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ELANDSFONTEIN COLLIERY

SURFACE WATER SPECIALIST STUDY

(BASELINE HYDROLOGY)

Report prepared for

BEAL
CONSULTING ENGINEERING & PROJECT MANAGEMENT

Report prepared by

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1. EXECUTIVE SUMMARY

BEAL Consulting and Project Management (Pty) Ltd (BEAL) commissioned iLanda Water Services CC (iLanda) to conduct a surface water specialist investigation and surface water impact assessment in support of an Environmental Authorisation and amendment process to be followed for Anker Coal and Mineral Holdings SA (Pty) Ltd Elandsfontein Colliery.

The objective of this investigation is to assess the potential impact of the proposed activities and associated facilities on the local and regional surface water regime.

The project extent and mine lease area is located on a portion of the remaining extent of portion 8; remaining extent of portion 1; a portion of the remaining extent of portion 6; portion 44; portion 14 and the remaining extent of portion 7 of the Farm Elandsfontein 309 JS, situated approximately 4.0 km south of Kwa-Guqa and about 16.0 km west of Emalahleni, Mpumalanga Province, South Africa.

Elandsfontein colliery is in the upper reaches of the Olifants River catchment. The mining rights area is in quaternary catchment B20G. The mining rights area is located just west of Clewer and approximately 15km west, south west of Emalahleni. Elandsfontein is an operational colliery with significant development within the mining rights area.

A small tributary of the Grootspruit flows in a south westerly direction through the mining rights area. Its confluence with the Grootspruit is just to the west of the mining rights area. The Grootspruit flows from south to north along the western boundary of the mining rights area before turning west to meet the Saalklapspruit, approximately 5 km west of the mining right area. The Grootspruit is a tributary of the Saalklapspruit, which is a tributary of the Wilge River. The Wilge-Olifants river confluence is downstream of Witbank Dam, but upstream of Loskop and Flag Boshielo Dams.

The Grootspruit and its tributary are heavily reeded in places. Both river floodplains are highly impacted by mining related activities and poorly constructed/informal road crossings. Both rivers are marked as perennial streams on the 50 000 topo sheets.

Apart from the Elandsfontein mining operations, the Grootspruit catchment is undeveloped and consists mostly of impacted grasslands and dry land agriculture. The topography is relatively flat. Localised areas have steeper slopes, particularly in the vicinity of the streams. The Grootspruit is dammed with multiple farm dams. The water course has an ill-defined channel in the study area and contains significant reedbeds. The flood plains are not well developed.

The Elandsfontein mining operations occur on both sides of Grootspruit tributary along most of its length. The upper reaches are dammed with pollution control and water supply dams. The natural tributary has a poorly defined water course but is generally heavily reeded. The lower reaches have been modified and the stream is canalised for roughly half its length.

The mean annual precipitation of the mining rights area is 706 mm. The mean annual evaporation of the mining rights area is 1 689 mm (S-Pan).

The Department of Water and Sanitation require a climatic water balance that incorporates a list of years which have the wettest six months of the year, either November to April or May to October. In this case November to April is wetter than May to October. The wettest six months between November and April vary between 1432 mm and 948.6 mm.

The 50-year and 100-year peak 24-hr rainfall depths for the mining rights area are 115 mm and 130 mm, respectively.

The Grootspruit has an 81.562 km^2 catchment up to just beyond the mining rights area. The tributary of the Grootspruit has a catchment measuring 8.169 km^2 up to its confluence with the Grootspruit. The mean annual runoff for the Grootspruit and its tributary are 3.57 Mm^3/a and 0.36 Mm^3/a, respectively. Dry weather flows are between May and October.

The 50-year and 100-year flood peaks for the Grootspruit are 246 m^3/s and 326 m^3/s respectively, calculated at the point just beyond the mining rights area. The 50-year and 100-year flood peaks for the Grootspruit tributary are 55 m^3/s and 75 m^3/s respectively, calculated at its confluence with the Grootspruit.

The surface water buffer zone is the greater of the 100-year floodline or 100 m from the water course. The buffer zone for the Grootspruit is a combination of these buffers. The buffer zone for the Grootspruit tributary is predominantly the 100 m offset from the water course.

2. INTRODUCTION

BEAL Consulting and Project Management (Pty) Ltd (BEAL) commissioned iLanda Water Services CC (iLanda) to conduct a surface water specialist study for Elandsfontein Colliery. This report details the results of the study, as well as recommendations emanating from the work done.

2.1 Project Background

Elandsfontein colliery is an existing colliery which holds two mining rights – MP 63 MR and MP 314 MR. The applicant plans to consolidate these two mining rights into one mining right. The applicant wishes to expand its mining operations with further opencast mine development as well as underground mine development.

2.2 Study Objectives and Terms of Reference

The study objectives and terms of reference are as follows:

- Baseline hydrological analysis
- Floodlines and buffer zones
- Surface water impact assessment

This report constitutes the outcome of the specialist studies undertaken by iLanda on behalf of BEAL, related to the environmental impact of Elandsfontein Colliery.

2.3 Battery Limits

The battery limits of the study are shown in Figure 1. All work is confined to this area unless otherwise specified.

2.4 Legislative and Policy Framework

The following legislation was adhered to:

- The South African National Water Act, Act 36 of 1998.
- GN 704, Regulations on the use of water for mining and related activities aimed at the protection of water resources (1999).
- Mineral and Petroleum Resources Development Act, Act 28 of 2002.

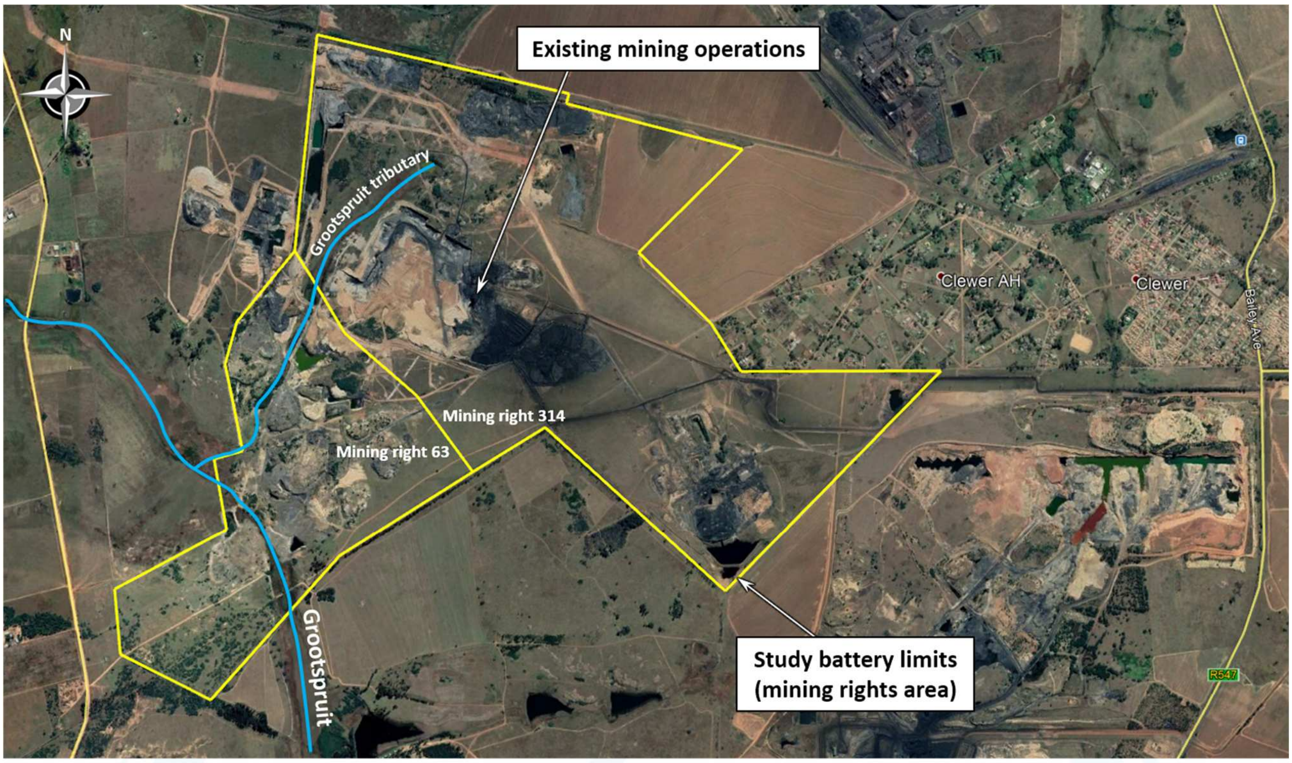

FIGURE 1: STUDY AREAS

3. DOCUMENT STRUCTURE

This report has been compiled in accordance with the EIA Regulations, 2014 (Government Notice (GN) R982). A summary of the report structure, and the specific sections that correspond to the applicable regulations, is provided in Table 1 below.

