additional capacity to act as a safety factor.

Care should however be taken to keep dam levels to a minimum in the wet season.

ANNEXURE A
PCD LAYOUT AND DETAILS

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PREPARED FOR:

ABS Africa
Sustainability Advisors

KRANSPAN COAL MINE
HYDROLOGICAL SPECIALIST REPORT

TITLE	**KRANSPAN COAL MINE** **HYDROLIGICAL SPECIALIST REPORT**
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DATE	18/02/2019
REFERENCE NUMBER	0155_KRANSPAN_HYDROLOGICAL SPECIALIST REPORT
PROJECT TEAM	H.S Peens *Pr.TechEng.*
STATUS	*SECOND DRAFT REPORT*

EXECUTIVE SUMMARY

Peens and Associates was appointed by ABS Africa (Pty) to produce a Hydrological Specialist Report for the proposed Kranspan Coal Mine that is situated on the farm Kranspan 49 Portions 1 to 8 and Remainder near Carolina in the Mpumalanga Province.

This report covers the current hydrological situation of the proposed mining right area. The outputs generated in the report will be utilised to populate the relevant sections of the EIA and EMPR.

The conclusions drawn from the analyses done for the current situation are as follows:

- The proposed mining right area is located in the **X11B** quaternary sub-catchment of the Komati River Drainage Basin;
- The Boesmanspruit is the major stream flowing past the proposed mining right area with effective catchment areas of **597** km^2;
- The proposed mining right area has a Mean Annual Precipitation (MAP) of **698** mm;
- The proposed mining right area has a Mean Annual Evaporation (MAE) of **1 450** mm;
- The Nett Mean Annual Runoff (MAR) of the Boesmanspruit is **26.2** mil m^3;
- The proposed mining right area contributes **1.05** mil m^3 or **4.0**% of the nett mean annual runoff of the Boesman Spruit
- The Base / Normal Flow of the Boesmanspruit is **0.1** m^3/s;
- The proposed mining right area contributes **0.0044** m^3/s or **4.0**% of the base flow for the Boesman Spruit
- The drainage density of the proposed mining right area was calculated at **0.18** km/km^2;
- The recommended 100 year flood levels of the three most significant pans are as follows:
    - "S1" = 1 654.90 masl
    - "S2" = 1 654.66 masl
    - "S3" = 1 651.80 masl

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1. INTRODUCTION

Peens and Associates was appointed by ABS Africa (Pty) to produce a Hydrological Specialist Report for the proposed Kranspan Coal Mine that is situated on the farm Kranspan 49 Portions 1 to 8 and Remainder near Carolina in the Mpumalanga Province.

This report covers the current hydrological situation of the proposed mining right area. The outputs generated in the report will be utilised to populate the relevant sections of the EIA and EMPR.

2. APPROACH AND METHODOLOGY

The following approach and methodology was adopted during the compilation of the hydrological specialist report:

- Gather existing information from credible sources such as those available from the Department of Water and Sanitation and site observations.
- Evaluate data sets such a rainfall data and river flow records for errors.
- Compile drawings and sketches on the 1:50 000 topographical maps for catchment delineation, catchment and river characteristics.
- Analyse data sets to determine the outputs such as the mean annual precipitation and the mean annual runoff.

3. DESCRIPTION OF BASELINE

3.1. CATCHMENT DESCRIPTION

3.1.1. Drainage Region

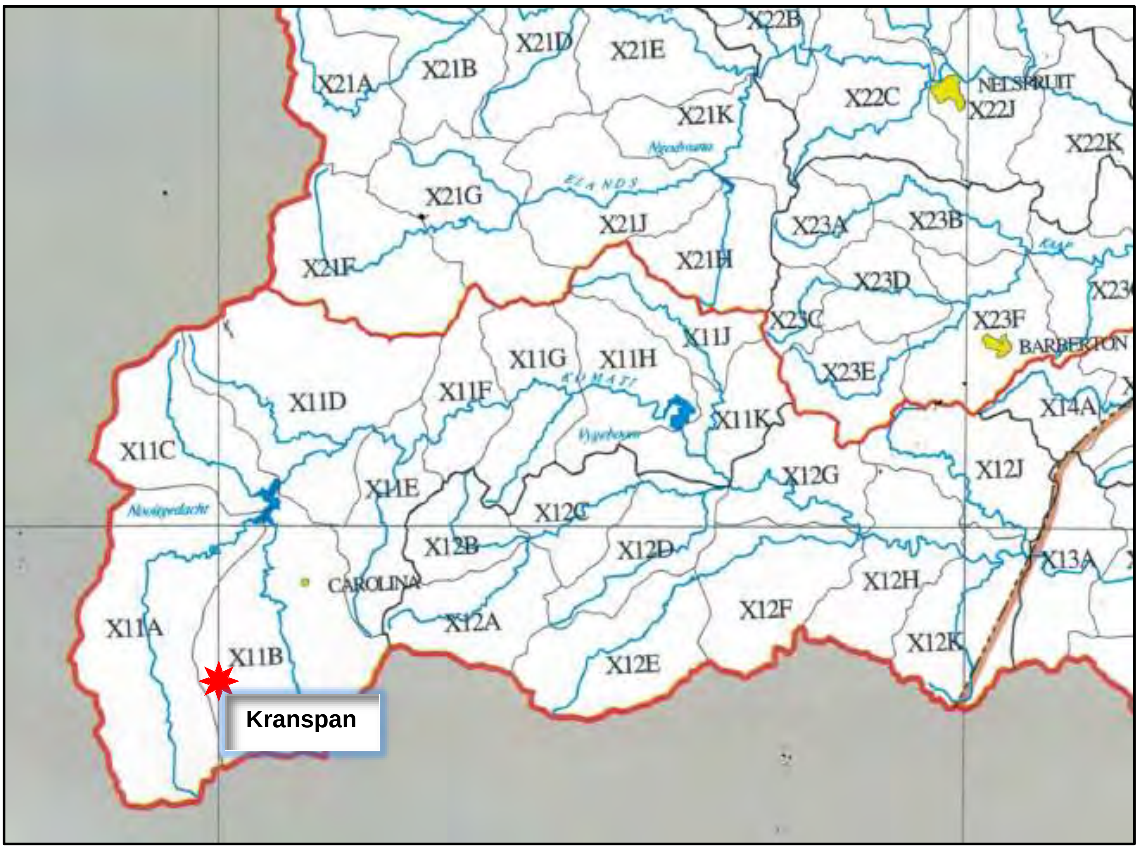
The proposed mining right area is situated in the X11B quaternary sub-catchment of the Komati River Drainage Region as per the Volume VI: Water Resources of South Africa 1990.

The Nooitgedacht Dam is the major reserving water body of the X11B quaternary sub-catchment that might be impacted by the proposed mine. The Nooitgedacht Dam total catchment area, i.e. quaternary sub-catchments; X11A, X11B and X11C combined is 1 588 km^2. The mean annual runoff (MAR) into Nooitgedacht Dam is 64.1 million m^3 per annum.

Quaternary sub-catchment X11B under laying geology is basic or mafic and ultramafic intrusive lavas, which forms part of the igneous group. Igneous rocks are formed by volcanic activities and in moderate to wet regions it decompose to form clay. The overburden soils are moderate to deep sandy loam.

The mean annual rainfall/ precipitation (MAP) of the quaternary sub-catchment is 714mm and the mean annual runoff (MAR) is 44mm. Quaternary sub-catchment X11B has a catchment area of 597 km^2 and its Nett MAR is 26.2 million m^3 per annum.

FIGURE 1: LOCATION OF PROPOSED MINING RIGHT AREA IN QUATERNARY SUB-CATCHMENT X11B



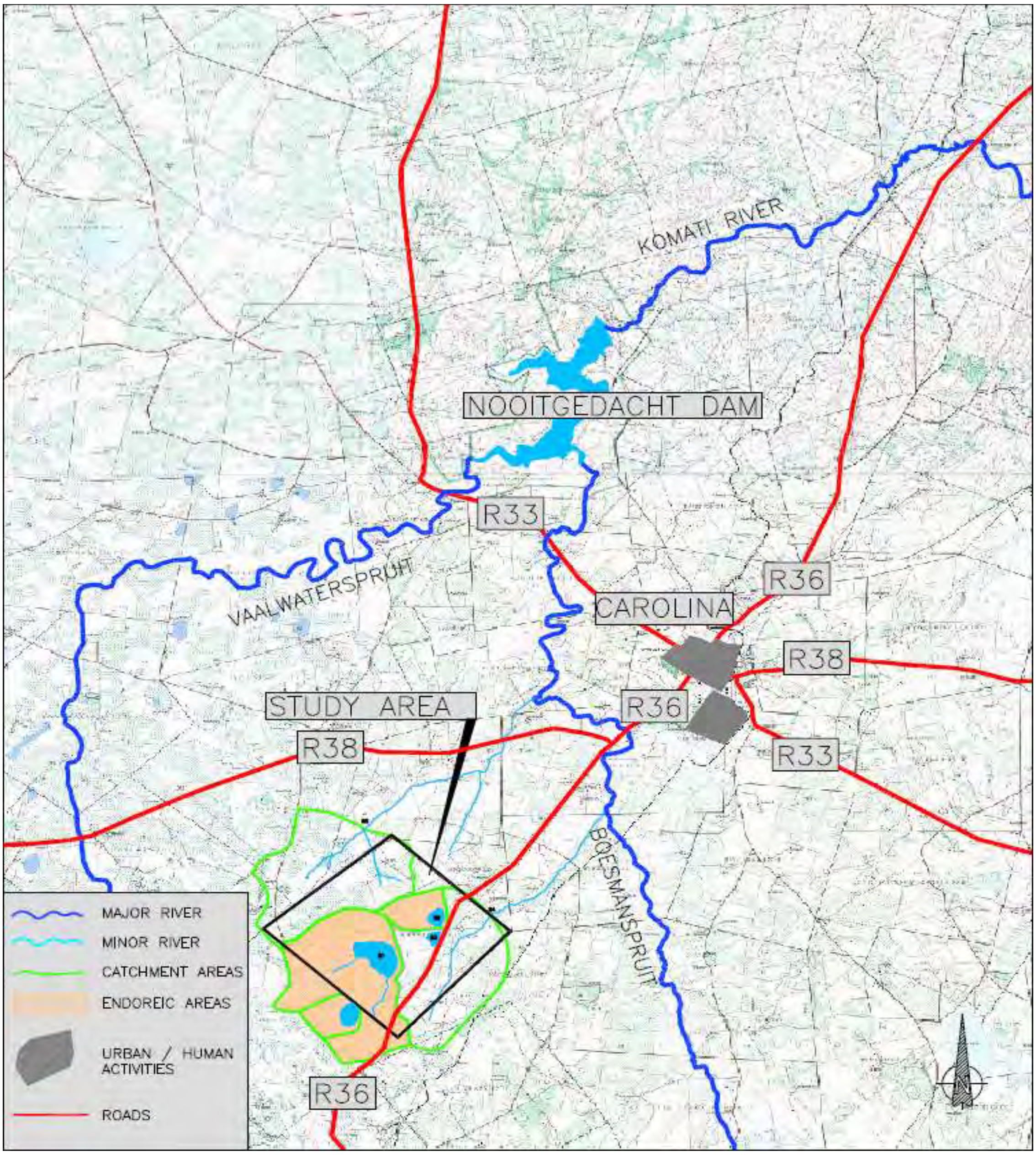
3.1.2. Major Rivers and Receiving Water Bodies

The Kranspan proposed mining right area is in the Boesmanspruit catchment area on the watershed between the Boesmanspruit and the Vaalwaterspruit catchments. Both the Boesmanspruit and the Vaalwaterspruit are tributaries of the Nooitgedacht Dam and the Komati River.

Three pans are located within the proposed mining right area of which two have no outflow and their catchment areas can therefore be classified as endorheic areas that do not contribute to the runoff towards Nooitgedacht Dam.

The proposed mining right area is 33.8 km^2 in size of which 37.6% (12.7km^2) is endorheic areas; hence the portion of proposed mining right area contribution to the Boesmanspruit runoff is 21.1 km^2. Thus the portion of the proposed mining right area that contributes to runoff in the Boesmanspruit is 3.5% of the Boesmanspruit catchment, which has a total catchment of 597 km^2.

FIGURE 2: PROPOSED MINING RIGHT AREA IN RELATION TO MAJOR RIVERS AND RECEIVING WATER BODIES



3.1.3. Minor Rivers / Watercourses in Proposed Mining Right Area

The proposed mining right area consists both of endorheic areas and non-endorheic areas. Nodes S1 and S2 are accumulation points of such endorheic areas, node S3 acts as an attenuation system with only extreme flood events discharging into the catchment of node S4.

However the discharge from S3 will never contribute to the flood peaks of S4 as the response times of the catchments will not synchronise with the same storm events. The locations for nodes S4 and S5 were selected to obtain the minimum catchment area of each stream that will be affected by the proposed mining right area. The catchment areas mainly consist of grass lands and cultivated fields with predominantly flat slopes. The overburden soils are moderate to deep sandy loam and are classified as permeable soils.

FIGURE 3: SUB-CATCHMENTS AND NODES

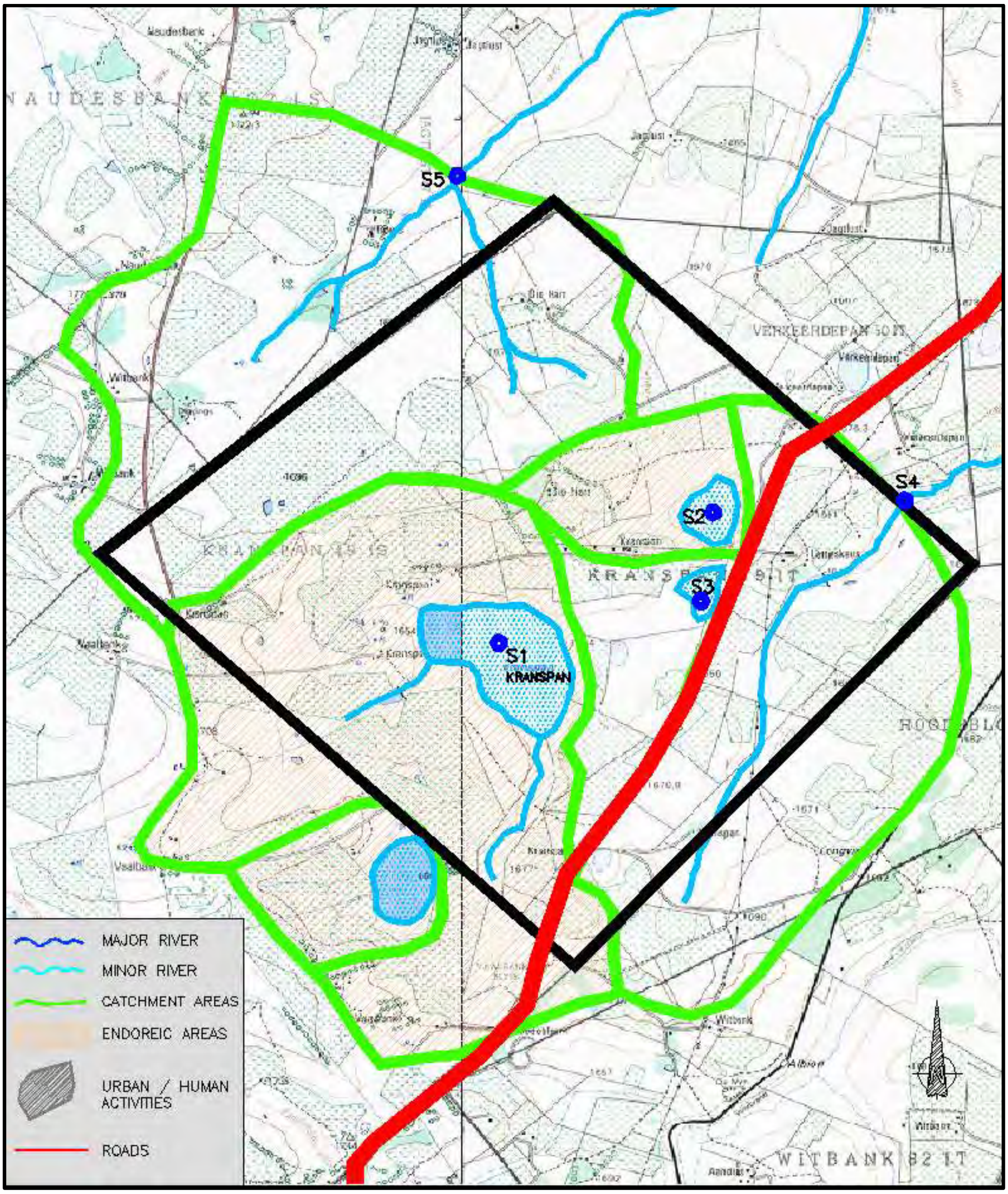


TABLE 1: SUMMARY OF WATERCOURSES CATCHMENTS ON SITE

Node Name	Effective Catchment Area (km^2)	Stream Length (Km)	10-85 Method Avg. Slope (1 :.....)	Overland Flow Length (Km)	Overland Avg. Slope (1: .....)
S1	15.490	3.62	49.35	-	-
S2	2.485	-	-	1.77	32.18
S3	2.222	-	-	3.37	134.77
S4	11.86	5.74	107.64	-	-
S5	16.49	4.62	86.66	-	-

Note: where no defined water course or stream is present in the catchment area the longest overland flow length and slope is determine to calculate the response time of the catchment.

3.2. SURFACE WATER RESOURCES HYDROLOGY

3.2.1. Rainfall

The rainfall characteristics of the proposed mining right area are documented in the Surface Water Resources of South Africa 1990 Volume VI and within the X1A rainfall zone as per Map No 1.3 in the Book of Maps. The closest rainfall station to the proposed mining right area is the South African Weather Station 0480267W – Kranspan which is located on the south-western boundary of the proposed mining right area, 2 km south-west of the node S1.

3.2.1.1. Mean Annual and Monthly Rainfall

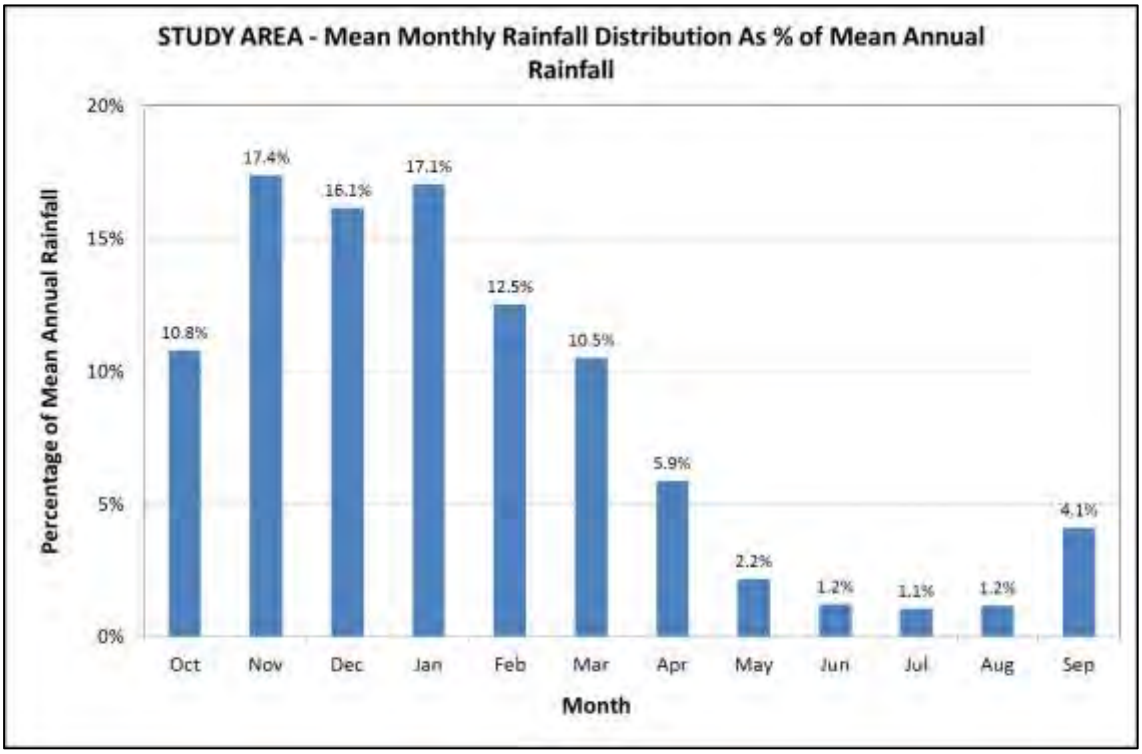
The mean annual rainfall for South African Weather Station 0480267W – Kranspan is **698mm** based on 44 years of data as indicated in the TR102 Southern African Storm Rainfall from PT Adamson. The mean monthly rainfall distributions as listed in the Surface Water Resources of South Africa 1990 Volume VI Appendix 2.2 were used to calculate the mean monthly rainfall and the annual standard deviation was used to estimate the typical wet and dry seasons.

The mean monthly rainfall distributions from Surface Water Resources of South Africa 1990 Volume VI Appendix 2.2 are listed in the table and shown in the figure below.