TABLE 1: REPORT STRUCTURE

Environmental regulation	Description	Section in report
NEMA EIA Regulations 2014 (as amended)		
Appendix 6 (1)(a):	Details of – 1. the specialist who prepared the report; and 2. the expertise of that specialist to compile a specialist report including a curriculum vitae;	Section 4 Appendix B
Appendix 6 (1)(b):	a declaration that the specialist is independent in a form as may be specified by the competent authority;	Appendix A

Appendix 6 (1)(c):	an indication of the scope of, and the purpose for which, the report was prepared;	Section 2.1
Appendix 6 (1)(cA):	an indication of the quality and age of base data used for the specialist report;	Section 8.1.2
Appendix 6 (1)(cB):	a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 12
Appendix 6 (1)(d):	the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 13.2.1
Appendix 6 (1)(e):	a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 8, 10.1, 13.2
Appendix 6(1)(f):	details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Section 6.1
Appendix 6(1)(g):	an identification of any areas to be avoided, including buffers;	Section 11
Appendix 6(1)(h):	a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 13.1
Appendix 6(1)(i):	a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 17
Appendix 6(1)(j):	a description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	
Appendix 6(1)(k):	any mitigation measures for inclusion in the EMPR;	Section 13.6 to 13.7.6
Appendix 6(1)(l):	any conditions for inclusion in the environmental authorisation;	
Appendix 6(1)(m):	any monitoring requirements for inclusion in the EMPR or environmental authorisation;	Section 14
Appendix 6(1)(n):	a reasoned opinion- (i) whether the proposed activity, activities or portions thereof should be	Section 16

	authorised; (ia) regarding the acceptability of the proposed activity or activities; and (ii) if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPR, and where applicable, the closure plan;	
Appendix 6(1)(o):	a description of any consultation process that was undertaken during the course of preparing the specialist report;	
Appendix 6(1)(p):	a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	
Appendix 6(1)(q):	any other information requested by the competent authority.	

4. SPECIALIST DETAILS

This specialist report was compiled by Dr Bruce Randell. Dr Randell has B.Sc. (Civil Engineering) and PhD degrees. Dr Randell's PhD thesis was in water resources. Dr Randell is a Water Resources Engineer with over 18 years' experience, mostly in water resources modelling and specialist surface water studies for environmental impact assessments. Dr Randell's CV is attached in Appendix B.

5. REGIONAL SETTING

Elandsfontein colliery is in the Mpumalanga Province of South Africa, in the upper reaches of the Olifants River catchment. The Grootspruit is a tributary of the Saalklapspruit, which is a tributary of the Wilge River. The Wilge-Olifants river confluence is downstream of Witbank Dam, but upstream of Loskop and Flag Boshielo Dams.

The Loskop and Flag Boshielo dams are located downstream of Witbank Dam and are an important source of domestic, irrigation and industrial water to their surrounding areas. The Olifants River is an international river, flowing through the Kruger National Park and into Mozambique. With the Olifants River flowing through the Kruger National Park, provision for meeting ecological requirements is one of the controlling factors for managing water resources throughout the Olifants River catchment.

The Wilge River catchment measures 4 360 km^2. The mean annual precipitation in this catchment is generally uniform with an average precipitation of approximately 670 mm, varying between 650 mm and 750 mm.

The mean annual evaporation (S-Pan) varies between 1 677 mm in the south western regions of the catchment and 1 800 mm in the north western regions of the catchment.

The natural vegetation in the catchment is predominantly grassland. Extensive irrigated and dry-land agricultural activities are prevalent, along with various forms of livestock farming. Power stations and mining activities occur in the Wilge River catchment, as do a number of small towns. These include Delmas, Bronkhorstspruit, Lionelton, Kendal, and New Largo.

6. LOCAL SETTING

The mining rights area is located in quaternary catchment B20G. The mining rights area is located just west of Clewer and approximately 15km west, south west of Emalahleni. Elandsfontein is an operational colliery with significant development within the mining rights area.

A small tributary of the Grootspruit flows in a south westerly direction through the mining rights area. Its confluence with the Grootspruit is just to the west of the mining rights area. The Grootspruit flows from south to north along the western boundary of the mining rights area before turning west to meet the Saalklapspruit, approximately 5 km west of the mining right area.

The Grootspruit and its tributary are heavily reeded in places. Both river floodplains are highly impacted by mining related activities and poorly constructed/informal road crossings. Both rivers are marked as perennial streams on the 50 000 topo sheets.

6.1 Specific Identified Sensitivities

The site is an existing operation and all surface environments within the study area are impacted. No specifically sensitivities were identified.

7. CATCHMENT DESCRIPTION

7.1 Grootspruit

Apart from the Elandsfontein mining operations, the Grootspruit catchment is undeveloped and consists mostly of impacted grasslands and dry land agriculture.

The topography is relatively flat. Localised areas have steeper slopes, particularly in the vicinity of the streams. The Grootspruit is dammed with multiple farm dams. The water course has an ill-defined channel in the study area and contains significant reedbeds. The flood plains are not well developed.

7.2 Grootspruit Tributary

The Elandsfontein mining operations occur on both sides of this stream along most of its length. The upper reaches are dammed with pollution control and water supply dams.

The natural tributary has a poorly defined water course but is generally heavily reeded. The lower reaches have been modified and the stream is canalised for roughly half its length.

8. BASELINE RAINFALL AND EVAPORATION

8.1 Mean Annual Precipitation and Evaporation

The mean annual precipitation of the mining rights area is 706 mm. The mean annual evaporation of the mining rights area is 1 689 mm (S-Pan). The monthly average rainfall, rainfall days, and evaporation rates are presented in Table 2. The Mpumalanga Highveld has distinct wet and dry seasons. 91% of the mining rights area's mean annual rainfall falls between October and April inclusively. 68% of the area's mean annual evaporation occurs in this period (Midgley et al., 1990).

8.1.1 Climatic water balance

The Department of Water and Sanitation require a climatic water balance that incorporates a list of years which have the wettest six months of the year, either November to April or May to October. In this case November to April is wetter than May to October. The wettest six months between November and April are listed in Table 3.

8.1.2 Sources of rainfall data

Daily rainfall data was sourced from the CCWR (Computing Centre for Water Research, Natal University) rainfall database (gauge number 0515382 – Witbank (MAG)). The gauge is located approximately 4 km east of the mining rights area. The CCWR data that was used contains daily records and patched records between September 1905 and December 1967, or over 72 years. An additional 46 years of daily data for Witbank (SAWB gauge number 0515412 2) was purchased from the South African Weather Bureau. The full data set therefore runs from September 1905 to August 2013. The data is considered representative of the mining rights area and is good quality.

8.1.3 Sources of evaporation data

The mean annual evaporation was sourced from the average evaporation for quaternary catchment B20G, documented in the Water Resources of South Africa, 2005 Study (Middleton and Bailey, 2009). Its monthly distribution was sourced from the Water Resources of South Africa Study data set, zone 4A (Midgley et al., 1990). The data is considered representative of the mining rights area.