TABLE 2: MEAN MONTHLY RAINFALL DISTRIBUTIONS IN PERCENTAGE (%)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep
Distribution	10.8	17.4	16.1	17.1	12.5	10.5	5.9	2.2	1.2	1.1	1.2	4.1

FIGURE 4: PERCENTAGE MEAN MONTHLY DISTRIBUTION OF MEAN ANNUAL RAINFALL (MAP)



The mean monthly and annual rainfall for the proposed mining right area as well as that for typical wet and dry years is listed in the table below.

TABLE 3: MEAN MONTHLY AND ANNUAL RAINFALL (MM)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
Wet	87	139	129	137	100	84	47	17	11	8	10	33	802
Mean	75	121	113	119	87	73	41	15	9	7	9	29	698
Dry	64	103	96	101	74	62	35	13	8	6	8	24	594

3.2.2. Evaporation (S – Pan)

There are no weather stations with evaporation data in the vicinity of the proposed mining right area, hence the recommended values in the Water Research Commission's "Surface Water Resources of South Africa 1990 Manual" Volume 1 were used.

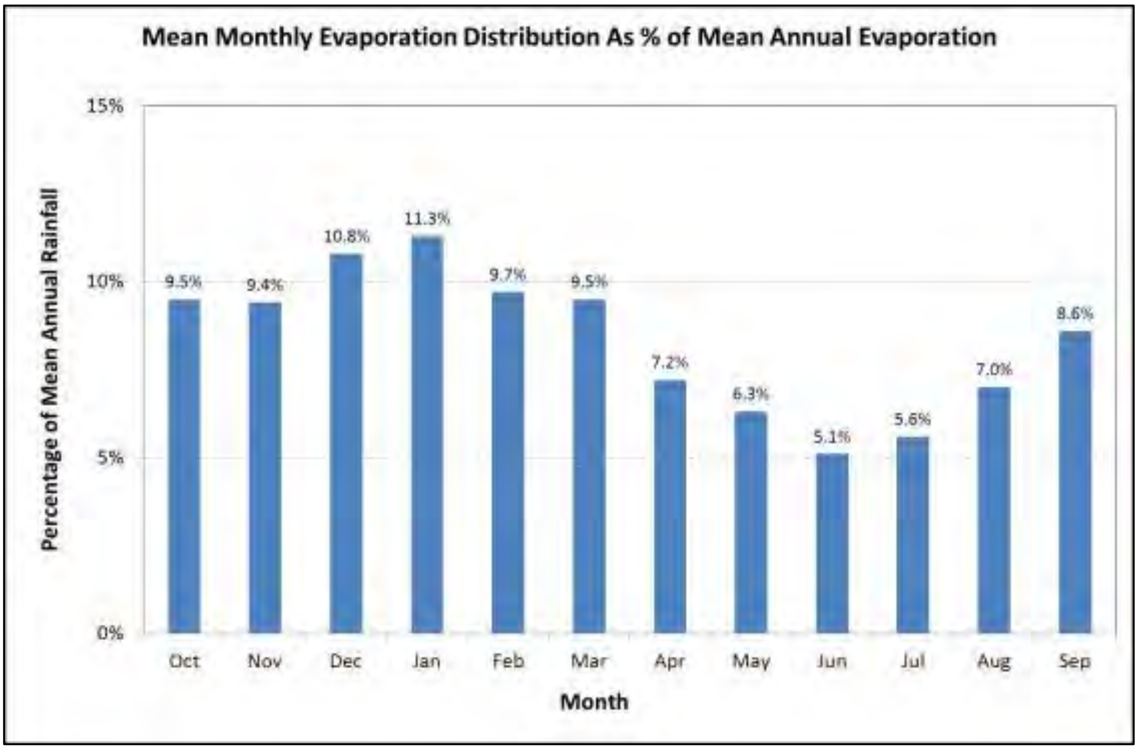
All the sub-catchments in the proposed mining right area are situated in quaternary sub-catchment X11B with a Mean Annual Evaporation (MAE) of 1 450mm. Quaternary sub-catchment X11B is within evaporation zone 5A.

The mean monthly evaporation distributions from Surface Water Resources of South Africa 1990 Volume VI Appendix 3.2 for zone 5A are listed in the table and shown in the figure below.

TABLE 4: MEAN MONTHLY EVAPORATION DISTRIBUTIONS IN PERCENTAGE (%)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep
Distribution	9.5	9.4	10.8	11.3	9.7	9.5	7.2	6.3	5.1	5.6	7	8.6

FIGURE 5: PERCENTAGE MEAN MONTHLY DISTRIBUTION OF MEAN ANNUAL EVAPORATION (MAE)



The mean monthly and annual evaporation for the proposed mining right area is listed in the table below.

TABLE 5: MEAN MONTHLY AND ANNUAL EVAPORATION (MM)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
Mean	138	136	157	164	141	138	104	91	74	81	102	124	1 450

3.2.3. Runoff

3.2.3.1. Mean Annual Runoff

There is no river flow gauging station in the Boesmanspruit in the vicinity of the proposed mining right area. Further, no gauging station could be located with sufficient data that can be used as a representation of this catchment area. In the absence of representative data, the recommended values in the Water Research Commission's "Surface Water Resources of South Africa 1990 Manual" Volume 1 were used.

a) Boesmanspruit

The proposed mining right area falls within quaternary sub-catchment X11B - Boesmanspruit. The calculated net MAR for the Boemanspruit is ***26.2 million m^3***.

TABLE 6: MEAN ANNUAL RUNOFF FOR THE BOESMANSPRUIT

Quaternary Sub – catchment Name	Net Area (km2)	Net MAR (10^6 m^3/a)
X11B	**597**	**26.2**

b) Proposed Mining Right Area

All the sub-catchments in the proposed mining right area are situated in quaternary sub-catchment X11B. The mean annual rainfall for this site is 698mm. The rainfall / runoff response number for this quaternary sub-catchment is 8, relating to a mean annual runoff (MAR) of 37mm runoff depth.

TABLE 7: MEAN ANNUAL RUNOFF OVER PROPOSED MINING RIGHT AREA

Catchment Name	Catchment Size (km^2)	MAR (m^3/a)	Comment
S1	15.490	573 130	Does not contribute to the mean annual runoff for the Boesmanspruit.
S2	2.485	91 945	
S3	2.222	82 214	
S4	11.86	438 820	Contributes to Boesmanspruit
S5	16.49	610 130	Contributes to Boesmanspruit
TOTAL	28.35	1 048 950	Total excludes S1, S2 and S3

3.2.3.2. Mean Monthly Runoff

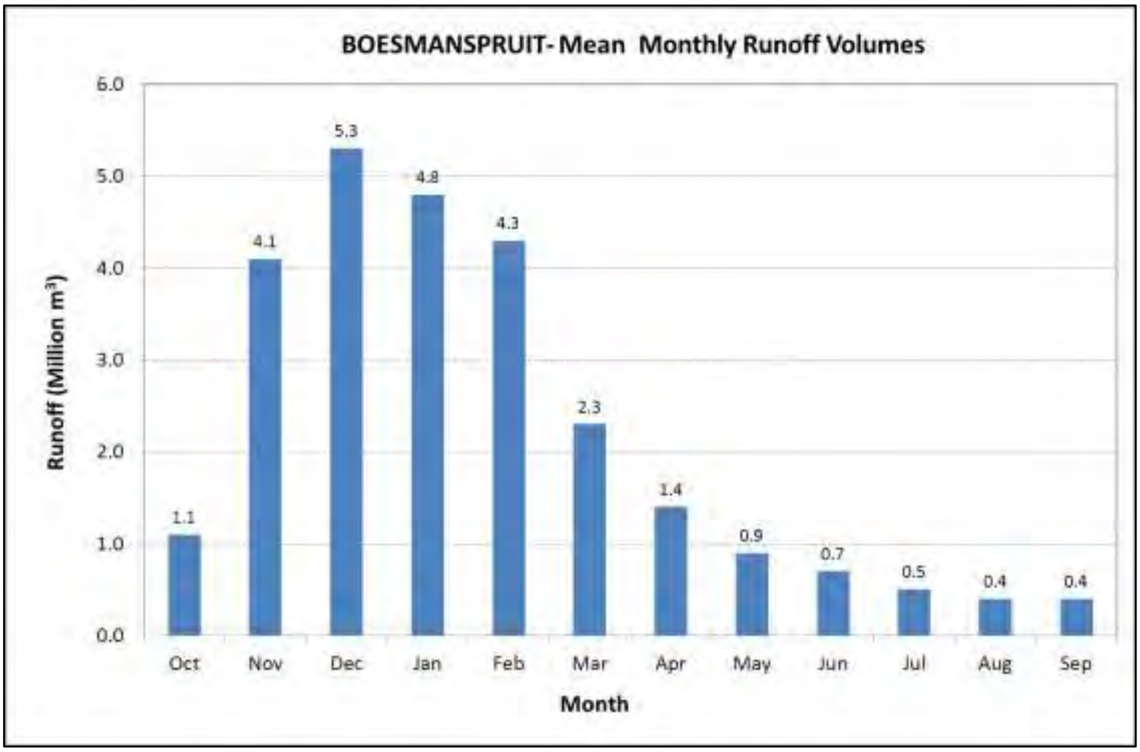
a) Boesmanspruit

The mean monthly runoff distribution ratios are obtained from the Water Research Commission's "Surface Water Resources of South Africa 1990 Manual Volume 1". The entire catchment of the Boesmanpruit is situated within the HYDRO Zone VI-P for which the manual recommends a percentage of the MAR for each month of the hydrological year.

TABLE 8: BOESMANSPRUIT MEAN MONTHLY RUNOFFS AND RATIOS

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	1.1	4.1	5.3	4.8	4.3	2.3	1.4	0.9	0.7	0.5	0.4	0.4	26.2
%	4.3	15.6	20.2	18.2	16.3	8.7	5.3	3.8	2.5	1.9	1.5	1.7	100

FIGURE 6: BOESMANSPRUIT MEAN MONTHLY RUNOFF VOLUMES



b) Proposed Mining Right Area

The mean monthly runoff distribution ratios used for the Boesmanspruit were utilised for each sub-catchment within the proposed mining right area and are listed in the tables below.

TABLE 9: "S1" MEAN MONTHLY RUNOFF

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	0.02	0.09	0.12	0.10	0.09	0.05	0.03	0.02	0.01	0.01	0.01	0.01	0.573

TABLE 10: "S2" MEAN MONTHLY RUNOFF

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	0.00	0.01	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.091

TABLE 11: "S3" MEAN MONTHLY RUNOFF

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	0.00	0.01	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.082

TABLE 12: "S4" MEAN MONTHLY RUNOFF

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	0.02	0.07	0.09	0.08	0.07	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.439

TABLE 13: "S4" MEAN MONTHLY RUNOFF

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	0.03	0.10	0.12	0.11	0.10	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.610

3.2.3.3. Base flow

The Water Act defines "Normal Flow" or base flow as that portion of the stream flow that can be beneficially used for irrigation without the aid of storage at a site.

Base flow is often estimated as the flow available 70% of the time during the critical irrigation season, i.e. the period of maximum demand and minimum runoff. This occurs usually during the months of June to September in the summer rainfall areas.

For the purpose of preliminary estimates the "Surface Water Resources of South Africa 1990 Manual" Volume 1 provides Deficient Flow – Duration – Frequency curves from where the base flow can be related to a percentage of the mean annual runoff.

TABLE 14: BASE FLOW FOR BOESMANSPRUIT

Quaternary Sub – catchment Name	Base Flow Ratio of MAR (%)	Base Flow (10^6 m^3/a)	Average Monthly Base Flow (10^6 m^3/a)	Average Base Flow Rate (m^3/s)
X11B	4.34	1.14	0.285	0.11

TABLE 15: BASE FLOW FOR SUB-CATCHMENT (S4)

Node Name	Base Flow Ratio of MAR (%)	Base Flow (10^6 m^3/a)	Average Monthly Base Flow (10^6 m^3/a)	Average Base Flow Rate (m^3/s)
S4	4.34	0.019	0.005	0.0018

TABLE 16: BASE FLOW FOR SUB-CATCHMENT (S5)

Node Name	Base Flow Ratio of MAR (%)	Base Flow (10^6 m^3/a)	Average Monthly Base Flow (10^6 m^3/a)	Average Base Flow Rate (m^3/s)
S5	4.34	0.026	0.007	0.0026

3.3. FLOOD HYDROLOGY

3.3.1. Design Storm

The closest rainfall gauging station to the proposed mining right area is the 0480267W – Kranspan. The design rainfall events associated with this gauging station is documented in the TR 102 Southern African Storm Rainfall.

For storm duration less than 6 hours the following relationship developed by Hershfield and later modified by Alexander is used to calculate point rainfall:

$P_t,T = 1.13(0.41 + 0.64^* \ell n\ T)(-0.11 + 0.27^* \ell n\ t)(0.79M^{0.69}R^{0.20})$

* R = 60 days/year that thunder is seen.

TABLE 17: DESIGN 24 HOUR RAINFALL DATA

Station Number	Description	MAP (mm)	24-Hour Rainfall (mm)						
			1:2	1:5	1:10	1:20	1:50	1:100	1:200
0480267	Kranspan	698	62	82	97	112	135	153	173

3.3.2. Flood Peaks and Volumes

The flood peaks was calculated utilising the Rational Method. The flood volume was calculated using a triangular hydrograph with the time of concentration equal to a third of the storm duration.

The table below summarises the peak flows and flood volumes for the range recurrence intervals.

TABLE 18: FLOOD PEAKS AND VOLUMES FOR WATER COURSES IN PROPOSED MINING RIGHT AREA

Catchment Name		Recurrence Interval						
		1:2	1:5	1:10	1:20	1:50	1:100	1:200
S1	Flood Peak (m^3/s)	32.7	58.9	81.3	107.1	141.5	171.6	194.3
	Flood Volume (10^3 m^3)	141.6	255.0	351.9	463.6	612.6	742.9	841.1
S2	Flood Peak (m^3/s)	4.0	7.2	10.0	13.0	17.2	20.9	23.7
	Flood Volume (10^3 m^3)	25.1	45.1	62.6	81.4	107.7	130.9	148.5
S3	Flood Peak (m^3/s)	2.3	4.2	5.8	7.6	10.1	12.2	13.8
	Flood Volume (10^3 m^3)	27.1	49.4	68.3	89.5	118.9	143.6	162.5
S4	Flood Peak (m^3/s)	14.2	25.5	35.5	46.4	61.4	74.4	84.3
	Flood Volume (10^3 m^3)	118.1	212.1	295.2	385.9	510.6	618.7	701.0
S5	Flood Peak (m^3/s)	23.7	42.6	59.2	77.4	102.4	124.2	140.6
	Flood Volume (10^3 m^3)	153.6	276.0	383.6	501.6	663.6	804.8	911.0

3.4. DRAINAGE DENSITY

The drainage density is the total stream and river lengths in a particular catchment divided by the total catchment area. The density of the drainage system will directly influence the proportion of the precipitation that will contribute to direct runoff.

The proposed mining right area's drainage density is therefore ***0.18 km/km²***.

4. Flood Levels In Pans

4.1. FLOOD VOLUMES

The maximum 100 year return period flood level in the pans was determined by calculating the water level associated with the largest runoff volume between the 1:100 year flood peak volume, the 1:100 year 1 day storm and the 1:100 year 7 day storm.

This approach was taken as the pans do not have outflows except for S3 which will only discharge a small portion of the incoming flood under extreme floods due to the culvert crossings under the R36 road beings roughly 1m above the current surveyed water level.

The flood volumes associated with various storm events are listed in the table below.

Table 19: Flood Volumes Into Pans

Node Name	1:100 year (flood peak volume) (10^3 m^3)	1:100 year (1 day storm flood volume) (10^3 m^3)	1:100 year (7 day storm flood volume) (10^3 m^3)
S1	742.9	710.9	***1 291.8***
S2	130.9	114.1	***207.2***
S3	143.6	127.1	***231.0***

4.2. PANS STAGE – STORAGE DATA

The stage versus storage volumes were calculated based on the survey with 1m contour intervals provided for the project. Although the pans dry up in winter the water edge level as on the day of the survey was taken as the normal water level. The mean annual runoff into all the pans is between two and four time less than the maximum 100 year flood volume.

It is expected that only during extreme events a noticeable rise in water level will be observed in the pans. The tables below list the stage vs accumulative storage volumes for the three pans marked as nodes “S1”, “S2” and “S3”

Table 20: Node “S1” Stage vs Volume

Node “S1”			
Stage (masl)	**Accu. Volume (10^3 m^3)**	**Stage (masl)**	**Accu. Volume (10^3 m^3)**
1654	0	1656	3 098
1655	1 444	1657	4 912

TABLE 21: NODE "S2" STAGE VS VOLUME

Node "S2"			
Stage (masl)	**Accu. Volume (10^3 m^3)**	**Stage (masl)**	**Accu. Volume (10^3 m^3)**
1654	0	1657	670.1
1656	312.8	1658	1 062.7

TABLE 22: NODE "S3" STAGE VS VOLUME

Node "S3"			
Stage (masl)	**Accu. Volume (10^3 m^3)**	**Stage (masl)**	**Accu. Volume (10^3 m^3)**
1651	0	1653	720.4
1652	298.3		

4.3. 100 YEAR FLOOD LEVELS

The water levels associated with the flood volumes for the three scenarios were calculated by applying a regression curve to the stage versus storage curves for each pan. In all three cases the 7 day storm event resulted in the highest water levels in the pans, the instantaneous flood peak events and the 1 day storm events produced similar levels.

These results support the observations from the site visit that no outflow from S1 and S2 is possible and that outflow from S3 is only expected for extreme events since the level reached during a 100 year event is still less than the estimated invert level of the culvert under the R36.

TABLE 23: 100 YEAR FLOOD LEVELS

Node Name	1:100 year (flood peak volume) Water Level (masl)	1:100 year (1 day storm flood volume) Water Level (masl)	1:100 year (7 day storm flood volume) Water Level (masl)
S1	1654.51	1654.49	***1654.90***
S2	1654.42	1654.37	***1654.66***
S3	1561.51	1561.46	***1651.80***

5. CONCLUSIONS

The conclusions drawn from the analyses done for the current situation are as follows:

- The proposed mining right area is located in the **X11B** quaternary sub-catchment of the Komati River Drainage Basin;
- The Boesmanspruit is the major stream flowing past the proposed mining right area with effective catchment areas of **597** km^2;
- The proposed mining right area has a Mean Annual Precipitation (MAP) of **698** mm;
- The proposed mining right area has a Mean Annual Evaporation (MAE) of **1 450** mm;
- The Nett Mean Annual Runoff (MAR) of the Boesmanspruit is **26.2** mil m^3;
- The proposed mining right area contributes **1.05** mil m^3 or **4.0**% of the nett mean annual runoff of the Boesman Spruit
- The Base / Normal Flow of the Boesmanspruit is **0.1** m^3/s;
- The proposed mining right area contributes **0.0044** m^3/s or **4.0**% of the base flow for the Boesman Spruit
- The drainage density of the proposed mining right area was calculated at **0.18** km/km^2;
- The recommended 100 year flood levels of the three most significant pans are as follows:
    - "S1" = 1 654.90 masl
    - "S2" = 1 654.66 masl
    - "S3" = 1 651.80 masl

6. REFERENCES

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*Alexander, W.J.R. 2000. **Flood risk reduction measures**, Revised Edition University of Pretoria*

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*Department of Water Affairs, PT Adamson, 1981, **Southern Africa Storm Rainfall, TR102***

APPENDIX A
WR90 - FIGURES AND TABLES

B.7

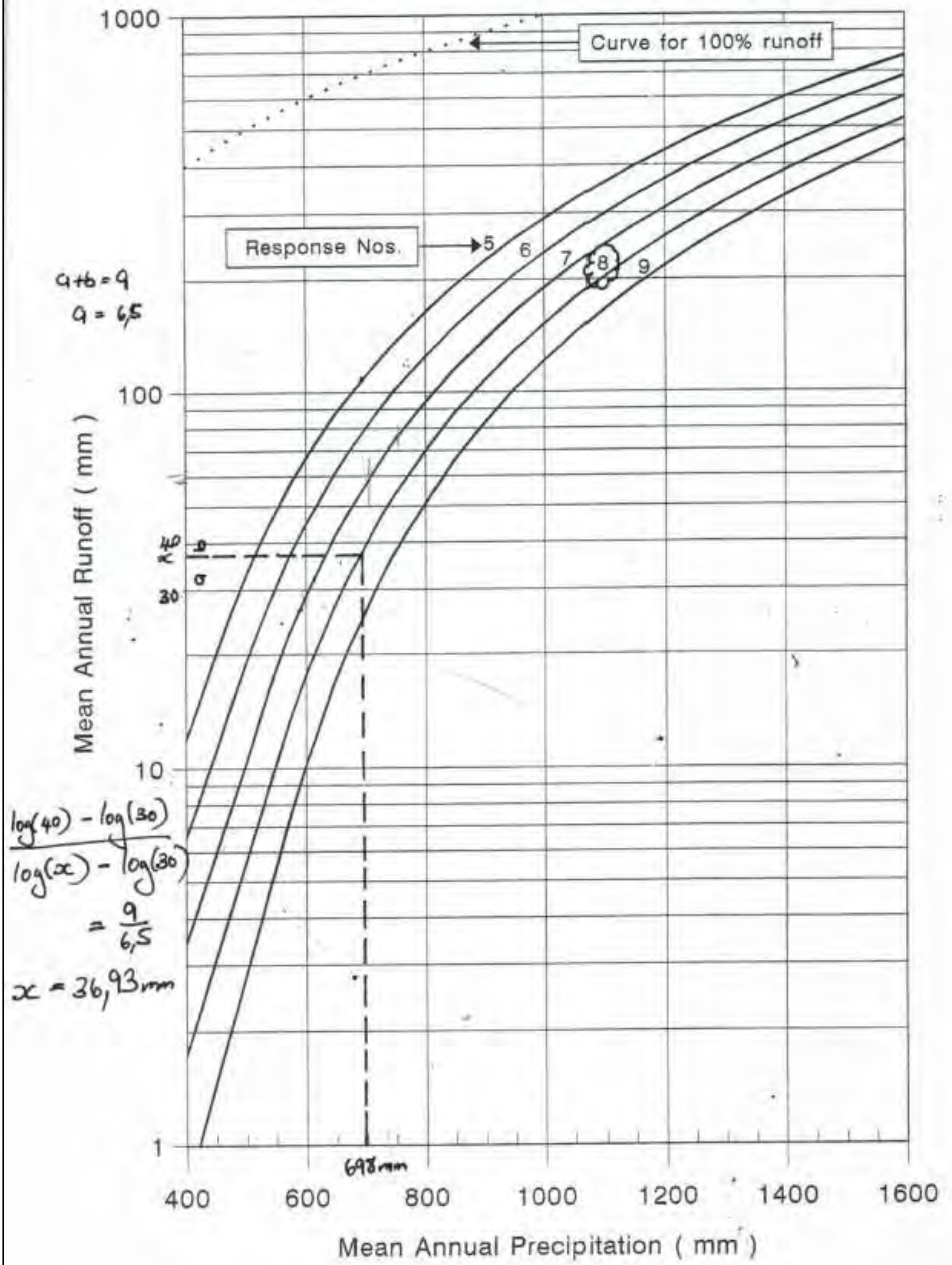
(VOLUME VI) APPENDIX B : QUATERNARY AND TERTIARY CATCHMENT INFORMATION (contd.)

CATCHMENT	GROSS AREA (km²)	NET AREA (km²)	FOREST AREA (km²)	IRRIG AREA (km²)	EVAP ZONE	MAE (mm)	RAIN ZONE	MAP (mm)	MAR (mm)	MAP-MAR RESP.	NET MAR (10^6m^3)	GROSS MAR (10^6m^3)	CV	HYDRO ZONE	DAMS
W57A	593	593		3.6	13A	1400	W5J	824	179	5	106.1	106.1	.704	C	
W57B	434	434		1.1	13A	1450	W5J	784	67	8	28.9	28.9	1.419	Q	
W57C	575	575		.4	13A	1450	W5J	755	59	8	33.7	33.7	1.463	Q	
W57D	366	366		2.4	13A	1400	W5J	862	197	5	72.0	72.0	.696	C	
W57E	403	403		13.7	13A	1450	W5J	701	46	8	18.4	18.4	1.541	Q	
W57F	223	223		.3	13A	1450	W5J	774	151	5	33.7	33.7	.720	C	
W57G	623	623		1.7	13A	1450	W5J	644	34	8	21.2	21.2	1.612	Q	
W57H	426	426		62.2	13A	1500	W5J	710	45	8	19.4	19.4	1.533	Q	
W57J	522	522		37.1	13A	1500	W5J	628	30	8	15.7	15.7	1.622	Q	
W57K	301	301	3		13A	1500	W5J	628	30	8	9.1	9.1	1.622	Q	
W57	4466	4466	3	122.5		1453		729	80		358.0		1.023		
W60A	172	172	1	1.7	13A	1400	W6A	1156	411	5	70.7	70.7	.406	A	
W60B	143	143		3.4	13A	1400	W6A	1201	439	5	62.8	62.8	.406	A	
W60C	233	233		5.1	13A	1400	W6A	1161	414	5	96.5	96.5	.406	A	
W60D	187	187		6.8	13A	1400	W6B	937	206	6	38.5	38.5	.626	C	
W60E	134	134		.2	13A	1450	W6B	806	73	8	9.8	9.8	1.254	Q	
W60F	418	418		2.2	13A	1450	W6B	801	71	8	29.9	29.9	1.259	Q	
W60G	222	222		.8	13A	1400	W6A	912	187	6	41.5	41.5	.549	C	
W60H	365	365		1.6	13A	1450	W6B	796	70	8	25.5	25.5	1.264	Q	
W60J	447	447			13A	1450	W6B	819	77	8	34.5	34.5	1.241	Q	
W60K	665	665		115.9	13A	1500	W6B	825	75	8	50.1	50.1	1.238	Q	
W60	2986	2986	1	137.7		1445		893	154		459.8		.693		
W70A	2589	589	255		22C	1500	W3E	769	43	9	25.3	111.2	1.049	L	
W70	2589	589	255			1500		769	9.8		25.3		1.049		
X11A	672	672			5A	1450	X1A	682	35	8	23.7	23.7	.900	P	$
X11B	597	597			5A	1450	X1A	714	44	8	26.2	26.2	.860	P	$
X11C	319	319	5		5A	1450	X1A	716	45	8	14.2	14.2	.857	P	$
X11D	590	590		11.8	5A	1450	X1B	744	88	6	51.8	51.8	.432	B	$
X11E	242	242	1	4.9	5A	1400	X1B	760	98	6	23.8	23.8	.441	B	$
X11F	183	183	1	3.7	5A	1400	X1B	820	120	6	22.0	22.0	.462	B	$
X11G	264	264	39	5.3	5A	1400	X1C	867	180	6	47.6	47.6	.333	B	$
X11H	265	265	42	5.3	5A	1400	X1C	951	222	6	58.8	58.8	.337	B	
X11J	186	186	138		5A	1400	X1C	1040	271	6	50.5	50.5	.334	B	$
X11K	211	211	21	16.3	5A	1400	X1C	895	194	6	40.9	40.9	.334	B	$
X11	3529	3529	247	47.3		1431		779	102		359.6		.410		
X12A	244	244	54	1.3	5A	1400	X1D	802	127	6	31.0	31.0	.446	B	
X12B	155	155	58	.8	5A	1400	X1D	834	140	6	21.8	21.8	.446	B	
X12C	186	186	1	1.1	5A	1400	X1D	876	160	6	29.7	29.7	.442	B	
X12D	223	223	14	8.2	5A	1400	X1D	860	80	8	17.9	17.9	.705	F	
X12E	333	333	113	2.0	5A	1400	X1D	889	91	8	30.3	30.3	.688	F	
X12F	313	313	22	1.9	5A	1400	X1D	870	84	8	26.2	26.2	.699	F	
X12G	239	239	3		5A	1400	X1D	901	96	8	22.9	22.9	.680	F	$
X12H	286	286			5A	1400	X1E	922	121	8	34.6	34.6	.772	F	
X12J	296	296	77		5A	1400	X1E	1158	232	8	68.6	68.6	.553	C	
X12K	286	286	4		5A	1400	X1E	911	116	8	33.2	33.2	.777	F	
X12	2561	2561	346	15.3		1400		910	123		316.2		.580		
X13A	245	245	50		5A	1400	X1E	1200	255	8	62.4	62.4	.549	C	
X13B	237	237	86		5A	1400	X1E	1157	231	8	54.8	54.8	.553	C	
X13C	195	195			5A	1400	X1E	1267	294	8	57.4	57.4	.540	C	
X13D	181	181	7	1.0	5A	1400	X1F	1185	268	8	48.5	48.5	.732	G	
X13E	212	212		1.2	5A	1400	X1F	1019	187	7	39.6	39.6	.746	G	
X13F	217	217	50	1.3	5A	1400	X1F	1007	182	7	39.4	39.4	.745	G	
X13G	335	335	6		5A	1400	X1F	822	82	8	27.4	27.4	1.287	Q	
X13H	306	306			5A	1450	X1F	742	54	8	16.5	16.5	1.429	Q	
X13J	789	789		7.7	5A	1500	X1H	676	32	8	25.4	25.4	1.796	R	
X13K	621	621		79.4	5A	1550	X1H	609	19	7	11.8	11.8	2.112	C	$
X13L	286	286		36.5	5A	1550	X1H	605	18	7	5.3	5.3	2.126	C	$
X13	3624	3624	199	127.1		1464		842	107		388.5		.777		

$ At least one registered dam situated in the quaternary catchment
# The quaternary has been split into two hydro zones
* The MAP derived from the CCWR isohyetal map has been adjusted

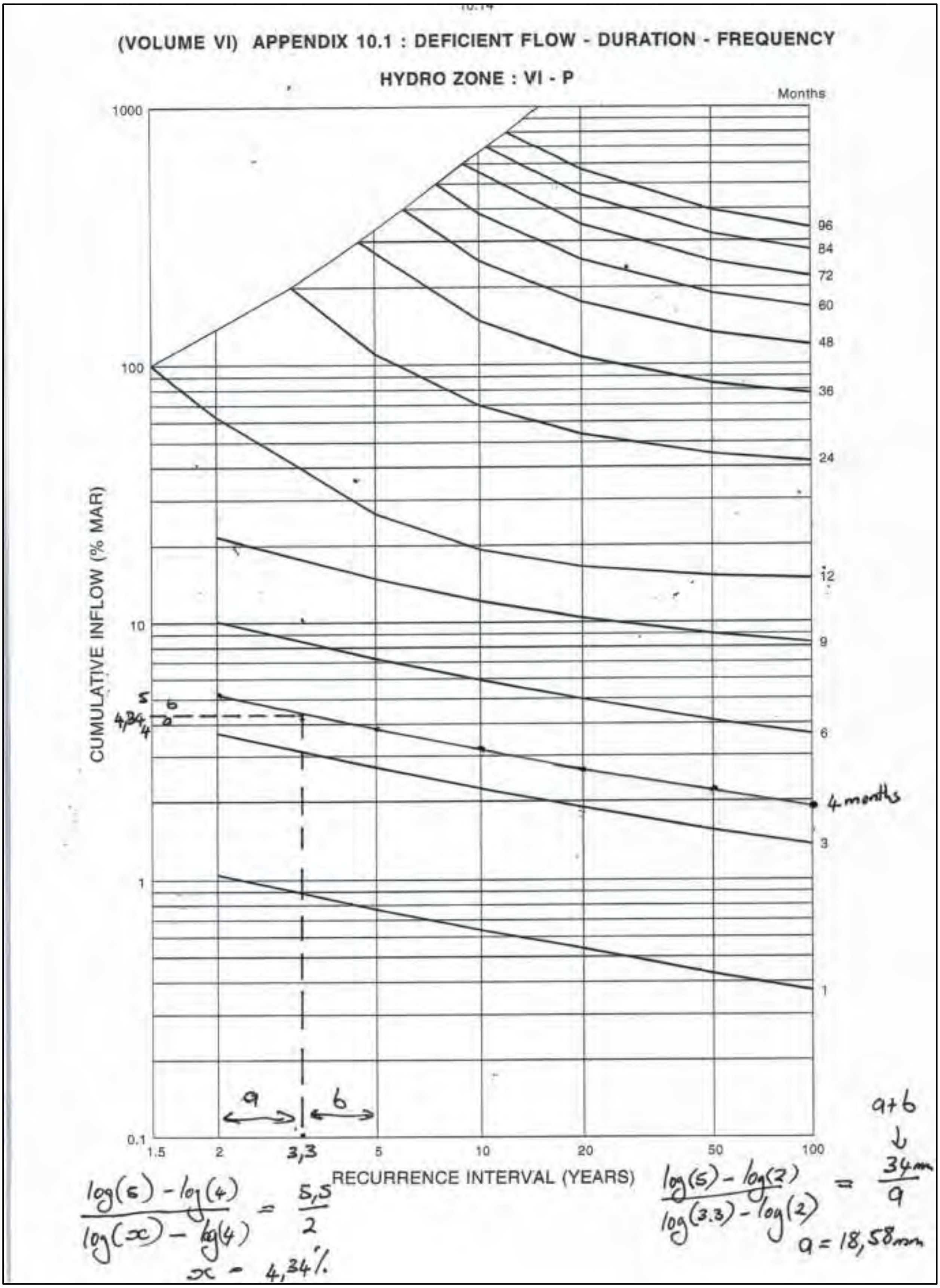
9.1

(VOLUME VI) APPENDIX 9 : RAINFALL - RUNOFF RESPONSE



(VOLUME VI) APPENDIX 10.2 : AVERAGE MONTHLY FLOWS EXPRESSED AS PERCENT MAR

HYDRO ZONE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
VI-A	4.4	7.3	10.8	14.1	15.8	13.7	9.8	6.9	5.3	4.4	3.9	3.6
VI-B	4.1	9.2	13.6	15.4	15.8	-12.3	8.7	6.3	4.7	3.8	3.2	2.9
VI-C	4.3	8.5	12.6	16.1	17.8	14.2	8.8	5.3	3.8	3.1	2.7	2.8
VI-E	4.8	9.3	13.6	17.7	18.8	16.9	8.0	3.3	1.8	1.3	1.5	3.0
VI-D	6.7	11.9	14.0	16.1	15.4	12.6	7.4	4.2	2.8	2.8	2.4	3.7
VI-F	3.5	6.7	11.8	15.6	19.4	14.4	8.2	5.6	4.5	3.8	3.4	3.1
VI-G	2.7	5.6	10.1	16.7	21.7	18.6	9.8	4.5	3.2	2.6	2.3	2.2
VI-H	5.8	12.9	16.6	20.0	17.3	11.5	6.1	3.0	1.7	1.4	1.4	2.3
VI-J	4.1	7.9	11.8	18.2	21.2	18.6	8.6	3.0	1.4	1.0	1.2	3.0
VI-K	6.8	9.3	10.0	10.5	13.1	16.5	10.2	6.2	5.0	3.5	2.9	6.0
VI-L	7.0	6.6	7.0	8.7	11.2	14.6	10.7	8.0	6.9	6.5	5.5	7.3
VI-M	8.5	8.5	9.1	8.3	12.9	14.3	8.9	7.3	5.6	4.9	3.8	7.9
VI-N	6.2	11.0	13.7	17.5	17.5	13.6	6.5	3.2	1.8	2.2	2.1	4.7
* VI-P	4.3	15.6	20.2	18.2	16.3	8.7	5.3	3.8	2.5	1.9	1.5	1.7
VI-Q	3.9	8.7	12.1	20.4	23.3	17.7	6.3	1.8	1.2	1.3	0.9	2.4
VI-R	0.3	3.7	8.9	22.2	35.4	23.1	5.7	0.4	0.0	0.0	0.0	0.3


(VOLUME VI) APPENDIX 10.1 : DEFICIENT FLOW - DURATION - FREQUENCY
HYDRO ZONE : VI - P
Months
96
84
72
60
48
36
24
12
9
6
4 months
3
1
1000
100
10
1
0.1
CUMULATIVE INFLOW (% MAR)
1.5
2
3,3
5
10
20
50
100
RECURRENCE INTERVAL (YEARS)
5
6
4,34
a
4
a
b
a+b
34mm
9
log(5) - log(4) / log(x) - log(4) = 5,5 / 2
x = 4,34%
log(5) - log(2) / log(3.3) - log(2) = 34mm / a
a = 18,58mm

APPENDIX B
FLOOD CALCULATIONS

Utility Programs for Drainage
Flood calculations

Sinotech

Project name: Kranspan - Coal Mine
Analysed by: HS Peens
Name of river: N/A
Description of site: C1
Filename: S:\Peens and Associates\01 Projects\0155_Kranspan Surface Water\02 CIVL\05 Calculations\Stormwater\C1.fld
Date: 9 January 2019

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Flood Frequency Analysis: Alternative Rational Method

Project	= Kranspan - Coal Mine
Analysed by	= HS Peens
Name of river	= N/A
Description of site	= C1
Date	= 2019/01/09
Area of catchment	= 15.49 km²
Dolomitic area	= 0.0 %
Length of longest watercourse	= 3.62 km
Flow of water	= Defined water course
Height difference along 10-85 slope	= 55.0 m
Area distribution	= Rural: 92 %, Urban: 0 %, Lakes: 8 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	8	Very permeable	0	Thick bush & forests	0
Flat area	92	Permeable	100	Light bush & cultivated land	40
Hilly	0	Semi-permeable	0	Grasslands	60
Steep areas	0	Impermeable	0	Bare	0

Days on which thunder was heard	= 60 days/year
Weather Services station number	= 480267
Weather Services station location	= KRANSPAN
Mean annual precipitation (MAP)	= 698 mm

Duration	2	5	10	20	50	100	200
1 day	62	82	97	112	135	153	173
2 days	77	102	120	140	167	189	213
3 days	86	115	136	158	188	213	240
7 days	113	151	179	207	246	278	312

The modified recalibrated Hershfield relationship was used to determine point rainfall.

Average slope	= 0.02026 m/m
Time of concentration	= 48.1 min
Run-off factor	
Rural - C1	= 0.326
Urban - C2	= 0.000
Lakes - C3	= 0.000
Combined - C	= 0.300

Return period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:2	0.80	27.89	97.1	33.81	0.75	22.5	32.72
1:5	0.80	47.05	97.1	57.03	0.80	24.0	58.88
1:10	0.80	61.55	97.1	74.60	0.85	25.5	81.83
1:20	0.80	76.05	97.1	92.17	0.90	27.0	107.05
1:50	0.80	95.21	97.1	115.39	0.95	28.5	141.47
1:100	0.80	109.70	97.1	132.96	1.00	30.0	171.59
1:200	0.80	124.20	97.1	150.53	1.00	30.0	194.26

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

Utility Programs for Drainage
Flood calculations

Sinotech

Project name: Kranspan - Coal Mine
Analysed by: HS Peens
Name of river: N/A
Description of site: C2
Filename: S:\Peens and Associates\01 Projects\0155_Kranspan Surface Water\02 CIVIL\05 Calculations\Stormwater\C2.fld
Date: 9 January 2019

Printed: 28 January 2019 **Page 1**

Flood Frequency Analysis: Alternative Rational Method

Project	= Kranspan - Coal Mine
Analysed by	= HS Peens
Name of river	= N/A
Description of site	= C2
Date	= 2019/01/09
Area of catchment	= 2.485 km²
Dolomitic area	= 0.0 %
Length of longest watercourse	= 1.77 km
Flow of water	= Overland flow
Height difference	= 55.0 m
Value of r for over land flow	= Moderate grass (r=0,4)
Area distribution	= Rural: 88 %, Urban: 0 %, Lakes: 12 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	12	Very permeable	0	Thick bush & forests	0
Flat area	88	Permeable	100	Light bush & cultivated land	36
Hilly	0	Semi-permeable	0	Grasslands	64
Steep areas	0	Impermeable	0	Bare	0

Days on which thunder was heard	= 60 days/year
Weather Services station number	= 480267
Weather Services station location	= KRANSPAN
Mean annual precipitation (MAP)	= 698 mm

Duration	2	5	10	20	50	100	200
1 day	62	82	97	112	135	153	173
2 days	77	102	120	140	167	189	213
3 days	86	115	136	158	188	213	240
7 days	113	151	179	207	246	278	312

The modified recalibrated Hershfield relationship was used to determine point rainfall.

Average slope	= 0.03107 m/m
Time of concentration	= 1.16 h
Run-off factor	
Rural - C1	= 0.328
Urban - C2	= 0.000
Lakes - C3	= 0.000
Combined - C	= 0.289

Return period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:2	1.16	30.84	100.0	26.68	0.75	21.6	3.986
1:5	1.16	52.03	100.0	45.00	0.80	23.1	7.173
1:10	1.16	68.06	100.0	58.86	0.85	24.5	9.969
1:20	1.16	84.09	100.0	72.73	0.90	26.0	13.04
1:50	1.16	105.28	100.0	91.05	0.95	27.4	17.23
1:100	1.16	121.30	100.0	104.92	1.00	28.9	20.90
1:200	1.16	137.33	100.0	118.78	1.00	28.9	23.67

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

Utility Programs for Drainage
Flood calculations

Sinotech

Project name:	**Kranspan - Coal Mine**
Analysed by:	**HS Peens**
Name of river:	**N/A**
Description of site:	**C3**
Filename:	**S:\Peens and Associates\01 Projects\0155_Kranspan Surface Water\02 CIVL\05 Calculations\Stormwater\Kranspan Third.fld**
Date:	**9 January 2019**

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Flood Frequency Analysis: Alternative Rational Method

Project	= Kranspan - Coal Mine
Analysed by	= HS Peens
Name of river	= N/A
Description of site	= C3
Date	= 2019/01/09
Area of catchment	= 2.222 km²
Dolomitic area	= 0.0 %
Length of longest watercourse	= 3.37 km
Flow of water	= Overland flow
Height difference	= 25.0 m
Value of r for over land flow	= Moderate grass (r=0,4)
Area distribution	= Rural: 90 %, Urban: 0 %, Lakes: 10 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	10	Very permeable	0	Thick bush & forests	0
Flat area	90	Permeable	100	Light bush & cultivated land	26
Hilly	0	Semi-permeable	0	Grasslands	74
Steep areas	0	Impermeable	0	Bare	0

Days on which thunder was heard	= 60 days/year
Weather Services station number	= 480267
Weather Services station location	= KRANSPAN
Mean annual precipitation (MAP)	= 698 mm

Duration	2	5	10	20	50	100	200
1 day	62	82	97	112	135	153	173
2 days	77	102	120	140	167	189	213
3 days	86	115	136	158	188	213	240
7 days	113	151	179	207	246	278	312

The modified recalibrated Hershfield relationship was used to determine point rainfall.