TABLE 2: MEAN MONTHLY RAINFALL, RAIN DAYS AND EVAPORATION DATA FOR THE MINING RIGHTS AREA

Month	Ave Rainfall (mm)	Ave rain days	Ave Evaporation (mm S-Pan)
October	73.6	7.0	182.1
November	119.3	9.6	171.8
December	119.4	9.6	189.2
January	136.1	10.4	185.8
February	95.6	7.3	154.9
March	81.6	6.8	152.9
April	40.6	4.2	117.6
May	17.6	2.0	99.0
June	9.0	0.9	80.4
July	6.4	0.8	88.0
August	8.9	1.1	116.5
September	22.4	2.6	151.0
Mean Annual	**705.8***		**1689**

** Note: The sum of the mean monthly rainfall depths does not necessarily equal the mean annual precipitation.*

TABLE 3: WETTEST YEARS BETWEEN NOVEMBER AND APRIL

Rating	Year	Total rainfall between November and April (mm)
Wettest year	2000	1432
2nd wettest year	1917	1184.6
3rd wettest year	1975	1087.7
4th wettest year	1939	1079.1
5th wettest year	2009	1007.1
6th wettest year	1922	993.9
7th wettest year	1969	980.9
8th wettest year	1942	970.1
9th wettest year	1978	968.9
10th wettest year	1924	948.6

8.2 Peak Rainfall Data

8.2.1 Maximum Monthly Rainfall Data

The maximum monthly rainfall data was distilled from the daily rainfall record (discussed in section 8.1.2) and is presented in Table 4.

TABLE 4: MAXIMUM MONTHLY RAINFALL DATA (MM)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
192.6	321.8	354.3	374.4	340.5	236.4	135.7	117.4	106.4	81.8	79.5	135.5

8.2.2 Peak 24-hr Rainfall Data

The peak 24-hr rainfall depths are presented in Table 5.

TABLE 5: PEAK 24-HR RAINFALL DEPTHS FOR THE MINING RIGHTS AREA

Recurrence Interval (year)	24-hour rainfall depth (mm)
2	53
10	83
20	96
50	115
100	130
200	146

The daily rainfall record, discussed in section 8.1.2, was analysed and the annual maximum series was extracted from the data. This annual maximum series was statistically analysed to determine various T-year recurrence interval 24-hour storm depths. A Log Pearson Type III fit was selected as the most appropriate statistical fit. The fit is slightly conservative, but results are appropriate to the region. This fit is shown in Figure 2. The rainfall record is long, consists of good data, is representative of the site, and is suitable be used to calculate peak rainfall.

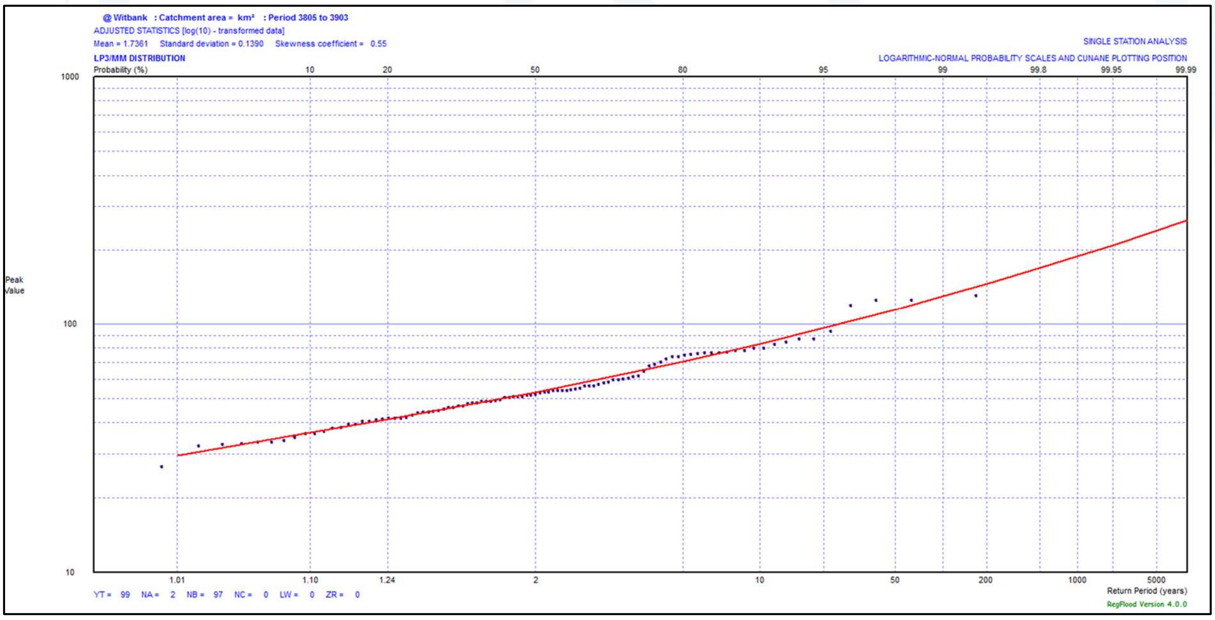

FIGURE 2: LOG EXTREME VALUE TYPE 1 STATISTICAL FIT TO THE ANNUAL MAXIMUM SERIES

9. BASELINE HYDROLOGY

9.1 Catchment Delineation

The Grootspruit has an 81.562 km^2 catchment up to just beyond the mining rights area. The tributary of the Grootspruit has a catchment measuring 8.169 km^2 up to its confluence with the Grootspruit. The catchment sizes and catchment boundaries are shown in Figure 3.

The mean annual runoffs for the catchments shown in Figure 3 are listed in Table 6.

TABLE 6: MEAN ANNUAL RUNOFF

Stream	Mean annual run-off (Mm^3/a)
Grootspruit	3.57
Grootspruit tributary	0.36

The mean annual runoff for the quaternary catchments B20G is 22.87 Mm^3 (Middleton and Bailey, 2009). The mean annual runoff values in Table 6 were scaled from the quaternary catchment runoff, based on relative catchment size.

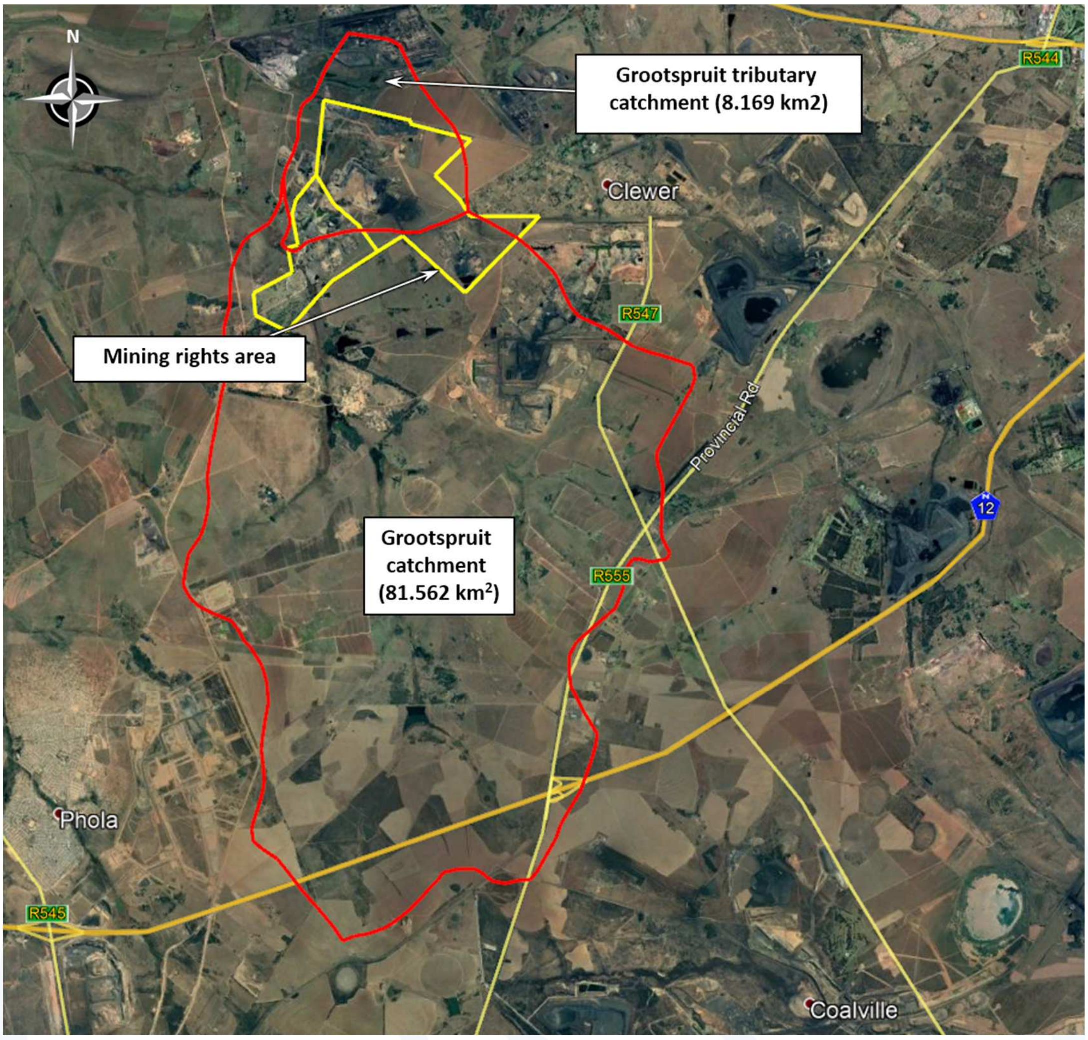

FIGURE 3: CATCHMENT DELINEATION

9.2 Normal Dry Weather Flows

Due to the small catchment size of the Grootspruit tributary, dry weather flows are likely to be very low and will often be limited to sub-surface flow only. Average dry weather flows appear high, but these are influenced by storm flow from occasional winter rainfall events and unseen subsurface flow.

The normal dry weather flows are based on the average monthly flows documented in the Water Resources of South Africa, 2005 Study (Middleton and Bailey, 2009) for quaternary catchment B20G. The flows were scaled based on relative catchment size. The dry weather flows are presented in Table 7. The dry weather flows have been highlighted in bold text.

TABLE 7: NORMAL DRY WEATHER FLOWS IN M³/MONTH (HIGHLIGHTED IN BOLD TEXT)

Month	Grootspruit	Grootspruit tributary
Oct	**166 194 m^3**	**16 645 m^3**
Nov	568 599 m^3	56 949 m^3
Dec	516 339 m^3	51 715 m^3
Jan	627 754 m^3	62 874 m^3
Feb	678 305 m^3	67 937 m^3
Mar	560 695 m^3	56 158 m^3
Apr	231 157 m^3	23 152 m^3
May	**88 768 m^3**	**8 891 m^3**
Jun	**49 264 m^3**	**4 934 m^3**
Jul	**33 327 m^3**	**3 338 m^3**
Aug	**26 342 m^3**	**2 638 m^3**
Sep	**26 250 m^3**	**2 629 m^3**

9.3 Flood Flow Analysis

The 50-year and 100-year flood peaks for the two streams were calculated and the results are presented in Table 8. The flood peaks were calculated for the catchments shown in Figure 3.

TABLE 8: PEAK FLOWS IN THE RIVERS AND STREAMS

Recurrence interval	Grootspruit	Grootspruit tributary
50-year	246 m^3/s	55 m^3/s
100-year	326 m^3/s	75 m^3/s

The Utility Programs for Drainage software was used to calculate the flood peaks. The Rational Method, Alternative Rational Method, SDF Method and Unit hydrograph Method were used to calculate the flood peaks. The Unit hydrograph Method was selected as the most appropriate flood peak to use for the Grootspruit. The Rational Method was selected as the most appropriate flood peak to use for the Grootspruit tributary.

10. FLOODLINES

10.1 Backwater analysis

The backwater analysis was performed using HEC-RAS. Cross sections for the Grootspruit and Grootspruit tributary were taken from survey data supplied by the client.

Both streams are small with ill-defined channels in most areas. Some areas have extensive reedbeds in the channels. The tributary is canalised in some places. The Grootspruit is generally free of trees and woody vegetation. The tributary has a stand of trees on one area that it flows through. The channels mostly consist of grasses, sedges and reed beds. The banks are well vegetated, mainly with grasses. A Manning’s n of 0.04 was used within the overbank stations and 0.06 outside of the overbank stations.

The flood peaks presented in Table 8 were used to calculate the floodlines. The 50-year and 100-year floodlines are shown in Figure 4. The accuracy of the survey data cannot be verified. It is assumed that the survey data provided is a true reflection of the topography within the study area. The accuracy of the floodlines is dependent on the accuracy of the survey data.

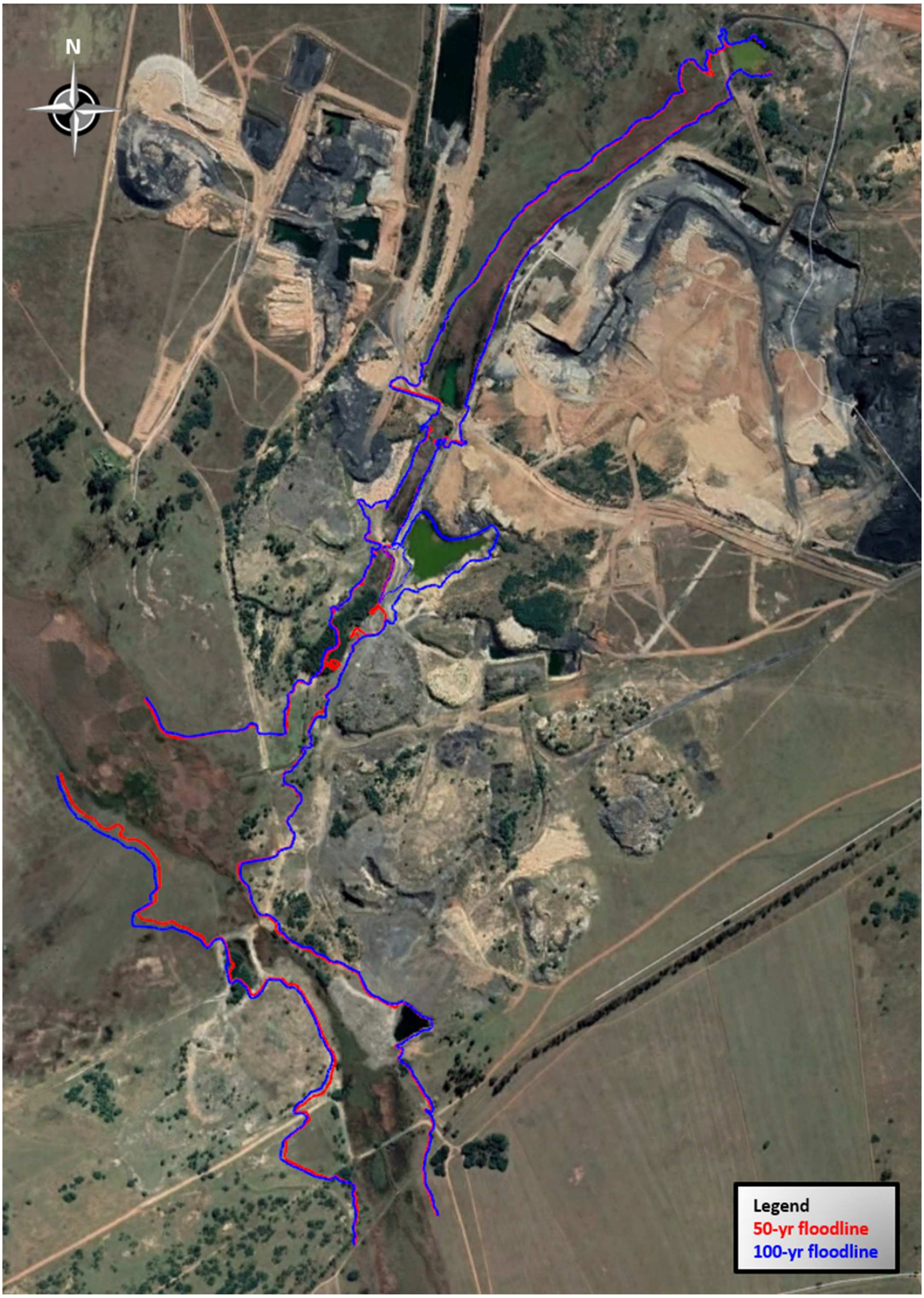

FIGURE 4: FLOODLINES

11. BUFFER ZONES

Section 4a of Government Notice 704 (GN 704) of the South African National Water Act states the following: "*No person in control of a mine or activity may locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year flood-line or within a horizontal distance of 100 metres from any watercourse…*".