Average slope	= 0.00742 m/m
Time of concentration	= 2.18 h
Run-off factor	
Rural - C1	= 0.339
Urban - C2	= 0.000
Lakes - C3	= 0.000
Combined - C	= 0.305

Return period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:2	2.18	35.95	100.0	16.48	0.75	22.9	2.327
1:5	2.18	60.65	100.0	27.80	0.80	24.4	4.187
1:10	2.18	79.34	100.0	36.36	0.85	25.9	5.820
1:20	2.18	98.02	100.0	44.92	0.90	27.5	7.613
1:50	2.18	122.73	100.0	56.24	0.95	29.0	10.06
1:100	2.18	141.41	100.0	64.80	1.00	30.5	12.20
1:200	2.18	160.10	100.0	73.37	1.00	30.5	13.82

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

Utility Programs for Drainage
Flood calculations

Sinotech

Project name:	**Kranspan - Coal Mine**
Analysed by:	**HS Peens**
Name of river:	**N/A**
Description of site:	**C4**
Filename:	**S:\Peens and Associates\01 Projects\0155_Kranspan Surface Water\02 CIVL\05 Calculations\Stormwater\C4.fld**
Date:	**9 January 2019**

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Flood Frequency Analysis: Alternative Rational Method

Project	= Kranspan - Coal Mine
Analysed by	= HS Peens
Name of river	= N/A
Description of site	= C4
Date	= 2019/01/09
Area of catchment	= 11.86 km²
Dolomitic area	= 0.0 %
Length of longest watercourse	= 5.74 km
Flow of water	= Defined water course
Height difference along 10-85 slope	= 40.0 m
Area distribution	= Rural: 90 %, Urban: 0 %, Lakes: 10 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	40	Very permeable	0	Thick bush & forests	0
Flat area	60	Permeable	100	Light bush & cultivated land	53
Hilly	0	Semi-permeable	0	Grasslands	47
Steep areas	0	Impermeable	0	Bare	0

Days on which thunder was heard	= 60 days/year
Weather Services station number	= 480267
Weather Services station location	= KRANSPAN
Mean annual precipitation (MAP)	= 698 mm

Duration	2	5	10	20	50	100	200
1 day	62	82	97	112	135	153	173
2 days	77	102	120	140	167	189	213
3 days	86	115	136	158	188	213	240
7 days	113	151	179	207	246	278	312

The modified recalibrated Hershfield relationship was used to determine point rainfall.

Average slope	= 0.00929 m/m
Time of concentration	= 1.54 h
Run-off factor	
Rural - C1	= 0.297
Urban - C2	= 0.000
Lakes - C3	= 0.000
Combined - C	= 0.267

Return period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:2	1.54	33.16	100.0	21.49	0.75	20.0	14.20
1:5	1.54	55.95	100.0	36.26	0.80	21.4	25.54
1:10	1.54	73.18	100.0	47.43	0.85	22.7	35.50
1:20	1.54	90.42	100.0	58.60	0.90	24.1	46.44
1:50	1.54	113.20	100.0	73.37	0.95	25.4	61.38
1:100	1.54	130.44	100.0	84.54	1.00	26.7	74.44
1:200	1.54	147.67	100.0	95.71	1.00	26.7	84.28

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

Utility Programs for Drainage
Flood calculations

Sinotech

Project name:	**Kranspan - Coal Mine**
Analysed by:	**HS Peens**
Name of river:	**N/A**
Description of site:	**C5**
Filename:	**S:\Peens and Associates\01 Projects\0155_Kranspan Surface Water\02 CIVL\05 Calculations\Stormwater\CA6.fld**
Date:	**9 January 2019**

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Flood Frequency Analysis: Alternative Rational Method

Project	= Kranspan - Coal Mine
Analysed by	= HS Peens
Name of river	= N/A
Description of site	= C5
Date	= 2019/01/09
Area of catchment	= 16.49 km²
Dolomitic area	= 0.0 %
Length of longest watercourse	= 4.62 km
Flow of water	= Defined water course
Height difference along 10-85 slope	= 40.0 m
Area distribution	= Rural: 90 %, Urban: 0 %, Lakes: 10 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	40	Very permeable	0	Thick bush & forests	0
Flat area	60	Permeable	100	Light bush & cultivated land	50
Hilly	0	Semi-permeable	0	Grasslands	50
Steep areas	0	Impermeable	0	Bare	0

Days on which thunder was heard	= 60 days/year
Weather Services station number	= 480267
Weather Services station location	= KRANSPAN
Mean annual precipitation (MAP)	= 698 mm

Duration	2	5	10	20	50	100	200
1 day	62	82	97	112	135	153	173
2 days	77	102	120	140	167	189	213
3 days	86	115	136	158	188	213	240
7 days	113	151	179	207	246	278	312

The modified recalibrated Hershfield relationship was used to determine point rainfall.

Average slope	= 0.01154 m/m
Time of concentration	= 1.20 h
Run-off factor	
Rural - C1	= 0.300
Urban - C2	= 0.000
Lakes - C3	= 0.000
Combined - C	= 0.270

Return period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:2	1.20	31.15	98.5	25.54	0.75	20.3	23.69
1:5	1.20	52.54	98.5	43.08	0.80	21.6	42.62
1:10	1.20	68.73	98.5	56.35	0.85	23.0	59.24
1:20	1.20	84.92	98.5	69.62	0.90	24.3	77.49
1:50	1.20	106.32	98.5	87.16	0.95	25.7	102.41
1:100	1.20	122.50	98.5	100.43	1.00	27.0	124.21
1:200	1.20	138.69	98.5	113.71	1.00	27.0	140.62

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

ILIMA COAL COMPANY (PTY) LTD

KRANSPAN 49-IT, MPUMALANGA

SURFACE WATER ECOSYSTEMS ECOLOGICAL SURVEYS & IMPACT ASSESSMENT

Prepared for:

ABS Africa (Pty) Ltd

Report authors: Dr Mathew Ross (*Pr Sci Nat*); Dr Tahla Ross
Report Ref: Kranspan_Wet 201903
Date: March 2019
Version: FINAL

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DECLARATION

PROJECT: ILIMA COAL COMPANY: KRANSPAN PROJECT: Surface Water Ecosystem Ecological and Impact surveys.

This report has been prepared according to the requirements of the Environmental Impact Assessments Regulations (GNR 982) in Government Gazette 38282 of 4 December 2014, and DWS (2008) Guidelines for wetland delineations. We (the undersigned) declare the findings of this report free from influence or prejudice.

Report Authors:

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Field of expertise:

Fish ecology, fishway evaluations, biomonitoring and wetland evaluations, aquatic ecology, aquatic & terrestrial fauna and flora.

____________________ Date: 8 June 2019

Dr M Ross (*Pr Sci Nat*)

Dr Tahla Ross

PhD (Zoology) (RAU)

Field of expertise:

Biomonitoring and wetland evaluations, aquatic ecology, aquatic & terrestrial fauna and flora.

____________________ Date: 8 June 2019

Dr T Ross

DISCLAIMER, ASSUMPTIONS & LIMITATIONS

The findings of the survey provided within this report, together with the results and general observations, and the conclusions and recommendations provided upon completion of the survey are based on the best scientific and professional knowledge of the field specialists. This is also dependent on the data and resources available at the time. The report is based on survey and assessment techniques that are limited by time and budgetary constraints relevant to the type and level of investigation undertaken.

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EXECUTIVE SUMMARY

Introduction & Background

Enviross CC was requested to undertake a survey and impact assessment of the surface water ecosystems for the proposed Ilima Coal Kranspan Project, located near Carolina in Mpumalanga Province. This report details the findings of a field survey undertaken during January 2019. The results within the report have been presented following collaboration with other specialists associated with the project, especially the soils and biodiversity specialists. The survey was undertaken to ascertain the overall ecological integrity of the wetland habitat units and watercourses, as well as to delineate ecologically sensitive wetland habitat features associated with the site/area that may be associated with the proposed mining activities, and to assess the possible impacts of the mining activities on the identified habitat units.

Methods & Materials

The methodologies employed for the wetland delineation were those outlined in the DWS (Department of Water and Sanitation) (2008) *Guidelines to identifying riparian zones and wetland boundaries*. These guidelines make use of four indicators of wetland habitats that enable the identification of a wetland. This does not necessarily mean that all four indicators are utilised, but rather that there are four indicators available to be utilised. Aspects such as severely degraded vegetation structures often lead to this indicator not being utilised. In this case, more emphasis is then placed on the other indicators. The four available indicators commonly used are:

- Terrain Unit Indicators (TUI)
- Soil Wetness Indicators (SWI)
- Soil Form Indicators (SFI)
- Vegetation Unit Indicators (VUI)

Consultation of various available mapping (1:50,000 topographical maps, GIS [Geographic Information Systems] databases), aerial photographs and catchment reviews formed part of an initial desktop study. The field survey concentrated on identifying the various wetland indicators by making use of samples taken with a soil auger, the digging of inspection pits, wetland floral species identification and the confirmation of topographical features that would support wetland formation and the observations of any saturated soils and surface water.

The outer edges of the temporary zones of the wetlands were then identified and mapped using a handheld GPS (Global Positioning System) unit. These data were then transformed into GIS (Geographic Information

System) shapefiles that can be incorporated into the construction and layout plans of the proposed development activities.

The ecological integrity of the various wetland units/systems, using the WETLAND-IHI and the ecological importance and sensitivity (EIS) were calculated. These indices take into consideration the water quality, vegetation structures, hydrological and geomorphological characteristics of the wetland units, as well as the wetland ecological services (such as water quality enhancement, flood attenuation, resource provision, etc) that the wetland units provide.

Results & Discussions

The proposed development area falls within the quaternary catchment of X11B, which falls within the Komati/Crocodile primary catchment area. The main watercourse draining X11B to the northeast is Boesmanspruit, which drains into the Nooitgedacht Dam, located at the northern point of the catchment area. Main watercourses within the catchment area are shown to have retained an overall B (largely natural) present ecological state (SANBI, 2010).

The desktop review reiterated by a ground-truthing field survey showed that the proposed development area has an association with relatively large expanses of wetland units. Being located relatively high in the catchment area, valley-head seep zones feeding into unchannelled and channelled valley-bottom wetland units were common. Valley-bottom wetland units were also supplemented by hillslope seepages. Depression wetland units were also noted to be relatively common within the survey area. The main present land use is formal agriculture and much of the outer wetland zones are impacted by cultivation. Impoundments, which have been historically constructed to aid in agricultural practice, are also commonplace and impact all of the watercourses.

The main present pressures and drivers of ecological change were shown to be the formal agriculture (cultivation) that surrounds the majority of the wetland units, and the numerous impoundments along all watercourses. The impact of current mining activities adjacent to the proposed Kranspan Mining Right Area (within the northern part of the survey area), was evident in the altered water quality of the one depression wetland that would be the recipient of runoff water from these areas. The water quality (following laboratory analysis) of the remaining surface waters has retained relatively good status, barring elevation of components that one would expect from the dominant land use being cultivation.

The proposed development area was delineated into three main surface water ecosystem units. The WETLAND-IHI rated all of these units to within a C Present Ecological State (PES) category (moderately modified), with a relatively high ecological importance and sensitivity.

The DWS Risk Assessment Matrix noted a high risk associated with all of the activities that would include wetland habitat units and cause the potential destruction, degradation or transformation thereof.

The impact significance ratings were also calculated, which showed that many impacts are rated as being high (before mitigation), which is largely due to the impacts being associated with wetland habitat units. The significance of the impacts is largely dependent on the extent of wetland habitat to be included in the development footprint and thus to be removed the severity of the associated impacting features if fringing on wetland habitat units. Applying appropriate mitigation measures shows that significance of most of the impacts can be reduced.

It should be noted, however, that much of the wetland complexes, especially peripheral temporary zones and less established wetland areas, have been cultivated and have therefore lost much of their function due to the land use. These areas, although considered to offer a supportive role to the more established wetland units, have largely lost their ecological function.

Conclusions & Recommendations

A field survey was undertaken during January 2019 in order to evaluate the surface water ecosystems associated with the area pertaining to the proposed development of the Ilima Coal Kranspan Project. Following the field survey of the proposed development area and the associated impact assessment, and taking into consideration the results and findings of the soils and biodiversity specialists associated with the project, the following salient recommendations can be proposed to aid in the conservation of the overall ecological integrity of the wetlands within the region:

- The proposed development area was shown to incorporate a relatively high proportion of wetland habitat units, ranging from valleyhead seeps, hillslope seeps, channelled and unchannelled valley-bottom and depression-type wetland units. These units have been delineated and their outer boundaries, together with conservation buffer zones, are presented in Figure 15;
- The wetland units are interspersed amongst formal cultivation, which is considered to be the main pressure and driver of ecological change at present, and much of the peripheral wetland units have

lost functionality and ecological contribution due to cultivation. This was taken into consideration when developing the final buffer zone designation (as indicated in Figure 15);

- The wetland units were shown to all fall within a PES category range of C (moderately modified) to D/E (largely modified), with a high ecological importance and sensitivity;
- Laboratory analysis of water samples showed that the wetlands retain a relatively good water quality, excepting for one depression wetland that is subject to runoff from mining areas located to the north, adjacent to the proposed Kranspan Mining Right Area. Water quality within this wetland unit has been degraded to the point of posing a risk to both human and livestock health;
- The DWS Risk Assessment Matrix indicates that all proposed mining activities that will impact the wetland directly carry a high risk factor. The impact significance ratings also indicate that the potential impacts carry a high significance post mitigation. The significance of the impacts is largely due to the direct involvement of deleterious impacts to wetland habitat units. The significance is, however, largely dependent on the extent of wetland habitat that will be directly affected by mining activities and the severity of those impacts;
- The presented infrastructure layout indicates that some wetland areas are required to be included within the mining area and therefore will be lost. The significance of the ecological loss is dependent on the sensitivity as well as the present functionality of the wetland units. Ultimately, infrastructure layout planning that takes into consideration the wetland delineation mapping, associated conservation buffer zones, as well as the proposed mitigation measures, can greatly reduce the overall significance of the impacts to the wetland systems associated with the site.

It should be noted that, in order to conserve the wetland ecological structures within the area, the wetland needs to be viewed as an interconnected larger system and the individual units should be managed as such. This includes keeping general habitat destruction and construction footprints to an absolute minimum within the terrestrial habitat as well. Conserving the habitat units will ultimately conserve the species communities that depend on it for survival. This can only be achieved by the efforts of the contractor during the construction phase and by strict management during the operations phase.

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1. INTRODUCTION

1.1. Background

Ilima Coal Company (Pty) Ltd has initiated the process of the mining rights application for all of the property portions of the farm Kranspan 49-IT, located to the southwest of the town of Carolina in Mpumalanga Province. EnviRoss CC has been requested by ABS Africa (Pty) Ltd to undertake the necessary ecological surveys and associated impact assessment pertaining to the surface water ecosystems associated with the project area. The locality of the site is presented in Figure 1. This report details the findings of a survey that was undertaken during January 2019.

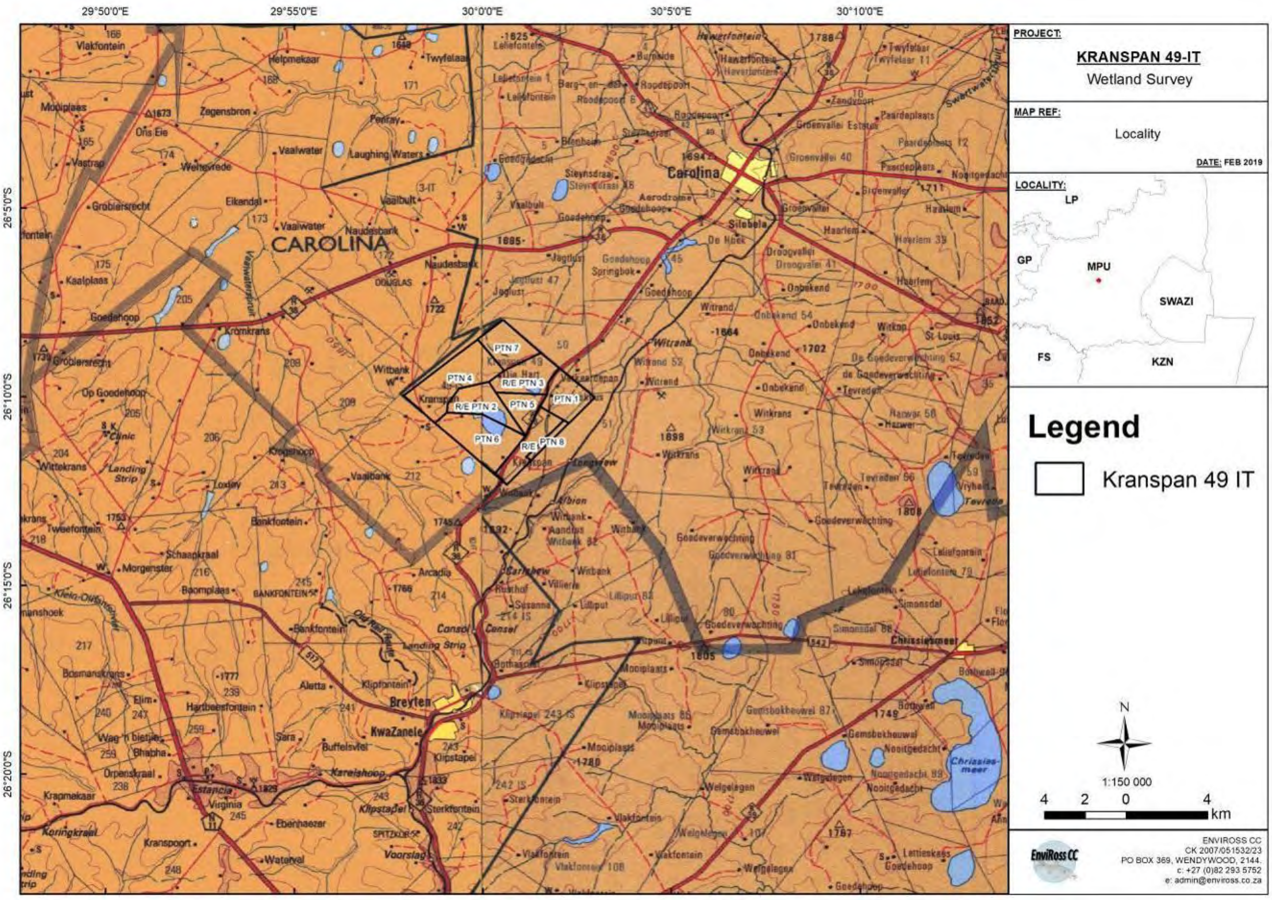


Figure 1: Locality of the survey area.

1.2. Scope of Work

The Scope of Work for the surface water ecosystem survey was to determine the overall ecological integrity and functionality of the surface water ecosystem units that are associated with the development area and to designate appropriate conservation buffers to these units as a protective factor to the wetland units from the terrestrial development activities. The ecological integrity of the wetland habitat units was also to be determined which would allow for the determination of the overall significance of the impacts to the wetland and aquatic habitat units.

Application of the DWS Risk Assessment Matrix was also to be applied to the wetland units associated to the development area as part of the survey.

1.3. Assumptions & Limitations

The conclusions to the overall perceived impacts have been based on a desktop survey that was reiterated by ground-truthing through a single field survey of the area encompassing the proposed development. Even though vegetation structures and some floral species are mentioned within the report, this mention is purely for the purpose of delineating the wetland boundaries and is not meant as an account of the full species lists and ecological potential of the proposed development site.

2. AIMS & OBJECTIVES

The objective of this report is to indicate the present ecological state of the surface water ecosystem units as well as to indicate the limits of the outer boundaries of these units that are associated with the survey area. The survey also aims to offer recommendations to the general management of the wetland units in order to limit the present and potential future deleterious impacts. This information can be utilised as supporting information for the design, construction and management teams of the proposed development activities.

The report was also to be generated as a supporting document according to the requirements of the Environmental Impact Assessments Regulations (GNR 982) in Government Gazette 38282 of 4 December 2014, and DWS (2008) Guidelines for wetland delineations.

3. APPLICABLE LEGISLATION

3.1. National

Conservation of aquatic and wetland habitat units and resources is protected by a myriad of legislature, including the Constitution of South Africa (Act no 108 of 1996), which states that everyone has a right to an environment that is not harmful or detrimental to their health and which is sustainable for future generations. Further to this, South Africa uses environmental-specific legal frameworks based on principles found in the National Environmental Management Act (NEMA) (Act no 107 of 1998). Section 28 (1) states that any person who causes or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot reasonably be avoided or stopped, to minimise and rectify such pollution or degradation of the environment.