Section 4b of Government Notice 704 of the South African National Water Act states the following: "*No person in control of a mine or activity may … carry on any underground or opencast mining, prospecting or any other operation or activity under or within the 1:50 year flood-line or within a horizontal distance of 100 metres from any watercourse…*"

Pollution control dams and stockpiles are required as part of the colliery so Section 4a of GN 704 will apply to these. Section 4b will apply to any opencast pits. The surface water buffer zone therefore is the greater of the 100-year floodline or 100 m from the water course. The buffer zones for the Grootspruit and its tributary are shown in Figure 5.

It must be noted that numerous infrastructures are located within the surface water buffer zones. This infrastructure should be applied to be exempt from the requirements of GN 704 or they should be removed.

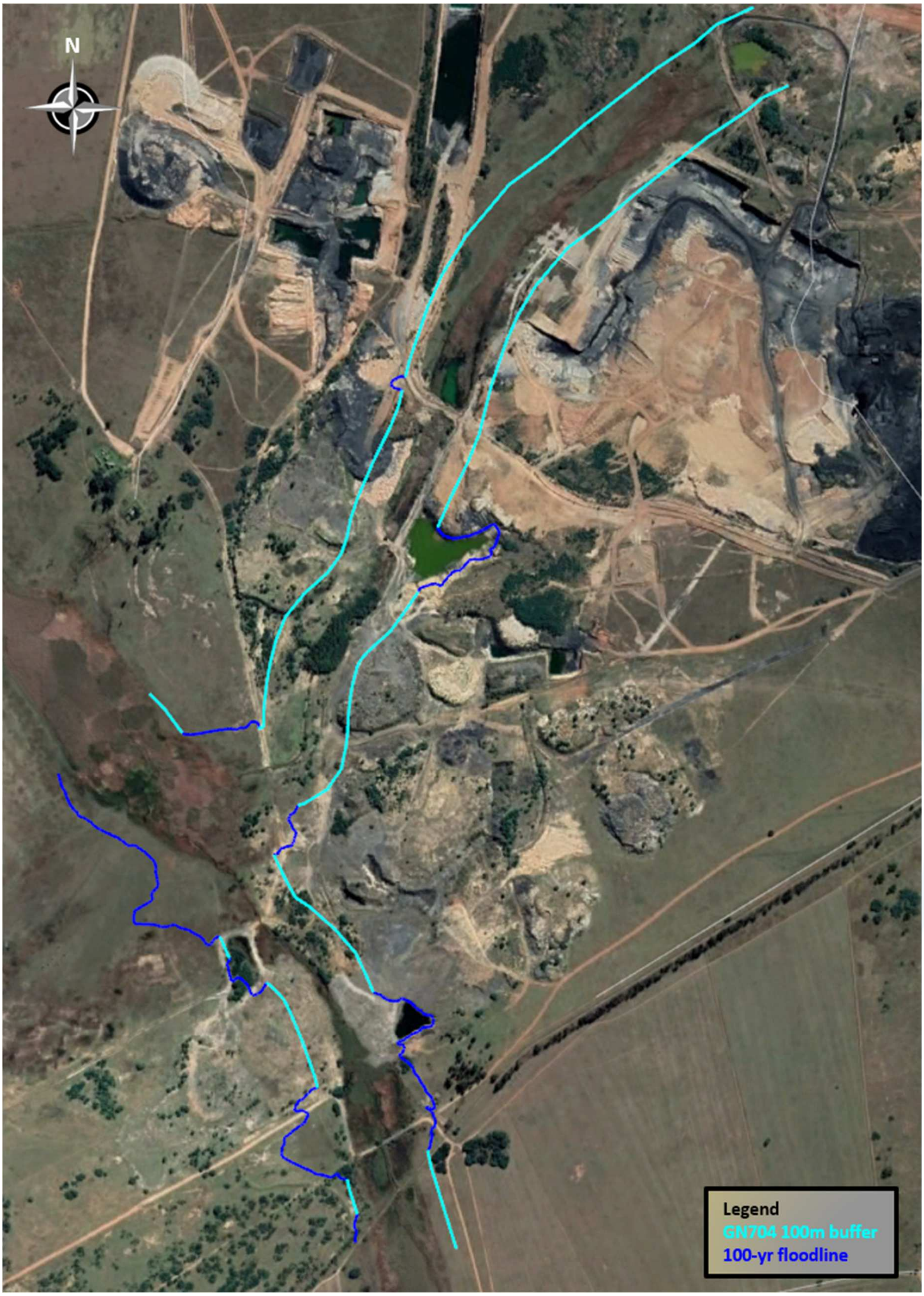

FIGURE 5: SURFACE WATER BUFFER ZONES

12. WATER QUALITY

Surface water quality data is collected at up to 13 locations within and close to the mining rights area. The sampling points are shown in Figure 6.

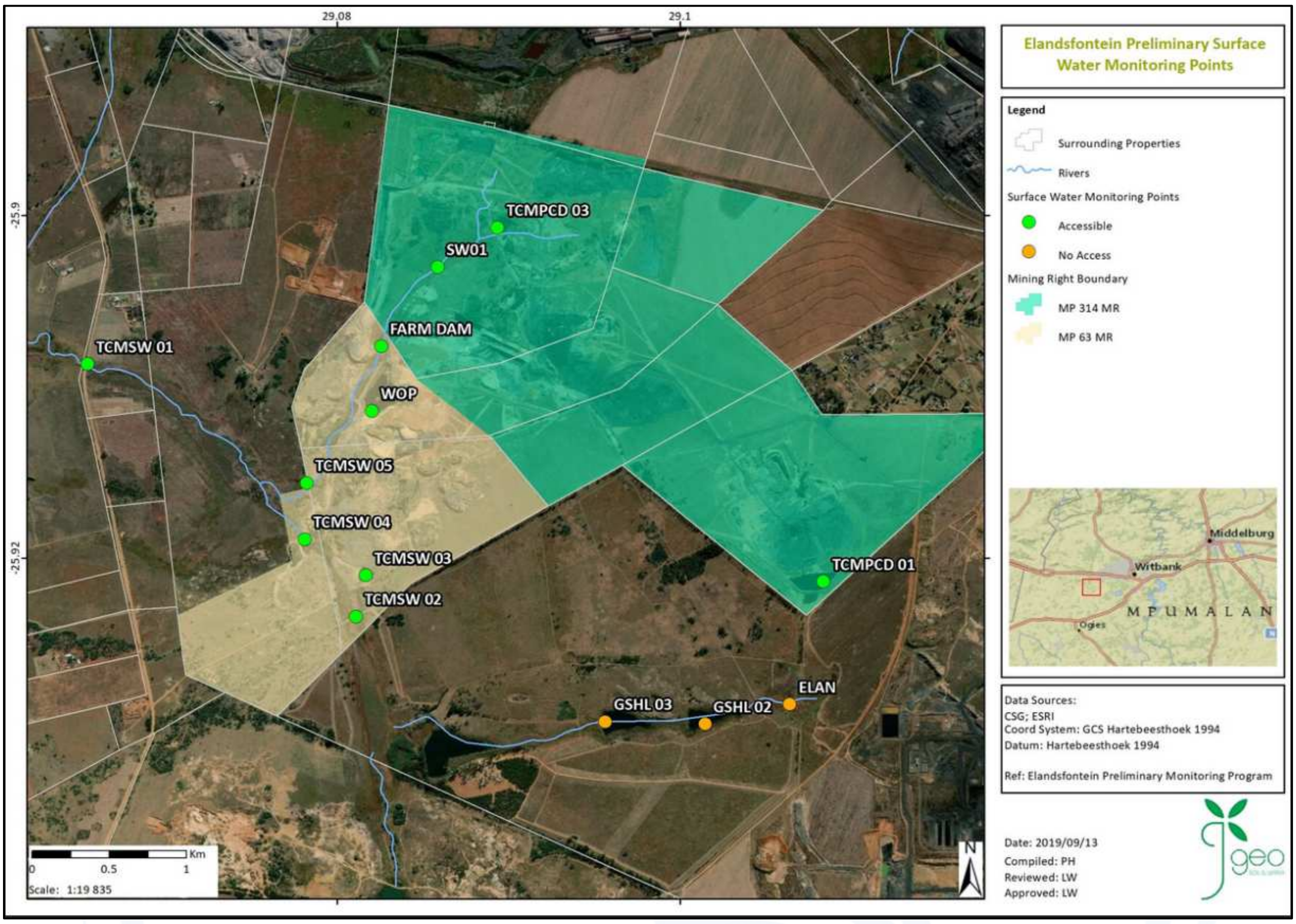

FIGURE 6: WATER QUALITY MONITORING POINTS (SOURCE: GEO SOIL & WATER)

Water quality monitoring data was made available for the purposes of this study. This comprised data from Elandsfontein colliery's 1st quarterly monitoring report for 2019 (shown in Figure 7) and data taken on 3 September 2019 (shown in Figure 8). The data shown in Figure 7 is representative of the wet season data. The data is shown in Figure 8 is representative of the dry season data. The data is compared to the resource water quality objectives, as provided in Elandsfontein colliery's 1st quarterly monitoring report for 2019. Exceedances against these resource water quality objectives are highlighted in red. The resource water quality objectives shown in the report are presented in Table 9.