The National Water Act (Act no 36 of 1998), which is the main water regulation statute of South Africa, defines what is meant as a "water use" as activities that require authorisation. Sections most applicable to developments impinging upon or within surface water ecosystem boundaries, including wetlands, are section 21(c) *impeding or diverting the flow of water in a watercourse;* and 21(i) *altering the bed, banks, course or characteristics of a watercourse*. As per definition, this means any change affecting the resource quality within the riparian habitat or 1:100 year flood line, whichever is the greater distance. Subsequent to this, DWA issued a Government Notice (GN) within the Government Gazette, No 1199 (18 December 2009), in which Section 6(b) indicates that any development within a 500 m radius of any wetland must seek authority through a Water User Licence Application (WULA) and that authority for these activities through a General Authorisation is no longer applicable (discretionary powers do, however, lie with DWS authorities on a *per project* basis). As the development activities are within a 500 m radial regulatory zone of the surrounding wetlands, authority will have to be sought prior to any development taking place.

4. WETLANDS FORMS AND FUNCTIONS

A wetland is defined as land that is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water and which, under normal circumstances, supports or would support vegetation typically adapted to life in saturated soil (National Water Act 36 of 1998). The identification of a wetland therefore requires a combination of factors, including hydrological (water drainage and movement), geomorphological (soil types, characteristics and inundation) as well as vegetation (identification of hydrophytic species and communities).

4.1. Hydrogeomorphic forms

The classification of the hydrogeomorphic forms of wetlands associated with the proposed development area are based on those defined in Table 1. Wetland units form and are supported by an interplay of various physical and biological features. Underlying soil layering that inhibits percolation through the soils, topographical features, erosive forces and the quantity and origin of the water source all dictates the hydrogeomorphic form of any particular wetland unit.

Table 1: Hydrogeomorphic forms of wetland habitat units.

Hydrogeomorphic types		Description	Source of water maintaining the wetland	
			Surface	Sub-surface
Floodplain		Valley bottom areas with a well-defined stream channel, gently sloped and characterised by floodplain features such as oxbow depressions and natural levees and the alluvial (by water) transport and deposition of sediment, usually leading to a net accumulation of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	***	*
Valley bottom with a channel		Valley bottom areas with a well-defined stream channel but lacking characteristic floodplain features. May be gently sloped and characterised by the net accumulation of alluvial deposits or may have steeper slopes and be characterised by net loss of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	***	*/***
Valley bottom without a channel		Valley bottom areas with no clearly defined stream channel, usually gently sloped and characterised by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from the channel entering the wetland and also from adjacent slopes.	***	*/***
Hillslope seepage linked to a stream channel		Slopes on hillsides, which are characterised by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and output is usually via a well-defined stream channel connecting the area directly to a stream channel.	*	***
Isolated hillslope seepage		Slopes on hillsides, which are characterised by the colluvial movement of materials. Water inputs mainly from sub-surface flow and outflow either very limited or through diffuse sub-surface and/or surface flow but with no direct surface water connection to a stream channel.	*	***
Depression (includes pans)		A basin shaped area with a closed elevation contour that allows for the accumulation of surface water (i.e. it is inward draining). It may also receive sub-surface water. An outlet is usually absent, and therefore this type is usually isolated from the stream channel network.	*/***	*/***

Wetland units also tend to be interconnected, with a seep zone often developing into a valley-bottom wetland, which then often develops into an established aquatic riverine system that then acts as a drainage watercourse for the catchment area.

4.2. Soil types and characteristics

The occurrence of wetland conditions is almost primarily due to a combination of soil conditions (including stratification characteristics), soil type, and a water source (surface water, lateral movement of soil water, or the upwelling of groundwater). Soil forms that are regarded as being always associated with wetland conditions include Champagne, Katspruit, Willowbrook and Rensburg soils. Those soil forms that are *sometimes* associated with wetlands include Inhoek, Klapmunts, Dresden, Bloemdal, Dundee, Longlands, Tukulu, Avalon, Witfontein, Wasbank, Cartref, Pinedene, Sterkspruit, Lamotte, Fernwood, Glencoe, Sepane, Estcourt, Westleigh, Bainsvlei and Valsrivier (DWAF, 1999).

The degree of soil saturation is also important in discerning temporary, seasonal and permanent zones of wetland habitat units, as well as the colour (chroma) and degree of ferrolysis (observable as mottling) within the upper 500 mm of the soil profile. This feature is elaborated on under the section of Wetland Delineation Methods.

A specialist soil survey was undertaken for the site and close interaction between the soil specialist (Earth Science) and Enviross (as the wetland ecologists) was undertake throughout the various phased of the survey. This was also true for the terrestrial biodiversity specialists (Ecorex) assigned to the project.

4.3. Vegetation structures

Wetlands tend to be transitional in nature and therefore a gradual transition of soils, inundation and vegetation structures can be observed from the terrestrial areas, temporary, seasonal and into the permanent zones of a wetland. The ability to identify and differentiate wetland floral species as being obligate wetland species, facultative wetland species, facultative species and facultative dryland species is important in discerning the occurrence of wetland conditions. Vegetation associated with any wetland units within the survey area tended to be facultative wetland species. Due to the arid climate of the region, surface water retention is limited to shortened periods and therefore wetland units tend to be temporary or seasonal in nature.

5. METHODS OF INVESTIGATION

5.1. Desktop survey

Scrutiny of topographical maps, aerial photography and available GIS mapping databases (provincial and national) as well as the latest available literature and online databases (from SANBI, DWS, DEAT, ADU, etc) were used to set the baseline data for the proposed development site.

5.2. Wetland delineation methods

The wetland delineation assessment includes review of topographical maps and aerial photographs and an 'on-site' evaluation of the wetland and associated vegetation structure condition. This includes the general ecological integrity of the wetland itself as well as the identification of any sensitive biota that are potentially dependant on the wetland (if applicable).

The wetland delineation procedure takes into account (according to DWS guidelines for wetland delineations, 2008) the following attributes to determine the limitations of the wetland:

- Terrain Unit Indicator – helps to identify those parts of the landscape where wetlands are more likely to occur (valley-bottoms, depressions, etc);
- Soil Form Indicator – identifies the hydromorphic soil forms, which are associated with prolonged and frequent saturation and associated anoxia and ferrolysis;
- Soil Wetness Indicator – identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation; and,
- Vegetation Indicator – identifies hydrophilic vegetation associated with frequently saturated soils.

According to the wetland definition used in the National Water Act, vegetation is the primary indicator, which must be present under normal circumstances. However, in practise the soil wetness indicator tends to be the most important, and the other three indicators are used in a confirmatory role. The reason is that vegetation responds relatively quickly to changes in soil moisture regime or management and may be transformed; whereas the morphological indicators in the soil are far more permanent and will hold the signs of frequent saturation long after a wetland has been drained (perhaps several centuries) (DWA. 2005).

5.2.1. Terrain Unit Indicator (TUI)

The TUI takes into consideration the topography of the area to determine those areas most likely to support a wetland (DWS, 2008). These include depressions and channels where water would be most likely to accumulate. This is done with the aid of topographical maps, aerial photographs and engineering and town planning diagrams (these are most often used as they offer the highest degree of detail needed to accurately delineate the various zones of the wetland). Seepage zones are also very often characterised by depressions, the identification of which aids in determining the presence of a wetland.

5.2.2. Soil Form Indicator (SFI)

The SFI takes into account the identification of hydromorphic soils that display unique characteristics resulting from prolonged and repeated saturation. This ongoing saturation leads to the soil eventually becoming anaerobic and therefore a change in the chemical characteristics of the soil. Certain soil components, such as iron and manganese, which are insoluble under aerobic conditions, become soluble when the soil becomes anaerobic, and can thus be leached out of the soil profile. Iron is one of the most abundant elements in soils, and is responsible for the red and brown colours of many soils. Once most of the iron has been dissolved out of the soil as a result of the prolonged anaerobic conditions, the soil matrix is left a greyish, greenish or bluish colour, and is said to be “gleyed”. A fluctuating water table, common in wetlands that are seasonally or temporarily saturated, results in alternation between aerobic and anaerobic conditions in the soil. Aerobic conditions in the soil leads to the iron returning to an insoluble state and being deposited in the form of patches or mottles within the soil. Recurrence of this cycle of wetting and drying over many decades concentrates these insoluble iron compounds. Thus, soil that is gleyed and has many mottles may be interpreted as indicating a zone that is seasonally or temporarily saturated (DWS, 2008).

Figure 2: Inspection pits dug to observe *in situ* soil profiles.

Soil samples are taken periodically in a line running perpendicular to the permanent water zone until the outer limits of this zone are identified. This normally coincides with a particular contour level, but transformations and modifications to the landscape often lead to the zone limits not conforming to this theory. Soil samples are taken using a Dutch-type soil auger to a depth of 500 mm. The soil sample is then examined for indications of soils particular to the characteristics described above. Sample pits are also dug periodically as a more thorough and therefore more reliable means of confirming the presence or absence of hydromorphic soil characteristics. These were dug using a garden spade and the profiles thus created were examined for hydromorphic processes within the soil.

5.2.3. Soil Wetness Indicator (SWI)

In practise, this indicator is used as the primary indicator, but can be rendered unreliable during heavy rainfall periods. The colour of various soil components are also often the most diagnostic indicator of hydromorphic soils. Colours of these components are strongly influenced by the frequency and duration of soil saturation. Generally, the higher the duration and frequency of saturation in a soil profile, the more prominent grey colours become in the soil matrix. Coloured mottles, another feature of hydromorphic soils, are usually absent in permanently saturated soils, and are at their most prominent in seasonally saturated soils, becoming less abundant in temporarily saturated soils, until they disappear altogether in dry soils (DWA, 2005). This indicator is also identified by taking a soil sample using a Dutch-type soil auger to a depth of 500 mm. The soil sample is then examined for indications of soils displaying these characteristics.

5.2.4. Vegetation Indicator (VI)

Vegetation is a key component of the wetland definition in the National Water Act (Act 36 of 1998). However, using vegetation as a primary indicator requires undisturbed conditions and expert knowledge (DWA, 2005). As a result of this, greater emphasis is often placed on the SWI and SFI. Nonetheless, plant community structure analyses are still viewed as helpful guides to finding the boundaries of wetlands. Plant communities undergo distinct changes in species composition along the wetness gradient from the centre of the wetland to the edge, and into adjacent terrestrial areas. This change in species composition provides valuable clues for determining the wetland boundary, and wetness zones. When using vegetation indicators for delineation, emphasis is placed on the group of species that dominate the plant community, rather than on individual indicator species (DWA, 2005). In wetlands that have undergone extensive transformation through landscaping, the vegetation unit indicators can potentially be absent.

5.3. Assessing the Present Ecological State (PES) of the wetland habitat units

5.3.1. Wetland Index of Habitat Integrity (WETLAND-IHI)

The WETLAND-IHI (Wetland Index of Habitat Integrity) was a wetland habitat assessment tool used to establish the overall PES of the wetland unit associated with the proposed development site. The WETLAND-IHI was developed as a tool for use in the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP), formerly known as the River Health Programme (RHP). The WETLAND-IHI was developed to allow the NAEHMP to include *floodplain and channelled valley bottom wetland types* to be assessed and the monitoring data incorporated into the national monitoring programme (DWA, 2007). Neither of these wetland hydrogeomorphic units were present at the site and therefore the WETLAND IHI methodologies do not apply. A descriptive analysis based on observations will therefore be provided in terms of hydrological, geomorphological, vegetation and water quality features.

Further observations of general ecological integrity at each site during the routine surveys will also be reported on. These points include:

- Erosion trends;
- Degree of siltation at downstream points;
- Unnecessary vegetation removal;
- Other general impacts on the aquatic system (dumping of rubble, litter, etc).

5.3.2. WET-Ecoservices

WET-Ecoservices was used to assess the goods and services that individual wetlands provide (Kotze et al, 2007). This is taken as a combination of both ecological services and provision of services and resources to users. Through a series of scoring matrices for 15 different goods and service characteristics of a particular wetland, a rating score (out of 4) is provided. This is then compared to the class categories presented in Table 2. This sensitivity categorisation is based on strategic ecological functionality classes typical of environmental scoring systems, with this particular categorisation being based on those established by Wetland Consulting Services (2007).

Table 2: Recommended ecological importance and sensitivity categories (*taken from* WCS, 2007). Interpretation of the median values and categories is also provided.

Ecological Importance and Sensitivity Category (EIS)	Range of Median	Recommended Ecological Management Class
<u>Very high</u> Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 and ≤4	A
<u>High</u> Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and ≤3	B
<u>Moderate</u> Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	>1 and ≤2	C
<u>Low/marginal</u> Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and ≤1	D

5.3.3. Water quality analysis

Samples from four localities that included persistent surface waters and represented the various main watercourses within the proposed development area were taken and sent to a laboratory for analysis for elemental components and bacterial inclusion.

5.3.4. Mapping, sensitivity analysis and designation of buffer zones

From the field survey observations and delineation procedures, a handheld GPS (Global Positioning System) (Model: *Garmin Montana 650*) was used to mark the outer edges of the various wetland zones. These data are then compared to aerial imagery to generate digital shapefiles (ArcGIS) and maps of the various wetland zones.

National legislature does not specify a distance for buffer zone regulations pertaining to wetland units, but developments that are associated with surface water ecosystems are required to gain permission through the Department of Water and Sanitation (DWS) prior to permission being granted to start the construction phase of the proposed development. The current DWS guidelines allude to an "appropriate buffer zone in accordance to the surrounding land use" (DWAF, 2008). The extent of the buffer zone is determined by taking into consideration the land use, the potential impacts to the surface water ecosystems, the ecological status of the wetland units and the systems that are fed by the water source that comes from the wetland units. Special restrictions should be imposed on construction activities that are to be undertaken within these conservation zones to limit the overall negative ecological impacts of these activities.

Workshop sessions and correspondence between the specialists pertaining to terrestrial biodiversity, soil profiles and wetland ecology were undertaken in order to draft a sensitivity map that indicates the sensitive ecological features of the site. An overall sensitivity map could then be developed for the proposed development area, which takes into consideration the ecologically sensitive features, whilst considering the overall ecological condition of the surrounding area.

5.4. Risk Assessment Matrix

The DWS developed a risk-based analysis matrix (published in Government Gazette 39458, Notice 1180 of 2015, 27 Nov 2015) that stipulates that a Risk Assessment Matrix be applied to water uses in terms of the National Water Act (Act 36 of 1998), which than allows for the categorisation of the severity of the ecological risks pertaining to proposed developments associated with wetland habitat units. Based on the outcome of the Risk Assessment Matrix, *Low* risk activities will be generally authorised with conditions, while *moderate* to *high* risk activities will be required to go through a Water Use Licence Application (WULA) Process. Water use activities that are authorised in terms of the General Authorisations (GA) will still need to be registered with the DWS. The Risk Assessment Matrix has been used in the assessment of the risk posed to the wetland ecosystems for the proposed development in an attempt to better quantify the risk to the resource.

The categories (and interpretations of the scores) are assigned to the final ratings based on the ratings analysis (Table 3).

Table 3: Ratings of the risk and associated management descriptions (DWS, 2015).

RATING	CLASS	MANAGEMENT DESCRIPTION
1 – 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated.
56 – 169	M) Moderate Risk	Risk and impact on watercourses are notably and require mitigation measures on a higher level, which costs more and require specialist input. Licence required.
170 – 300	(H) High Risk	Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve. Licence required.

6. RESULTS & DISCUSSIONS

6.1. Study area & catchment characteristics

The survey area falls within the Sabie/Crocodile/Komati (X) Primary catchment, the X1 Secondary catchment and the Inkomati/Usuthu (3) DWS water management area. It falls within the X11B quaternary catchment. The watershed associated with the survey area drains toward the Boesmanspruit, which drains northwards. The Nooitgedacht Dam is located at the northern end of the quaternary catchment, at the confluence of the Boesmanspruit, Vaalwaterspruit and Witkloofspruit. The watercourse from the dam draining toward the northeast is the Komati River. The DWS has designated Present Ecological State (PES), Ecological Importance (EI) and Ecological Sensitivity (ES) for all of the catchment areas nationally. The quaternary catchment of X11B has a PES of C (moderately modified), an EI of moderate and an ES of high (DWS, 2014). The Boesmanspruit has retained a PES of B (near natural) up until it drains into Nooitgedacht Dam, after which the Komati River (which is the main watercourse leaving the dam) has a PES of C (moderately modified) (SANBI, 2009 & NFEPA, 2010) (Figure 3). The region is shown to have a relatively low mean annual runoff as well as a relatively low groundwater recharge (Figure 4 and Figure 5). Land use within the region is dominated by formal agriculture and mining and the associated transformation to physical characteristics and degradation of water quality tend to be the main pressures and drivers of ecological change of the surface water ecological features.

Mpumalanga Province conservation authorities have developed a biodiversity spatial conservation plan (Mpumalanga Biodiversity Conservation Plan – MBCP) that details the importance of various regions to the conservation of natural resources throughout the province. Figure 6 shows that much of the site has been categorised as “highly significant”. This is due to the area providing a source of water and the refugia offered and biodiversity supported by the interconnected wetland habitat.

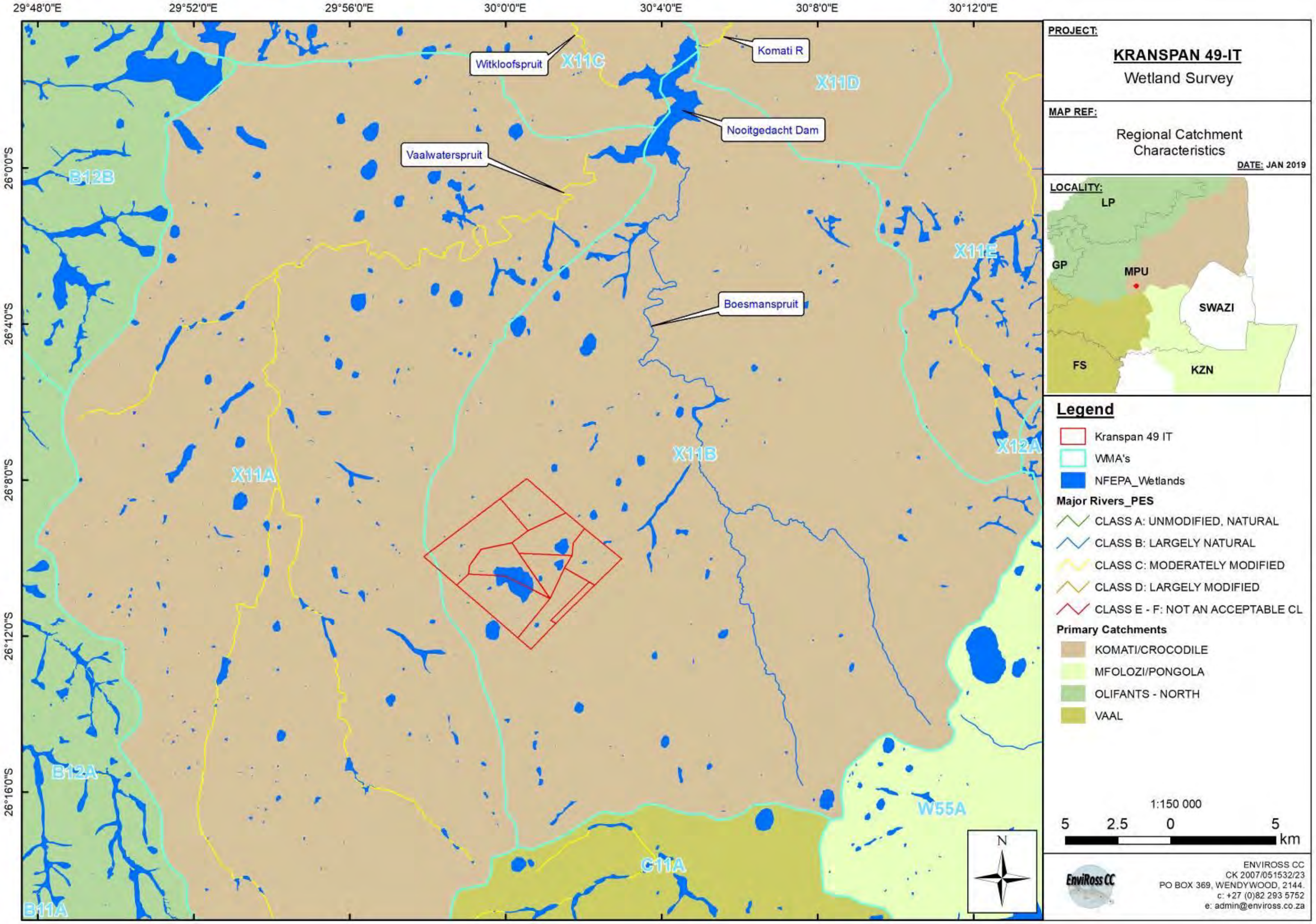


Figure 3: Regional catchment details.