TABLE 9: RESOURCE WATER QUALITY OBJECTIVES SHOWN IN ELANDSFONTEIN COLLIERYVARIABLE'S 1ST QUARTERLY REPORT

Variable	Quality objective
pH value at 25°C	4-5 or 9.5 - 10
Total Alkalinity as CaCO3	N/A
Chloride (Cl) in mg/l	200 – 600
Sulphate (SO_4) in mg/l	400 – 600
Calcium (Ca) in mg/l	150 – 300
Sodium (Na) in mg/l	200 – 400
Magnesium (Mg) in mg/l	70 – 100
Fluoride (F) in mg/l	1 – 1.5
Iron (Fe) in mg/l	0.2 – 2
Manganese (Mn) in mg/l	0.1 – 1
Electrical Conductivity in mS/m (EC)	150 – 370
Aluminium (Al) in mg/l	0.3 – 0.5
Free and Saline Ammonia as N in mg/l	1 – 2
Potassium (K) in mg/l	50 – 100

Date measured	Sample ID / Olifants RWQO	pH	EC	TDS	Cl	SO4	NO3	NH4	F	Ca	Mg	Na	K	Al	Fe	Mn
		6.5 - 8.4	111	No Limit	5	500	4	0.1	3	No Limit	No Limit	No Limit	No Limit	No limit	No Limit	No Limit
2018-11-05	TCMSW01	3.7	285.0	2858.0	30.8	1874.0	BDL	-1.0	BDL	518.0	149.0	75.6	1.4	10.1	0.3	21.5
2019-01-31	TCMSW01	3.4	226.0	1886.0	42.8	1280.0			BDL	303.0	89.5	58.3	15.4	7.1	1.3	12.5
2019-02-28	TCMSW01	3.6	184.0	1534.0	28.5	1022.0	0.2	0.2	BDL	253.0	83.8	45.1	8.5	4.8	0.9	12.0
2019-03-30	TCMSW01	3.5	230.0	2208.0	37.9	1356.0	BDL		BDL	332.0	101.0	51.4	15.0	8.1	1.0	15.4
2018-10-06	TCMSW02	3.4	267.0	2452.0	35.9	1677.0	BDL	BDL	BDL	401.0	125.0	71.2	6.9	9.5	1.7	15.2
2018-11-05	TCMSW02	3.1	140.0	918.0	3.4	606.0	0.1	BDL	BDL	160.0	46.9	15.1	0.8	0.5	2.7	11.6
2019-02-28	TCMSW02	3.2	114.0	776.0	9.1	502.0	<0.1	BDL	0.3	103.0	39.8	17.4	3.7	1.5	4.5	10.8
2019-03-30	TCMSW02	3.1	98.6	606.0	9.7	408.0	<0.1	BDL	0.4	88.5	28.6	15.3	3.2	1.0	2.8	8.7
2018-11-05	Farm Dam	6.4	309.0	2990.0	107.0	1889.0	0.2	BDL	BDL	467.0	140.0	159.0	22.5	0.1	0.1	16.6
2019-01-31	Farm Dam	5.0	217.0	1696.0	78.2	1192.0		BDL	0.3	277.0	90.6	95.9	24.8	0.5	0.1	13.9
2019-02-28	Farm Dam	4.6	264.0	2412.0	91.0	1510.0	1.4	BDL	0.2	369.0	124.0	133.0	28.0	1.5	0.1	19.6
2019-03-30	Farm Dam	6.6	302.0	2484.0	103.0	1760.0	0.4	BDL	0.20	417.0	137.0	136.0	30.5	0.0	0.1	18.6
2019-01-31	TCMSW04	4.5	92.6	786.0	9.6	511.0		BDL	0.5	93.4	49.3	18.4	5.1	0.6	0.1	7.7
2019-02-28	TCMSW04	5.1	52.1	406.0	12.2	249.0	0.2	BDL	0.2	47.1	25.1	16.1	4.2	0.1	0.1	4.1
2019-03-30	TCMSW04	6.5	46.8	360.0	10.7	220.0	0.1	BDL	BDL	44.6	20.8	14.7	2.8	0.0	0.1	3.4

Constituents are in mg/L except for pH, and EC is in mS/m

Red highlighted values/cells indicate concentrations exceeding the maximum allowable Olifants Water quality range

BDL - Below Detection Limi

FIGURE 7: WATER QUALITY DATA REPORTED IN ELANDSFONTEIN COLLIERY 1ST QUARTERLY REPORT FOR 2019 (JAN-MAR)

SAMPLE DESCRIPTION		TCM - SW 01	TCM - SW 02	TCM - SW 03	TCM - PCD 01	WOP	ELAN	SW - 01	Decant	Farm Dam	GSH - L 02	GSH - L 03
SAMPLED		03/09/2019	03/09/2019	03/09/2019	03/09/2019	03/09/2019	03/09/2019	03/09/2019	03/09/2019	03/09/2019	03/09/2019	03/09/2019
Remarks		Clear	Clear	Clear	Clear	Clear	No Acces	Clear	Clear	Clear	No Access to Game Farm	
Total Alkalinity (pH>4.5)	mg CaCO3/L	2.60	15.20	0.00	0.00	0.00		5.20	13.80	12.20		
Bicarbonate Alkalinity	mg CaCO3/L	2.60	15.20	0.00	0.00	0.00		5.20	13.80	12.20		
Carbonate Alkalinity	mg CaCO3/L	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00		
M Alkalinity (8.3>pH>4.5)	mg CaCO3/L	2.60	15.20	0.00	0.00	0.00		5.20	13.80	12.20		
P Alkalinity (pH>8.3)	mg CaCO3/L	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00		
Conductivity (Laboratory)	mS/m	226	30.8	121	674	293		314	319	332		
pH (Laboratory)		4.74	6.31	3.45	2.43	3.33		5.58	6	6.36		
Total Hardness	mg CaCO3/L	1437	120	549	2145	1953		2064	2008	2285		
Calcium Hardness	mg CaCO3/L	996	65	365	1320	1343		1365	1311	1517		
Magnesium Hardness	mg CaCO3/L	441	55	184	825	609		699	696	768		
Total Dissolved Solids (TDS)	mg/L	2073	172	774	7026	2953		3047	3135	3379		
Suspended Solids (TSS)	mg/L	10.0	2.4	1.2	20.4	14.0		7.6	44.0	2.8		
Temperature	°C	21.0	21.0	21.0	21.0	21.0		21.0	21.0	21.0		
Turbidity	NTU	6.20	2.09	2.08	8.11	33.40		1.88	124.00	1.54		
Oxygen Dissloved (DO)	mg O2/L	6.58	6.39	6.81	6.11	6.91		6.35	6.55	6.12		
Ammonia and Ammonium	mg N/L	<0.45	<0.45	<0.45	4.09	1.74		1.33	5.5	<0.45		
Calcium	mg Ca/L	399	26	146	529	538		547	525	608		
Chloride	mg Cl/L	44.7	6.43	5.04	3.17	34.4		85.6	62.4	95.2		
Magnesium	mg Mg/L	107	13.3	44.7	200	148		170	169	187		
Nitrate and Nitrite (TON)	mg N/L	0.4	<0.35	<0.35	<0.35	0.45		2.12	<0.35	0.64		
Potassium	mg K/L	13.3	1.21	8.23	3.72	18.5		32.7	25.3	36.7		
Sodium	mg Na/L	43.4	6.78	7.11	28.66	41.9		115	70.81	136.9		
Silicon	mg Si/L	6.7	2.06	5.93	67.1	6.04		3.42	6.07	0.72		
Sulphate	mg SO4/L	1448	108	554	5231	2122		2070	2223	2301		
Aluminium	mg Al/L	3.02	0.01	4.4	403	17.1		<0.01	<0.01	0.02		
Fluoride	mg F/L	1.05	0.15	2.75	117	0.12		<0.09	2.93	<0.09		
Iron	mg Fe/L	0.13	0.15	1.69	437.3	13.73		0.52	29.79	0.1		
Manganese	mg Mn/L	9.75	0.87	<0.01	68.25	14.47		12.55	11.15	5.13		