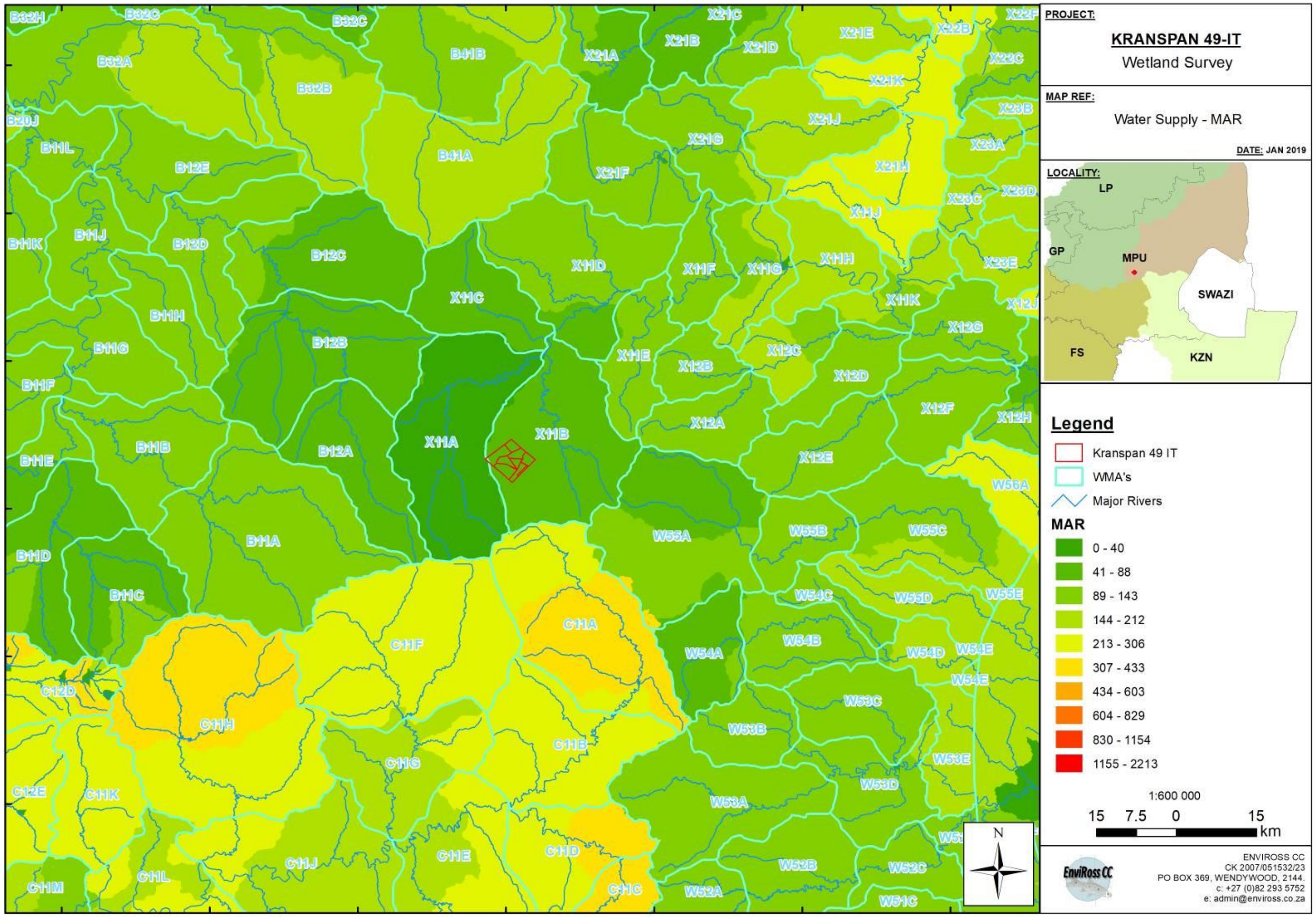


Figure 4: The Mean Annual Runoff (MAR) of the region.

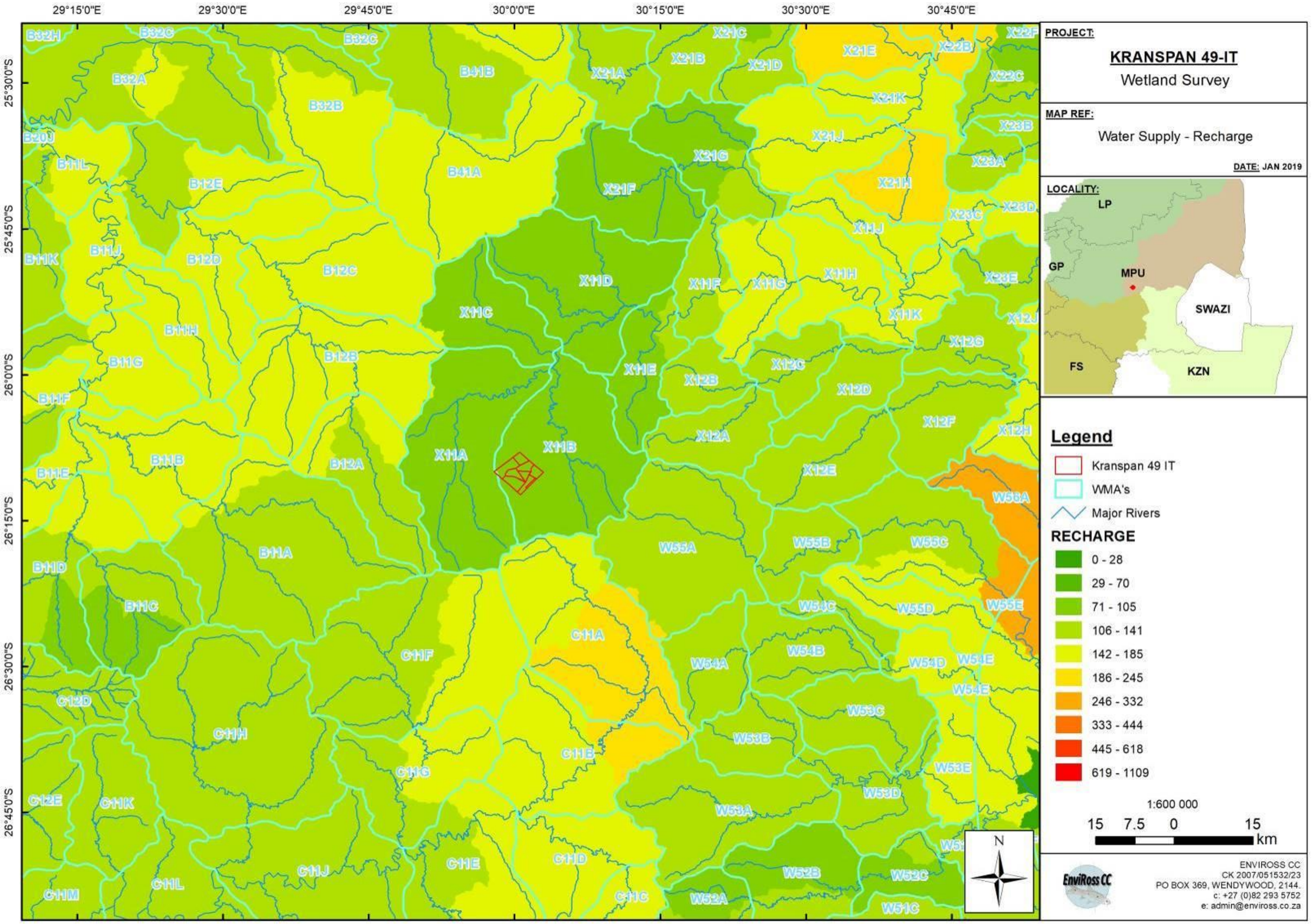


Figure 5: The recharge status of the region.

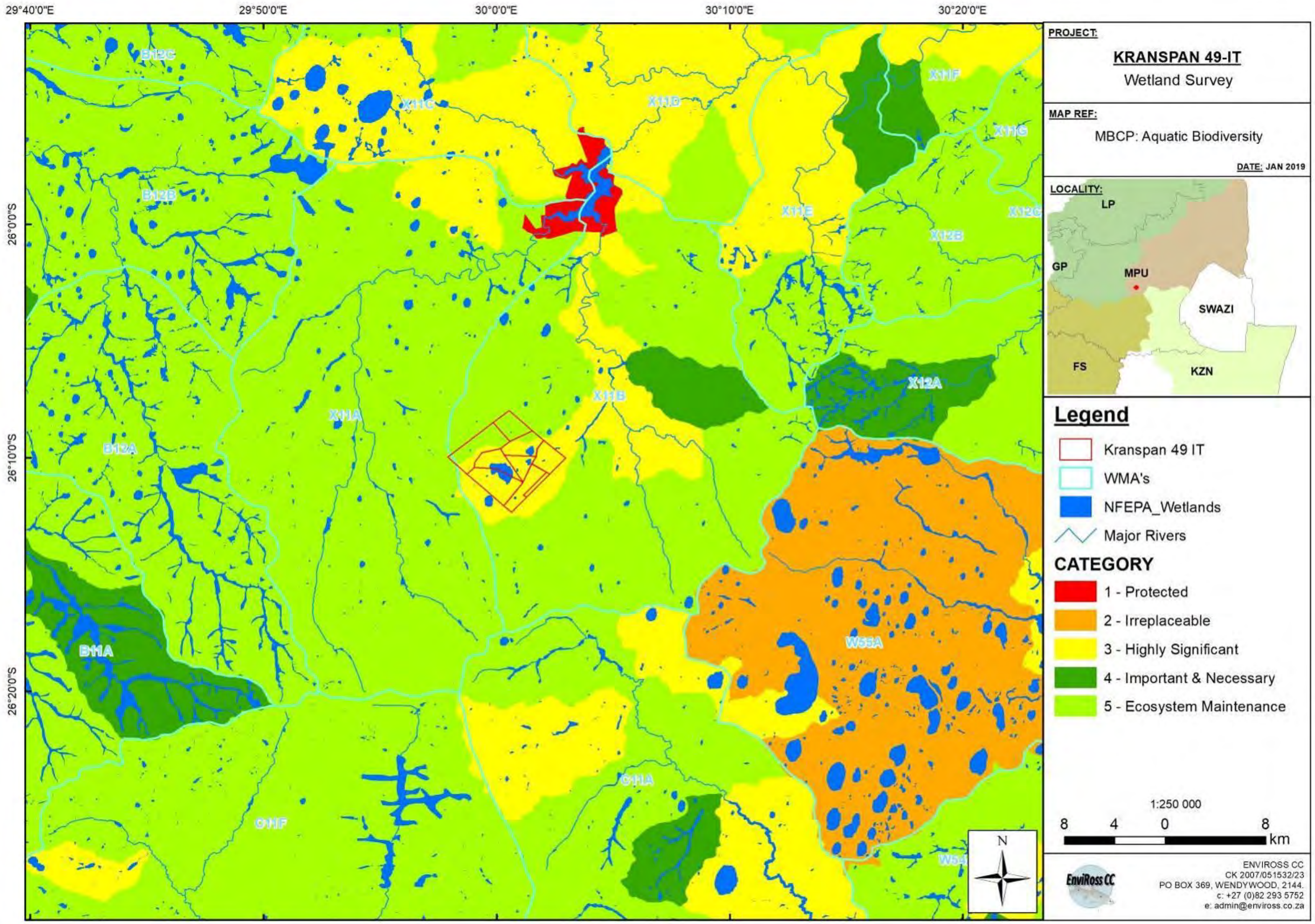


Figure 6: The MBCP for the region associated with the proposed development area pertaining to the protection of the aquatic resources.

The dominant veld type of the surrounding area is Eastern Highveld Grassland, of the Mesic Highveld Grassland bioregion within the Grassland biome. Conservationally, this is regarded as an *endangered* vegetation type, which is largely due to largescale transformation to accommodate the agricultural and mining sectors and the general lack of protection within conservation areas. Well-developed wetlands within the region include the vegetation type of Eastern Temperate Freshwater Wetlands, which is an azonal inland freshwater vegetation type. This is regarded as *Least Threatened* conservationally (Mucina & Rutherford, 2006).

6.2. General local survey area condition

The survey area is dominated by formal agriculture and cultivation seems to have occurred wherever soil and physical characteristics have allowed for it. Waterlogged areas and areas with a steep topography tend to have retained natural features. Formal mining occurs on properties adjacent to the proposed Kranspan Mining Right Area to the nearby north and northeast. The development area has an undulating terrain and valley-bottoms tend to support a well-developed wetland feature and wetland features tend to be commonplace within the area. Small impoundments along watercourses are common. Surface water persists within depression-type wetland units, but the main wetland feature located centrally within the proposed development site (Kranspan) seemingly only retains surface water following exceptional rainfall events.

A view of the largest depression wetland within the site (Kranspan), looking north.

A view of the largest depression wetland within the site (Kranspan), looking south.

An artificial impoundment constructed within a valley-bottom wetland area, which allows for permanent surface water features to develop.

Typical grassland habitat that is utilised for livestock grazing in and around wetland units.

Well-established valley-bottom wetland units occur within the scope of the site.

Another artificial impoundment constructed within a valley-bottom wetland area, which allows for permanent surface water features to develop.

Floral zonation indicating a transitional zone of a wetland unit.

Typical wetland vegetation within a seasonal zone wetland unit. Exotic agricultural weeds are commonly included within these areas.

The cultivation of maize is regarded as a major land use within the survey site and most wetland units have been encroached upon by cultivation.

Grassland areas that are suffering from disturbance impacts. Lowered ground cover rate and subsequent destabilisation of soils are the precursors for erosion development.

Permanent surface water created through artificial impoundments often included a high density of aquatic plants. This is often an indication of an unbalanced nutrient cycle within the system.

The wall of an artificial impoundment. Kikuyu grass dominates areas such as this, which is often the case following soil disturbances. Kikuyu is also often used as a soil stabiliser species but then does spread further than the intended target site..

Figure 7: Various views of the survey area.

6.3. Wetland hydrogeomorphic (HGM) forms present within the area

The region is characterised by depression-type wetland units, supplemented by hillslope seep wetlands that are often interconnected by valley-bottom wetland types. Valleyhead seeps often are associated at the origin of the valley topographical feature that develops into a valley-bottom wetland feature. The proposed development site includes two watershed zones, with the bulk of the runoff water collecting the southern, central and eastern runoff water and draining it south-eastwards to drain along a watercourse (Boesmanspruit) that flows north-eastwards. Another watershed collects runoff from the central north-western portions and drains it northwards, with the watercourse (Vaalwaterspruit) draining north-eastwards.

Figure 8 presents a digital elevation terrain model of the proposed development site, which is based on 1m contour data. It can be seen that the majority of Portion 4 and Portion 7 drain north-westwards, whereas the remaining portions tend to drain eastwards and northwards.

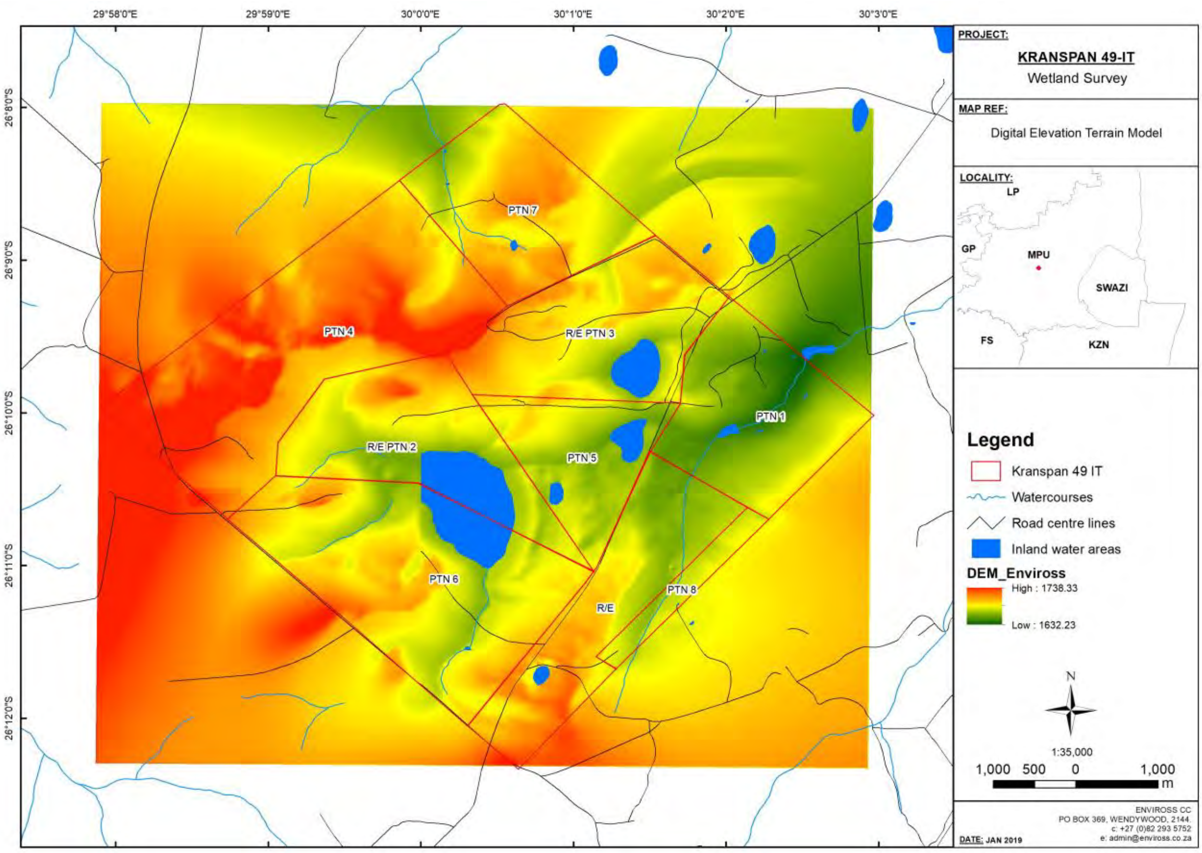


Figure 8: A digital elevation model (DEM) showing the terrain of the proposed development area.

The site is located within the upper reaches of the catchment area and therefore valleyhead seep zones that develop into valley-bottom wetland units are common. Depression wetlands that are either ephemeral (short-lived/seasonal) or more perennial (persistent) in occurrence are common. Kranspan, being the largest wetland unit within the survey area is regarded as a typical ephemeral wetland unit. There are impoundments along the watercourses of the valley-bottom units that induce persistent surface waters. Although the wetland clusters and complexes are largely isolated in terms of surface water flow, overtopping of the wetland units and surface interconnection would happen following exceptional rainfall events. They are, however, also interconnected via subsurface flows and interchanges.

Figure 9: The different HGM wetland units associated with the site. From this it can be seen that many of the peripheral wetland areas have been utilised for cultivation.

Wetland habitat units are regarded as well-established and developed within the area, with underlying soil and geological features that support a high water table and a relatively large ground-surface water interchange and therefore soil characteristics indicate that the majority of the area was historically established wetland areas. Land use that has led to unnatural channelling of valley-bottom wetlands that decreases landscape water retention periods, catchment management practices, as well as cyclic climate changes are all contributing factors that have induced the overall reduction of the functional areas of the wetland units. Hydromorphic soils reminiscent of historical wetland zones therefore tend to indicate larger expanses than what are considered to be functional and active wetland zones (detailed under section 6.6.2.).

6.4. Ecological functionality & ratings

Although there is a relatively high degree of interlinking, the survey area includes three main drainage areas. These areas are subject to similar pressures and drivers of ecological change and all have similar catchment characteristics. There are numerous small impoundments located along all watercourses, cultivation is commonplace within the higher-lying areas and livestock graze generally throughout all of the grassland areas, which are all factors that have deleterious impacts on the overall functionality of the wetland features. Hydrological, vegetation and geomorphological features are therefore generally similar for all units. All of the individual wetland units within these three areas have therefore been grouped in order to evaluate their overall ecological status. These three groups have been further broken down into subunits. If the wetlands within these individual subunits are to be impacted directly by the proposed development, then they have been analysed separately. The three functional systems of the survey area are indicated in Figure 10.

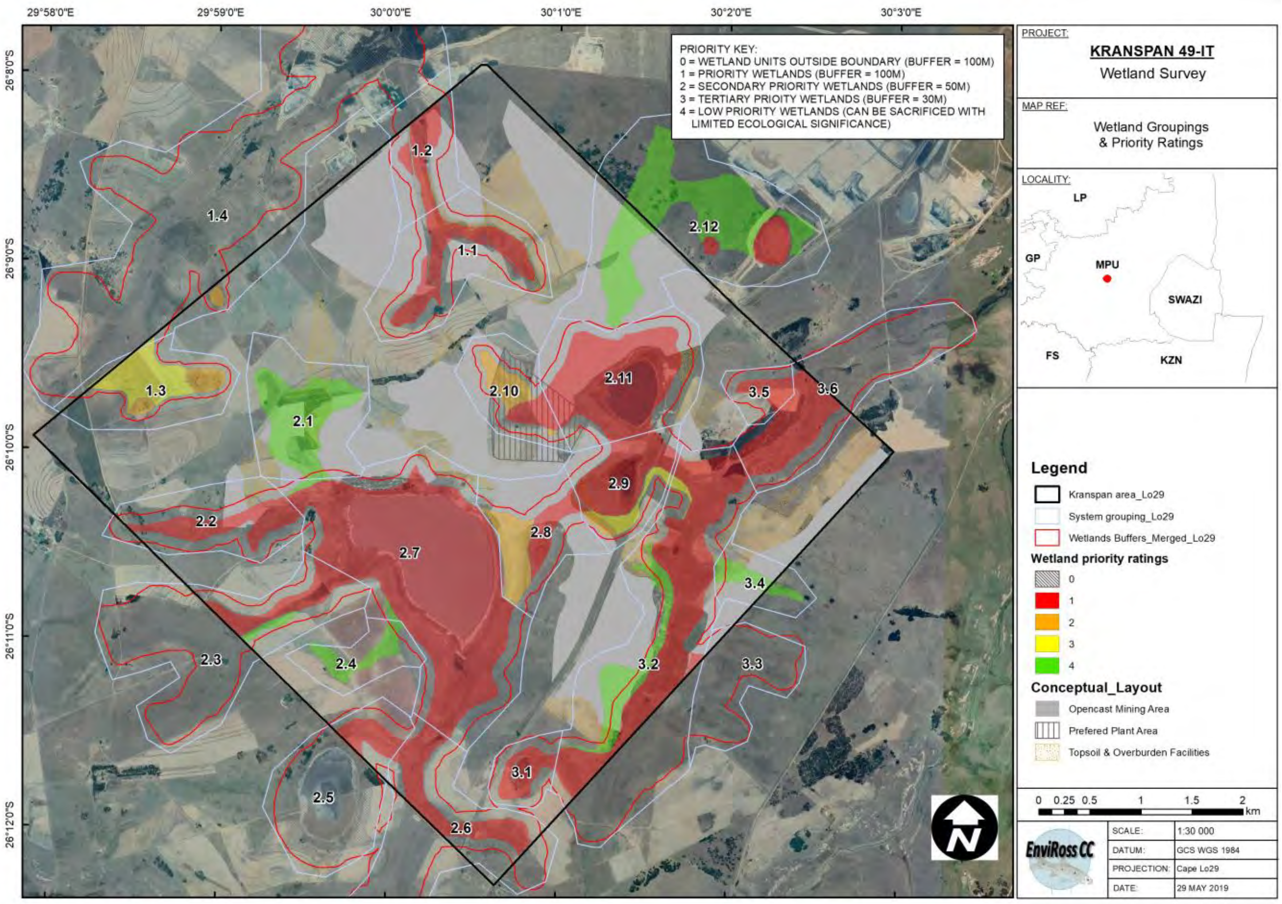


Figure 10: The three major groupings of the main wetland systems within the survey area.