RWQO exceedances

RWQO exceedances in PCDs

RWQO exceedances in pits

FIGURE 8: WATER QUALITY DATA TAKEN ON 3 SEPTEMBER 2019

The water quality data is typical of a coal mine with low pH values and high salinity in process waters. The Grootspruit shows a significant deterioration from SW02 to SW01. This is a clear indication of significant impacts from the existing operations. The surface water sampling in the Grootspruit tributary are further evidence of these impacts. The WOP sample point, which samples old open pit water shows typical coal mining impacts, implying shallow groundwater pollution exists. This is corroborated by the poor water quality in the decant sample. Impacts in Grootspruit are worse in the dry season than in the wet season, further implying shallow groundwater seepage pollution.

13. IMPACT ASSESSMENT

13.1 Project Description

The project involves opencast and underground coal mining, the construction of topsoil, hards and softs dumps, the construction of run of mine stockpile areas, washing and screening activities with their associated stockpiles, storm water management infrastructure (diversion channels and pollution control dams), and administration buildings. Discards are being stockpiled in old opencast pits. Some of these activities are shown in Figure 9.

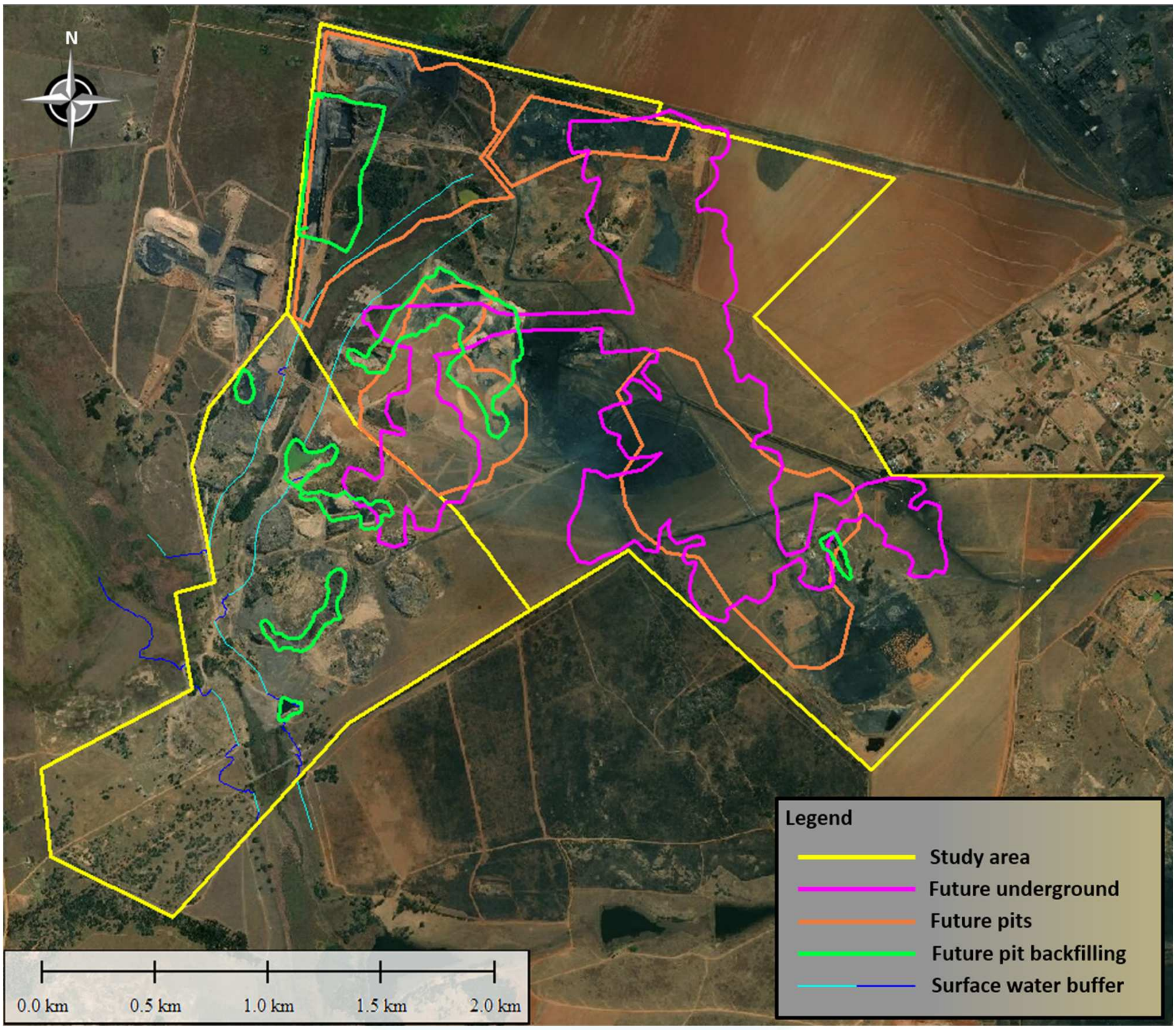

FIGURE 9: ACTIVITIES AND BUFFER ZONES

13.2 Methodology for Impact Assessment

13.2.1 Site visit

Two site visits were conducted in early November 2019 and February 2020. Both of these visits were during the traditional wet season, although the 2019/20 rainfall season started late so the November 2019 site visit was technically during the late dry season. The February site visit can be regarded as the mid wet season. All observations made during this site visit are therefore representative of the wet season.

13.2.2 Impact assessment

Activities on the mine have been taken through an impact assessment prior to and post mitigation measures. Impacts are noted when flow volumes, velocities, characteristics and qualities are anticipated to change as a result of the mining activities. These changes can be to the detriment or the benefit of the receiving environment. This is done through a significance rating methodology which is guided by the requirements of the NEMA EIA Regulations 2014.

The broad approach to the significance rating methodology is to determine the environmental risk (ER) by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relate this to the probability/ likelihood (P) of the impact occurring. This determines the environmental risk. In addition, other factors, including cumulative impacts and potential for irreplaceable loss of resources, are used to determine a prioritisation factor (PF) which is applied to the ER to determine the overall significance (S). The impact assessment will be applied to all identified alternatives. Where possible, mitigation measures will be recommended for impacts identified.

13.3 Determination of Environmental Risk

The significance (S) of an impact is determined by applying a prioritisation factor (PF) to the environmental risk (ER). The environmental risk is dependent on the consequence (C) of the particular impact and the probability (P) of the impact occurring. Consequence is determined through the consideration of the Nature (N), Extent (E), Duration (D), Magnitude (M), and reversibility (R) applicable to the specific impact. For the purpose of this methodology the consequence of the impact is represented by:

$$c = \frac{(E + D + M + R) * N}{4}$$

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in Table 10 below.