From this figure it can be seen that much of the areas delineated as part of the wetland units have been cultivated and therefore lost their vegetation and other biodiversity support roles. These areas are largely considered to be supportive zones due to hydromorphic soil conditions and add to wetland function as a whole due to having retained soil layering characteristics that allows for a perched water table. Loss of these areas would not have the overall impact significance when compared to the impact significance of losing wetland features that still offer surface water persistence, and which support a community of wetland biodiversity.

6.4.1. WETLAND-IHI

The WETLAND-IHI was applied to the three wetland units associated with the survey area. These scores are presented in Table 4. Due to the largely homogenous land use throughout the catchment area and the similar pressures and drivers of ecological change experienced by the wetland units, there is little variation in scores and ratings within the units themselves. Overall, the wetland units fall within a C PES range. Variations do occur due to differences in vegetation cover, proximity to formal agriculture and mining (where the water quality would be more prone to deleterious effects of agrochemicals and other contaminants), erosion features and proximity to and number of impoundments. All of the wetland units are considered to be classified as 'moderately modified' due to factors outlined above. The depression wetland unit located on R/E Ptn 3 (sub unit 2.11) suffers a higher level of water quality degradation that was not observed within the remaining units. The source of this contamination was not ascertained during the field survey, but it is assumed to originate from the mining activities located to the nearby northern area, a large cattle presence and increased runoff from the immediate surrounding catchment area (formal agriculture and sand winning). In isolation, this wetland unit would be classified as a D/E PES rather, but, as a collective within the greater wetland unit/system, it does not proportionally contribute enough to change the PES of the overall unit. Water quality attributes are discussed in more detail under the relevant section.

Wetland sub unit 2.1 is considered a minor tributary and poorly-developed wetland feature that shows the retention of hydromorphic soil characteristics (reminiscent of historical wetland function) but has since been lost to cultivation and overall reduction of the extent of the source of water that feeds it. This unit, due to its use for cultivation, shows obvious reductions in scores in relation to the wetland unit as a whole. Water quality is shown to be rated higher than the whole wetland unit as potential sources of contamination are from only one source (one land use type) whereas, holistically, wetland unit 2 has a much wider potential source of water contamination.

Sub unit 2.8 includes a cultivated area that is regarded as a linkage between two depression-type wetland units. The PES of this unit calculated to 37.2% due to a diversity of pressures and drivers of ecological change, mostly emanating from cultivation. As this is a linkage zone between two established wetland features, the significance of impact of losing this functionality, although it shows a relatively low PES, would be greater.

Wetland sub unit 2.10 includes a feeder seepage zone that develops into a valley-head seep and unchannelled valley bottom, which feeds into sub unit 2.11, which is a depression wetland with permanent surface waters. The seep zones associated with this depression wetland within sub unit 2.10 were also considered when calculating the PES and evaluating the significance of the impacts. These units were separated due to differences in hydrogeomorphic types. The overall PES of sub unit 2.10 calculated to 44.5% (D), which is again largely due to cultivation through the unit that has led to altered vegetation structures, hydrology and geomorphological features. The PES of sub unit 2.11 calculated to 79.8% (B/C), with the main pressure and driver of ecological change being degraded water quality.

Table 4: Results from the WETLAND-IHI for the wetlands associated with the proposed development area.

Wetland unit	Sub unit	Vegetation	Hydrology	Geomorphology	Water quality	Overall PES
Wetland unit 1	Holistically	72.8%	61.3%	52.7%	72.7%	65.5% (C)
Wetland unit 2	Holistically	87.8%	70.0%	56.4%	72.7%	75.2% (C)
	2.1	43.4%	29.6%	23.6%	85.3%	38.9% (D/E)
	2.8	43.4%	29.6%	23.6%	64.3%	37.2% (E)
	2.10	59.9%%	29.6%	23.6%	64.3%	44.5% (D)
	2.11	83.7%	86.4%	70.0%	62.7%	79.8% (B/C)
	2.12	43.4%	29.6%	23.6%	85.3%	38.9% (D/E)
Wetland unit 3	Holistically	80.4%	66.5%	75.0%	72.7%	75.0% (C)

6.4.2. Ecological Importance-Sensitivity (EIS)

The EIS was undertaken according to the methods outlined in WET-EcoServices (Kotze et al, 2007). The wetland units throughout the survey area are all subject to similar pressures and drivers of ecological change, and all of the units fall within a catchment area that shares a similar land use and are located on private land, so uses of the wetland resources by local inhabitants are limited. Impoundments are located along the vast majority of the watercourses, which is typical of an established agricultural area. The EIS of the wetland units are therefore all similar as they all share similar features. The generalised rating for the EIS is indicated in Table 5.

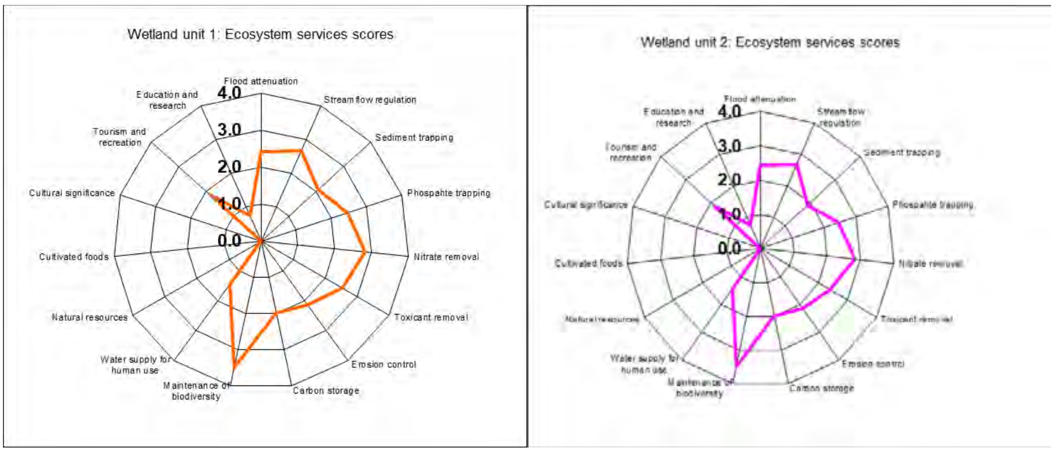
Table 5: The results of the WET-Ecoservices index to determine the EIS of the wetland units.

Wetland functional feature	Unit 1	Unit 2	Unit 3
Flood attenuation	2.4	2.4	2.4
Stream flow regulation	2.7	2.7	2.7
Sediment trapping	2.1	1.9	2.3
Phosphate trapping	2.5	2.5	2.5
Nitrate removal	2.8	2.8	2.8
Toxicant removal	2.5	2.4	2.7
Erosion control	2.1	2.1	2.1
Carbon storage	2.0	2.0	2.0

Wetland functional feature	Unit 1	Unit 2	Unit 3
Maintenance of biodiversity	3.5	3.5	3.5
Water supply for human use	1.4	1.4	1.4
Natural resources	0.0	0.0	0.0
Cultivated foods	0.0	0.0	0.0
Cultural significance	0.0	0.0	0.0
Tourism and recreation	1.9	1.9	1.9
Education and research	0.8	0.8	0.8
Runoff intensity from the wetland unit's catchment	2.0	2.0	2.0
Alteration of sediment regime	3.0	1.0	3.0
Alteration of nutrient/toxicant regime	3.0	1.0	3.0
Level of threat	3.0	3.0	3.0
Levels of opportunity	3.0	3.0	3.0
Rating	2.04	1.82	2.06

These scores indicate that the wetlands supply a moderate to high ecological service. The threat level to the habitat units remain as relatively high (3 out of 4), with the levels of opportunity, which could be interpreted as the degree to which the wetland habitat units could perform these services, also scored relatively high as well (3 out of 4) (Table 5).

The various input features and how they scored for the wetland unit are presented in Figure 11. This shows which features (services) that are performed by the wetlands are currently scoring the highest, and which ones are ranked lower. It can be seen that the ecological services supplied by the wetlands are rated as the relative highest. The wetland functionality elements (flood attenuation, and water purification) are also ranked high. Tourism and recreation also ranks relatively high due to the opportunity for birding within these areas, but the area does not fall within a tourist-friendly area, which lowers the relevance of these factors. Low-scoring elements include the dependency of the rural sector on the resources offered by the wetland units (all located on private land) and cultural significance of the wetland units.



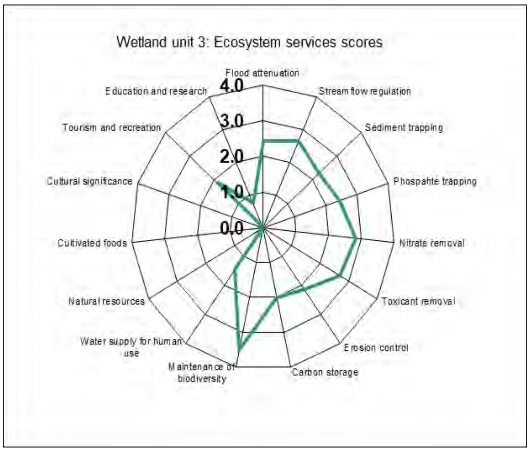


Figure 11: Scoring of the various aspects of ecological services provided for by the wetland habitat units present within the survey area.

Although the wetland units have scored average EIS and PES ratings, they remain ecologically sensitive habitat units, and they do offer value to protecting the water resource, maintenance of biodiversity, as well as provision of water to downstream ecosystems and water users, as well as provision of flood attenuation. The ecological value of such wetland units should therefore not be discounted.

6.5. Water quality analysis

Four water samples were collected during the field survey and sent to an accredited laboratory for analysis. The site localities of the sampling sites are presented in Figure 12. The results are presented in Table 6 and Table 7, with a graphical representation of the site comparative results presented in Figure 13. Results from Table 6 show that site 4 has been subject to external contamination, with relatively higher values for those parameters tested for than other watercourses from within the same catchment area. It is assumed that this is from runoff water emanating from sand winning and mining operations located to the nearby north of the site, which is regarded as a diffuse source of pollution and contamination. This is considered to be relatively more difficult to manage in relation to a point source of pollution. The depression wetland from where the sample was taken showed obvious signs of pollution sources, with a high turbid discoloured water and obvious odour.

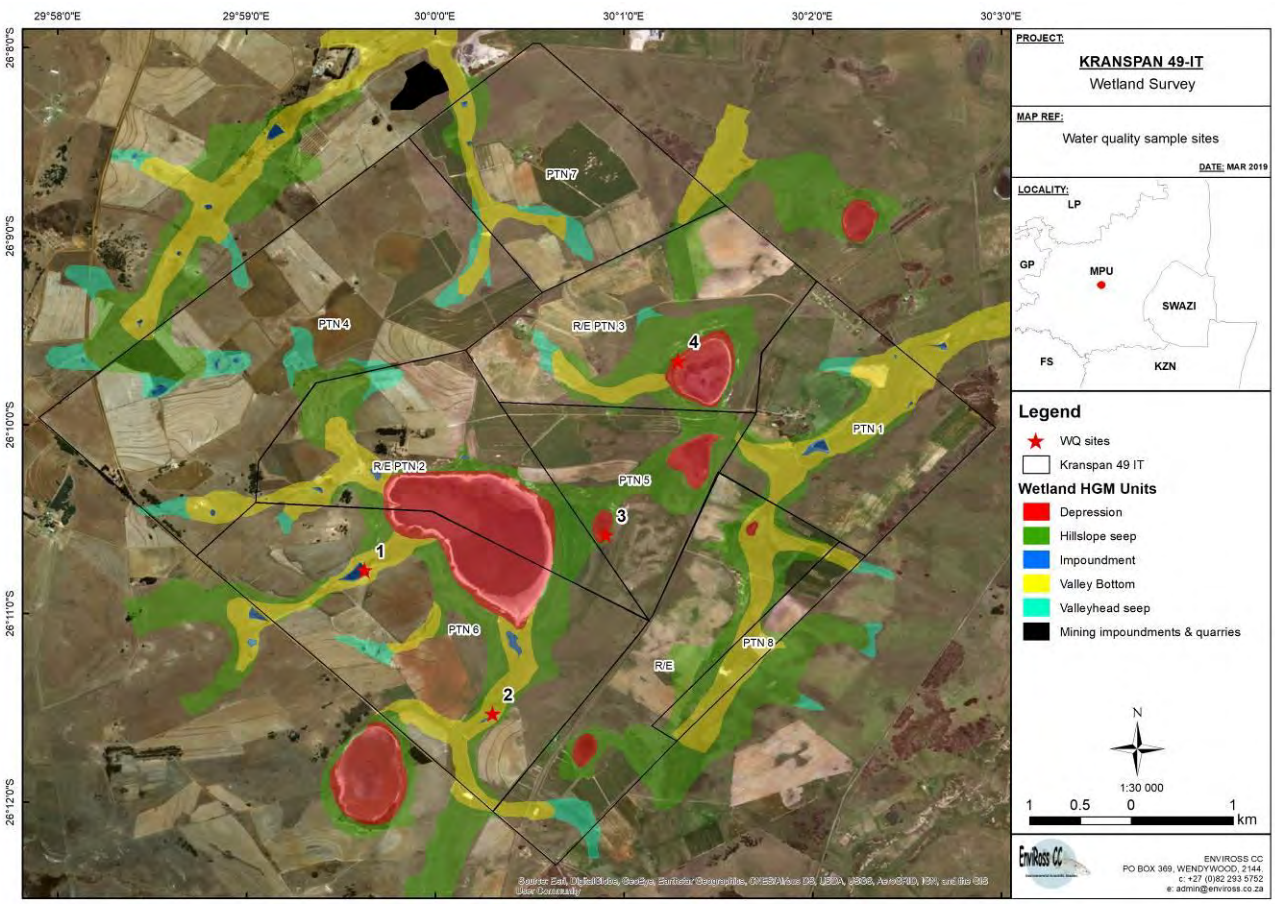


Figure 12: Water quality sampling sites.

Table 6: General water quality parameters for the four sampling sites. Parameters of concern are highlighted.

Analyses in mg/ℓ (Unless specified otherwise)	**Method Identification**	**Sample Identification**			
		Site 1	**Site 2**	**Site 3**	**Site 4**
Sample Number (Lab ref)		55147	55148	55149	55150
pH – Value at 25°C	WLAB065	6.9	7.4	6.9	7.5
Electrical Conductivity in mS/m at 25°C	WLAB002	30.0	31.6	29.1	203
Total Dissolved Solids at 180°C	WLAB003	184	222	218	1 342
Suspended Solids at 105°C	WLAB004	12.2	6.7	126	1 714
Turbidity in N.T.U	WLAB005	5.5	4.8	38	1 092
Total Alkalinity as $CaCO_3$	WLAB007	24	52	40	556
Chloride as Cl	WLAB046	51	57	57	286
Sulphate as SO_4	WLAB046	26	3	7	147
Fluoride as F	WLAB014	0.4	0.3	0.3	1.0
Nitrate as N	WLAB046	0.1	<0.1	0.1	<0.1
Total Coliform Bacteria / 100 mℓ	WLAB021	58 000	980	1 600	6 200
Faecal Coliform Bacteria / 100 mℓ	WLAB021	0	0	0	340
E. coli / 100 mℓ	WLAB021	0	0	0	280
Free & Saline Ammonia as N	WLAB046	0.4	0.4	0.5	0.5
% Balancing *	---	94.8	92.4	96.8	98.9

Electrical conductivity and total dissolved and suspended solids are all high (as is reiterated by the high positive cation concentrations shown in Table 7). Increased sulphate values indicate that the source of pollution is probably from dewatering opencast pits associated with existing coal mines.

Table 7: Results of the element scan of the four samples. Outlying concentrations (indicating extraordinarily high values are highlighted).

Element	Sample 1	Sample 2	Sample 3	Sample 4		Element	Sample 1	Sample 2	Sample 3	Sample 4
Ag	< 0.010	< 0.010	< 0.010	< 0.010		Na	34	36	39	428
Al	0.309	0.449	0.237	3.66		Nb	< 0.010	< 0.010	< 0.010	< 0.010
As	< 0.010	< 0.010	< 0.010	< 0.010		Nd	< 0.010	< 0.010	< 0.010	< 0.010
Au	< 0.010	< 0.010	< 0.010	< 0.010		Ni	< 0.010	< 0.010	< 0.010	< 0.010
B	0.011	< 0.010	0.021	0.029		Os	< 0.010	< 0.010	< 0.010	< 0.010
Ba	0.055	0.090	0.080	0.551		P	0.058	< 0.010	< 0.010	1.56
Be	< 0.010	< 0.010	< 0.010	< 0.010		Pb	< 0.010	< 0.010	< 0.010	0.012
Bi	< 0.010	< 0.010	< 0.010	< 0.010		Pd	< 0.010	< 0.010	< 0.010	< 0.010
Ca	8	9	6	21		Pr	< 0.010	< 0.010	< 0.010	< 0.010
Cd	< 0.010	< 0.010	< 0.010	< 0.010		Pt	< 0.010	< 0.010	< 0.010	< 0.010
Ce	< 0.010	< 0.010	< 0.010	0.014		Rb	0.010	0.011	< 0.010	< 0.010
Co	< 0.010	< 0.010	< 0.010	< 0.010		Rh	< 0.010	< 0.010	< 0.010	< 0.010
Cr	< 0.010	< 0.010	< 0.010	< 0.010		Ru	< 0.010	< 0.010	< 0.010	< 0.010
Cs	< 0.010	< 0.010	< 0.010	< 0.010		Sb	< 0.010	< 0.010	< 0.010	< 0.010
Cu	< 0.010	< 0.010	< 0.010	< 0.010		Sc	< 0.010	< 0.010	< 0.010	< 0.010
Dy	< 0.010	< 0.010	< 0.010	< 0.010		Se	< 0.010	< 0.010	< 0.010	< 0.010
Er	< 0.010	< 0.010	< 0.010	< 0.010		Si	0.7	0.7	2.5	18.5
Eu	< 0.010	< 0.010	< 0.010	< 0.010		Sm	< 0.010	< 0.010	< 0.010	< 0.010
Fe	1.59	1.25	0.859	2.41		Sn	< 0.010	< 0.010	< 0.010	< 0.010
Ga	< 0.010	< 0.010	< 0.010	0.012		Sr	0.039	0.049	0.035	0.090
Gd	< 0.010	< 0.010	< 0.010	< 0.010		Ta	< 0.010	< 0.010	< 0.010	< 0.010
Ge	< 0.010	< 0.010	< 0.010	< 0.010		Tb	< 0.010	< 0.010	< 0.010	< 0.010
Hf	< 0.010	< 0.010	< 0.010	< 0.010		Te	< 0.010	< 0.010	< 0.010	< 0.010
Hg	< 0.010	< 0.010	< 0.010	< 0.010		Th	< 0.010	< 0.010	< 0.010	< 0.010
Ho	< 0.010	< 0.010	< 0.010	< 0.010		Ti	< 0.010	< 0.010	< 0.010	0.095
In	< 0.010	< 0.010	< 0.010	< 0.010		Tl	< 0.010	< 0.010	< 0.010	< 0.010
Ir	< 0.010	< 0.010	< 0.010	< 0.010		Tm	< 0.010	< 0.010	< 0.010	< 0.010
K	11.3	11.9	12.3	43		U	< 0.010	< 0.010	< 0.010	< 0.010
La	< 0.010	< 0.010	< 0.010	< 0.010		V	< 0.010	< 0.010	< 0.010	0.010
Li	< 0.010	< 0.010	< 0.010	< 0.010		W	< 0.010	< 0.010	< 0.010	< 0.010
Lu	< 0.010	< 0.010	< 0.010	< 0.010		Y	< 0.010	< 0.010	< 0.010	< 0.010
Mg	7	10	5	12		Yb	< 0.010	< 0.010	< 0.010	< 0.010
Mn	0.061	0.042	0.050	0.281		Zn	0.028	0.016	0.017	0.010
Mo	< 0.010	< 0.010	< 0.010	< 0.010		Zr	< 0.010	< 0.010	< 0.010	< 0.010

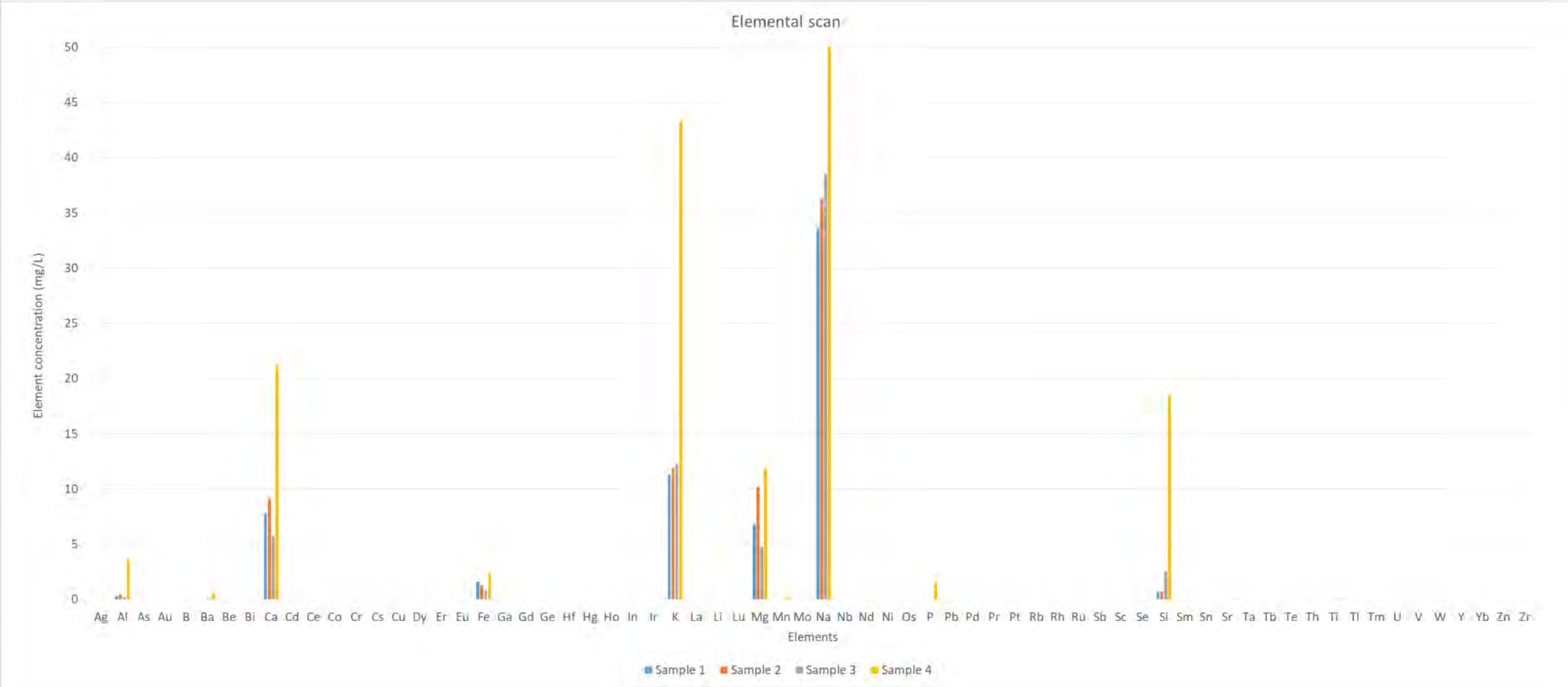


Figure 13: Elemental scan results for the four sampling sites (showing site comparisons).

The presence of *E. coli* is an indication of contamination from untreated sewerage, which would emanate from failing or inadequate sewerage infrastructure or disposal of sewerage into the system and requires urgent rectification as this poses a risk to human and livestock health.

Results of the water quality analysis shows that the surface waters have generally retained good water quality. This is what would be expected from wetland units located high up within the catchment area. The dominant surrounding land use is formal agriculture (cultivation) and therefore elements typical of fertilizers (nitrates, phosphates and trace elements such as potassium, iron, calcium, magnesium, etc) are expected to show elevated levels (pesticide contamination was not tested for). This is what was observed throughout all of the samples. Sample 4, however, has been subject to diffuse contamination by runoff from sand winning and mining activities located to the north, which is apparent by relatively higher elemental concentrations (as graphically represented in Figure 13). High levels of aluminium, calcium, potassium, sodium and silicone are all apparent within this sample. Detectable levels of lead are also shown to occur, which poses a threat to human and livestock health.

6.6. Standard Wetland Delineation Indicators

It is important to note that not all of the four wetland indicators will necessarily be present at any particular site. Disturbance factors and landscaping often lead to the vegetation indicators being largely transformed and unreliable. Landscaping also often diverts surface water flow that often dries certain areas of the wetlands, leading to the loss of the soil wetness indicators, or an arid climate could mean that limited soil moisture occurs if the survey takes place outside of the wet season. Therefore, the combination of all four unit indicators should be taken into consideration as well as a certain degree of “intuitive rationalisation” gained through experience when assessing the existence of wetland zones. Analysis of aerial imagery also is a very useful tool in analysing wetland drainage and flow patterns, especially for projects that span over a relatively large area.

6.6.1. Terrain Unit Indicator (TUI)

The TUI (taken from topographical maps, GIS data and visual observations at the site) indicated that the terrain is topographically conducive to supporting wetlands. The topography of the survey area supports a west-east watershed that then drains northwards. The application of the other indicators was therefore applied to facilitate the determination of the limits of the wetland zones if applicable.

Depression wetlands were noted to be the most abundant wetland unit throughout the survey area. Depression wetlands within this area are thought to be created through aeolian (wind) action, where livestock and wildlife favoured particular areas (a shallow water table would support better grazing and therefore concentrate it within a small area for a longer period of time). The resulting trampling would loosen the soil, making it vulnerable to dispersion from wind action when dry.

6.6.2. Soil Form Indicator (SFI)

Sampling pits were dug using a garden spade at strategic points in order to observe soil profiles *in situ*. Iron nodules were readily observed on the surface and some Laterite formation was also observed (examples of ferrolysis are shown in Figure 14). The survey area was dominated by deep, iron-rich, red soils of the Rensburg form. Observations of bleached soils associated with shallow and fluctuating water tables typical of wetland units were positive indications of ferrolysis within soils. This is where iron is leached out due to a cyclic fluctuation of a shallow water table. The soil form indicator therefore was strongly supported throughout the survey area, indicating wetland (hydromorphic) soils.

Figure 14: Examples of indications of ferrolysis (mottling) within the soils is a positive indication of hydromorphic conditions. These are samples taken within the seasonal zones and the degree of mottling is typical of seasonal wetland zonation.

During periods when the water table recedes and oxygen is able to penetrate the soil, the iron undergoes reduction to iron oxide. This remains localised and tends to be visible in the form of reddish mottles within the soil profile. Iron deposits in the form of nodules were also readily observed throughout the wetland zones.

6.6.3. Soil Wetness Indicator (SWI)

Soil wetness indicators were not strongly supported for delineation purposes due to the temporary nature of the wetland units.

6.6.4. Vegetation Indicator (VI)

Wetland-dependent (hydrophytic) vegetation has a floral species community structure that is dominated by species specifically adapted to inhabiting soils of varying degrees of water-logging, and what can flourish in oxygen-poor (hypoxic) soils. Various species are adapted to survive under varying periods of prolonged water saturated soils and therefore form distinct communities. This is largely true for undisturbed floral community structures associated with wetlands. The outer limits of the various wetland zones can therefore very often be determined by the changes in floral community structures. This unit indicator was found to be a useful tool as floral species indicative of the various wetland zones were observed. The wetland units were regarded as being well-developed, with structures typical of floral zonation being readily observed. The vegetation indicator was regarded as a reliable indicator of discerning the limits of the various zones of the wetland units. Table 8 presents the dominant floral species pertaining to the wetland units noted during the field survey.

Table 8: Dominant floral species noted within the wetland zones pertaining to the survey area.

Family	Species	Zonal indicator
Cyperaceae	*Alinula paradoxa*	Seasonal & outer permanent zones
	Ascolepis capensis	Seasonal & outer permanent zones
	Bulbostylis hispidula	Seasonal & outer permanent zones
	Carex austro-africana	Seasonal & outer permanent zones
	Cyperus compressus	Seasonal & outer permanent zones
	Cyperus congestus	Seasonal & outer permanent zones
	Cyperus denudatus	Seasonal & outer permanent zones
	Cyperus laevigatus	Seasonal & outer permanent zones
	Cyperus longus var. tenuiflorus	Seasonal & outer permanent zones
	Cyperus sexangularis	Seasonal & outer permanent zones
	Eleocharis acutangula	Seasonal & outer permanent zones
	Eleocharis dregeana	Seasonal & outer permanent zones
	Fimbristylis dichotoma	Seasonal & outer permanent zones
	Fuirena pubescens	Seasonal & outer permanent zones
	Fuirena stricta	Seasonal & outer permanent zones
	Isolepis fluitans	Seasonal & outer permanent zones
	Isolepis sepulcralis	Seasonal & outer permanent zones
	Kyllinga erecta	Seasonal & outer permanent zones
	Pycreus nitidus	Seasonal & outer permanent zones
	Schoenoplectus brachyceras	Seasonal & outer permanent zones
	Schoenoplectus corymbosus	Seasonal & outer permanent zones
Juncaceae	*Juncus dregeaus*	Seasonal & outer permanent zones
	Juncus lamatophyllus	Seasonal & outer permanent zones

Family	Species	Zonal indicator
Poaceae	*Hemarthria altissima*	Seasonal zones
	Agrostis lachnantha	Seasonal zones
	Arudinella nepalensis	Seasonal zones
	Imperata cylindrica	Seasonal to temporary zones
	Leersia hexandra	Seasonal to permanent zones
	Sporobolus pyramidalis	Seasonal to temporary zones
	Andropogon eucomus	Seasonal to temporary zones
	Ischaemum fasciculatum	Seasonal to temporary zones
	Paspalum distichum	Seasonal to permanent zones
	Andropogon appendiculatus	Seasonal zones
	Paspalum dilitatum	Seasonal zones
	Paspalum scrobiculatum	Seasonal zones
	Setaria sphacelata var. sphacelata	Seasonal zones
Potamogetonacaea	*Potamogeton thunbergii*	Permanent zones
Apiaceae	*Centella asiatica*	Exotic (seasonal zones)
Menyanthaceae	*Nymphoides thunbergiana*	Permanent zones
Iridaceae	*Watsonia densiflora*	Seasonal to temporary zones
Scrophulariaceae	*Cycnium tubulosum*	Seasonal to temporary zones

6.7. Buffer Zones

The proposed development does have an association with wetland habitat units and therefore conservation buffer zones are applicable. The wetland habitat units associated with the proposed development area perform vital functions within the landscape and should be regarded as being ecologically sensitive features. Conservation of this habitat unit forms an integral part of the conservation of the surface water resources throughout the catchment area. The proposed development is also regarded as being of a relatively high impact to the wetland units associated with it. The wetlands that are regarded as priority (high value) features have been designated a 100 m buffer zone. Those units and areas that perform lesser functions and are not regarded as priority features have been designated 50 m buffer zones, whilst those features regarded as being peripheral in both their development and ecological role have been designated a 30 m buffer zone. This is in accordance to the industry norms. The buffer zones are indicated in Figure 15.

6.8. DWS risk assessment matrix

The Department of Water and Sanitation (DWS) has developed a risk assessment matrix for development activities within a wetland or watercourse. The wetland units associated to the project have all been delineated and the appropriate conservation buffer zones have been designated to the units. The risk assessment matrix is aimed at activities that are to take place within these areas. As infrastructure is planned for within wetland areas and wetland zones will be impacted, many ratings are defaulted to having a high risk. After calculation of the various impacts, all of the impacts were rated as having a ***high*** risk to the present ecological integrity of the surface water ecosystems and associated habitat units. The significance of the impacts is largely related to the scale and intensity of the wetland habitat that will be impacted, and therefore can be greatly reduced by taking into consideration that wetland delineation mapping and associated conservation buffer zones. The calculations of the DWS Risk Assessment, detailing of the impacts and outline of the mitigation measures are provided as an Addendum to this report.

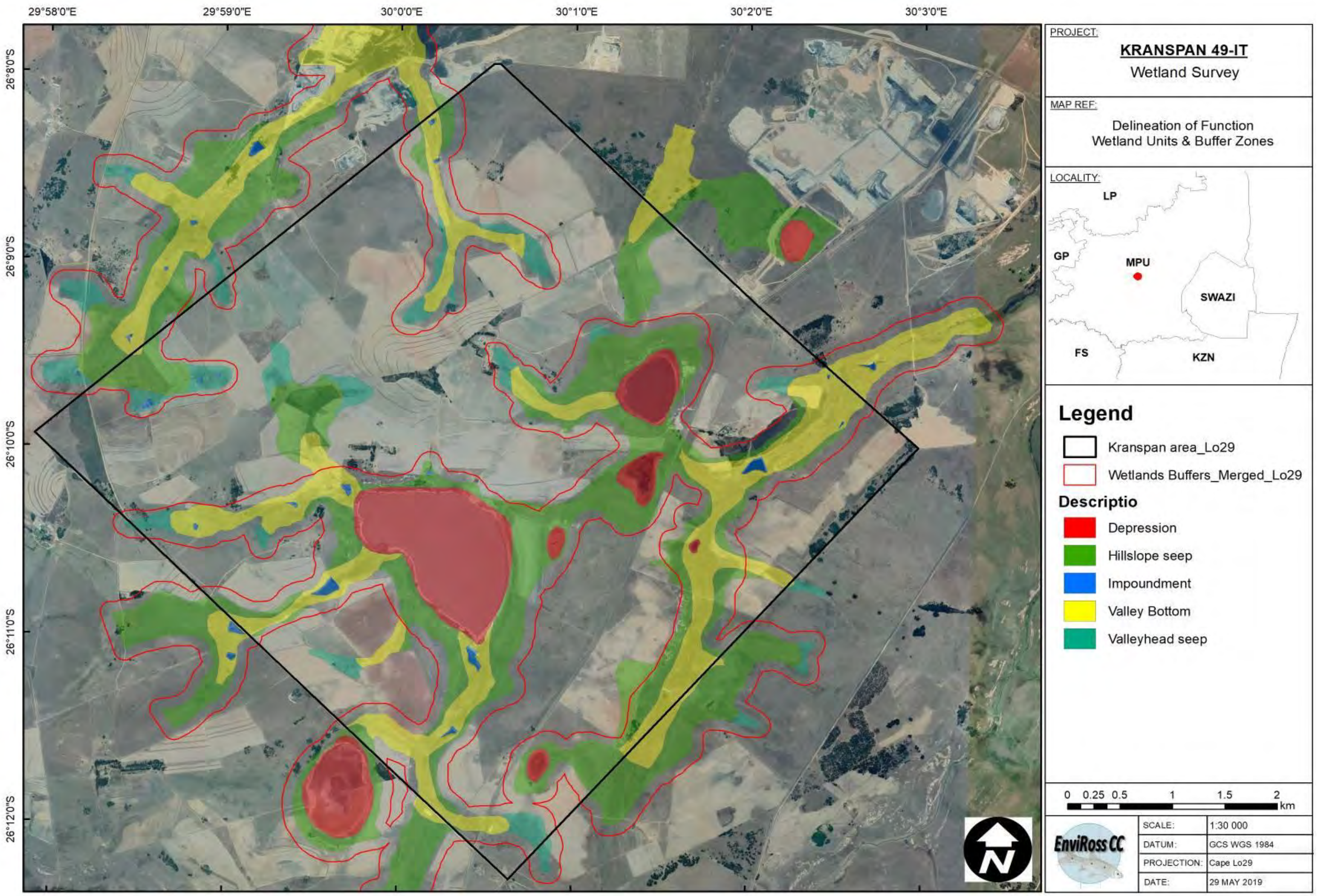


Figure 15: The delineation of functional wetland units and conservation buffer zones for the site.

7. SIGNIFICANCE RATINGS OF PERCEIVED ENVIRONMENTAL IMPACTS

The proposed development activities include the development of processes and infrastructure to aid in the establishment of the mining operations. The development area has been historically utilised for formal agriculture and therefore all mining infrastructure will be newly-established. Therefore planning of infrastructure layout, which is largely dependent on physical and geological factors, will also have to take ecological features into account to reduce overall negative ecological impacts. With mitigation measures in place, the overall ecological impacts that will persist beyond the construction and rehabilitation phases can be reduced in terms of conservation of the surface water ecosystems within the region. Table 12 presents the significance ratings of the potential ecological impacts for the *pre-construction and construction* as well as the *management phases* of the proposed development activities. The ratings are calculated for the scenarios of both before and after the implementation of mitigation measures. This was done in order to show how the degree of impacts can be reduced by careful planning and the following of relatively simple mitigation measures.

7.1. Introduction

The first phase of impact assessment is the identification of the various project activities which may impact upon the identified environmental aspects. The identification of significant project activities is supported by the identification of the various receiving environmental receptors and resources. These receptors and resources allow for an understanding of the impact pathways and assessment of the sensitivity of the receiving environment to change. The significance of the impact is then assessed by rating each variable numerically, according to defined criteria as provided in .

7.2. Impact significance rating

The purpose of the significance rating of the identified impacts is to develop a clear understanding of the influences and processes associated with each impact. The severity (magnitude), spatial scope and duration of the impact together comprise the consequence of the impact; and when summed can obtain a maximum value of 15. The frequency of the activity and the frequency of the impact together comprise the likelihood of the impact, and can obtain a maximum value of 10. The values for likelihood and consequence of the impact are then read from a significance rating matrix as shown in Table 10 and Table 11.

The model outcome of the impacts is then assessed in terms of impact certainty and consideration of available information. The Precautionary Principle is applied in instances of uncertainty or lack of information by increasing assigned ratings or adjusting final model outcomes. In certain instances where a variable or outcome requires rational adjustment due to model limitations, the model outcomes are adjusted. Arguments and descriptions for such adjustments, as well as arguments for each specific impact assessments are presented in the text and encapsulated in the assessment summary table linked to each impact discussion.

Table 9: Criteria for Assessing the Significance of Impacts.

SEVERITY OF IMPACT	RATING	
Insignificant / non-harmful	1	CONSEQUENCE
Small / potentially harmful	2	
Significant / slightly harmful	3	
Great / harmful	4	
Disastrous / extremely harmful	5	
SPATIAL SCOPE OF IMPACT	**RATING**	
Activity specific	1	
Area specific	2	
Whole project site / local area	3	
Regional	4	
National	5	
DURATION OF IMPACT	**RATING**	
One day to one month	1	
One month to one year	2	
One year to ten years	3	
Life of operation	4	
Post closure / permanent	5	
FREQUENCY OF ACTIVITY / DURATION OF ASPECT	**RATING**	LIKELIHOOD
Annually or less / low	1	
6 monthly / temporary	2	
Monthly / infrequent	3	
Weekly / life of operation / regularly / likely	4	
Daily / permanent / high	5	
FREQUENCY OF IMPACT	**RATING**	
Almost never / almost impossible	1	
Very seldom / highly unlikely	2	
Infrequent / unlikely / seldom	3	
Often / regularly / likely / possible	4	
Daily / highly likely / definitely	5	

Activity: a distinct process or task undertaken by an organisation for which a responsibility can be assigned.

Environmental aspect: an element of an organisation's activities, products or services which can interact with the environment.

Environmental impacts: consequences of these aspects on environmental resources or receptors.

Receptors: comprise, but are not limited to people or man-made structures.

Resources: include components of the biophysical environment.

Frequency of activity: refers to how often the proposed activity will take place.

Frequency of impact: refers to the frequency with which a stressor will impact on the receptor.

Severity: refers to the degree of change to the receptor status in terms of the reversibility of the impact; sensitivity of receptor to stressor; duration of impact (increasing or decreasing with time); controversy potential and precedent setting; threat to environmental and health standards.

Spatial scope: refers to the geographical scale of the impact.

Duration: refers to the length of time over which the stressor will cause a change in the resource or receptor.

Table 10: Significance Rating Matrix

	CONSEQUENCE (SEVERITY + SPATIAL SCOPE + DURATION)														
LIKELIHOOD (FREQUENCY OF ACTIVITY + FREQUENCY OF IMPACT)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

Table 11: Positive/Negative mitigation rating

Colour Code	Significance Rating	Value	Negative Impact Management Recommendation	Positive Impact Management Recommendation
	Very High	126-150	Improve current management	Maintain current management
	High	101-125	Improve current management	Maintain current management
	Medium-High	76-100	Improve current management	Maintain current management
	Low-Medium	51-75	Maintain current management	Improve current management
	Low	26-50	Maintain current management	Improve current management
	Very Low	1-25	Maintain current management	Improve current management

7.3. Activities having an impact

The key project activities for the Project upon which the impact assessment was based are described in the EIS. These activities are summarised below per project phase.