TABLE 10: CRITERIA FOR DETERMINING IMPACT CONSEQUENCE

Aspect	Score	Definition
Nature	-1	Likely to result in a negative/ detrimental impact
	+1	Likely to result in a positive/ beneficial impact
Extent	1	Activity (i.e. limited to the area applicable to the specific activity)
	2	Site (i.e. within the development property boundary),
	3	Local (i.e. the area within 5 km of the site),
	4	Regional (i.e. extends between 5 and 50 km from the site
	5	Provincial / National (i.e. extends beyond 50 km from the site)
Duration	1	Immediate (<1 year)
	2	Short term (1-5 years),
	3	Medium term (6-15 years),
	4	Long term (the impact will cease after the operational life span of the project),
	5	Permanent (no mitigation measure of natural process will reduce the impact after construction).
Magnitude/Intensity	1	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected),
	2	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected),
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way),
	4	High (where natural, cultural or social functions or processes are altered to the 4 extent that it will temporarily cease), or

	5	Very high / don't know (where natural, cultural or social functions or processes 5 are altered to the extent that it will permanently cease).
Reversibility	1	Impact is reversible without any time and cost.
	2	Impact is reversible without incurring significant time and cost.
	3	Impact is reversible only by incurring significant time and cost.
	4	Impact is reversible only by incurring prohibitively high time and cost.
	5	Irreversible Impact

TABLE 11: PROBABILITY SCORING

Probability	1	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%),
	2	Low probability (there is a possibility that the impact will occur; >25% and <50%),
	3	Medium probability (the impact may occur; >50% and <75%),
	4	High probability (it is most likely that the impact will occur- > 75% probability), or
	5	Definite (the impact will occur),

The result is a qualitative representation of relative ER associated with the impact. ER is therefore calculated as follows:

$$ER = C * P$$

TABLE 12: DETERMINATION OF ENVIRONMENTAL RISK

Consequence	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
	Probability	1	2	3	4	5

The outcome of the environmental risk assessment will result in a range of scores, ranging from 1 through to 25. These ER scores are then grouped into respective classes as described in Table 13.

TABLE 13: SIGNIFICANCE CLASSES

Environmental Risk Score	
Value	Description
<9	Low (i.e. where this impact is unlikely to be a significant environmental risk).
≥ 9 - <17	Medium (i.e. where the impact could have a significant environmental risk),
≥ 17	High (i.e. where the impact will have a significant environmental risk).

The impact ER will be determined for each impact without relevant management and mitigation measures (pre- mitigation), as well as post implementation of relevant management and mitigation measures (post-mitigation). This allows for a prediction in the degree to which the impact can be managed/mitigated.

13.4 Impact Prioritisation

Further to the assessment criteria presented in the section above, it is necessary to assess each potentially significant impact in terms of:

1. Cumulative impacts; and
2. The degree to which the impact may cause irreplaceable loss of resources.

To ensure that these factors are considered, an impact prioritisation factor (PF) will be applied to each impact ER (post-mitigation). This prioritisation factor does not aim to detract from the risk ratings but rather to focus the attention of the decision-making authority on the higher priority/significance issues and impacts. The PF will be applied to the ER score based on the assumption that relevant suggested management/mitigation impacts are implemented.

TABLE 14: CRITERIA FOR DETERMINING PRIORITISATION

Cumulative Impact (CI)	Low (1)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.
	Medium (2)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.
	High (3)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/definite that the impact will result in spatial and temporal cumulative change.
Irreplaceable Loss of Resources (LR)	Low (1)	Where the impact is unlikely to result in irreplaceable loss of resources.
	Medium (2)	Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.
	High (3)	Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).

The value for the final impact priority is represented as a single consolidated priority, determined as the sum of each individual criteria represented in Table 14. The impact priority is therefore determined as follows:

$$Priority = CI + LR$$

The result is a priority score which ranges from 3 to 9 and a consequent PF ranging from 1 to 2 (Refer to Table 15).

TABLE 15: DETERMINATION OF PRIORITISATION FACTOR

Priority	Ranking	Prioritisation Factor
2	Low	1
3	Medium	1.125
4	Medium	1.25
5	Medium	1.375
6	High	1.5

In order to determine the final impact significance, the PF is multiplied by the ER of the post mitigation scoring. The ultimate aim of the PF is an attempt to increase the post mitigation environmental risk rating by a full ranking class, if all the priority attributes are high (i.e. if an impact comes out with a medium environmental risk after the conventional impact rating, but there is significant cumulative impact potential and significant potential for irreplaceable loss of resources, then the net result would be to upscale the impact to a high significance).

TABLE 16: FINAL ENVIRONMENTAL SIGNIFICANCE RATING

Rating Environmental Significance Rating	
Value	Description
≤ -20	High negative (i.e. where the impact must have an influence on the decision process to develop in the area).
> -20 - ≤ -10	Medium negative (i.e. where the impact could influence the decision to develop in the area).
> -10	Low negative (i.e. where this impact would not have a direct influence on the decision to develop in the area).
0	No impact
<10	Low positive (i.e. where this impact would not have a direct influence on the decision to develop in the area).
≥10 - < 20	Medium positive (i.e. where the impact could influence the decision to develop in the area).

The significance ratings and additional considerations applied to each impact will be used to provide a quantitative comparative assessment of the alternatives being considered. In addition, professional expertise and opinion of the specialists and the environmental consultants will be applied to provide a qualitative comparison of the alternatives under consideration. This process will identify the best alternative for the proposed project.

13.5 Summary of Impacts and Significant Ratings

13.5.1 Construction phase

Elandsfontein Colliery is an existing operation, so construction impacts are limited. However new roads and footprints may be constructed in the future.

Likely impacts are:

- Impacts due to topsoil stripping
- Impacts due to construction related pollution

Proposed management and mitigation measures are summarised as:

- Optimising areas that are stripped
- Optimising the timing of activities to limit storm water impacts, along with effective storm water management.
- Vegetation management.
- Maintenance of construction vehicles and effective storm water management around wash bays and service and storage areas.

13.5.2 Operational phase

Likely impacts are:

- Impacts due to contaminated water discharge
- Impacts due to leaking or burst dirty water pipes
- Loss of catchment yield
- Impacts due to wash bays and workshops
- Impacts due to vehicle fleet-related pollution

Proposed management and mitigation measures are summarised as:

- GN 704 compliance.
- Maintenance of pipelines.
- Maintenance of construction vehicles and effective storm water management around wash bays and service and storage areas.

13.5.3 Decommissioning phase

Likely impacts are:

- Impacts due to the removal of surface infrastructure and rehabilitation

Proposed management and mitigation measures are summarised as:

- Effective plant maintenance.
- Footprint optimisation.

13.5.4 Rehabilitation and closure phase impacts

Likely impacts are:

- Impacts due to pit decant.

Proposed management and mitigation measures are summarised as:

- Effective rehabilitation to reduce infiltration.
- Passive or active treatment of decant water.

13.5.5 Summary of impact rating scores

The impact and significant ratings are summarised in **Error! Reference source not found.**.

13.6 Impacts During the Construction Period

13.6.1 Impacts due to topsoil stripping

Alternatives applicable

Impacts due to topsoil stripping are applicable to the following activity alternatives:

- Mining option (Activity Alternative A1)

Impacts due to topsoil stripping are applicable to the following process alternatives:

- Open Cast (Process Alternative P3a)
- Underground (Process Alternative P3b)

Impact assessment

During the construction phase, topsoil from all facility footprints will be stripped and stockpiled for future use. This may result in the following impacts:

- Areas that have been stripped of vegetation and topsoil will be prone to erosion. This could lead to increased suspended solids being deposited into the local streams. It is unlikely that impacts will extend beyond the Grootspruit and the Grootspruit tributary.
- The topsoil stockpile will be prone to erosion prior to it being vegetated. Natural re-vegetation will likely take more than one season to completely cover the topsoil stockpile. The resultant erosion could lead to increased suspended solids being deposited into the Grootspruit and the Grootspruit tributary.

The affected areas will be relatively small. Erosion impacts will be short-term and will cease once the facilities are constructed and the topsoil stockpile is vegetated.

Mitigation

Mitigation of the impacts should include the following:

- Areas that are stripped should be optimised to limit unnecessary stripping.
- Storm water from upslope of the stripped areas should be diverted around these areas to limit the amount of storm water flowing over from these areas.
- The timing of the topsoil stripping should be optimised to limit the time between stripping and construction. Where practical constraints exist and areas need to be left stripped for long periods, contour ploughing, or ripping could reduce run-off and hence reduce erosion.
- Dry season construction is preferable where practical.
- Hydro seeding of the topsoil stockpile is recommended to speed up vegetation cover. An appropriate seed mix should be designed by a vegetation specialist.

Cumulative impact

Topsoil stripping will add to sediment loads produced by erosion from upstream agricultural activities. While it occurs, the impact will be significant compared to upstream impacts of a similar nature. However, the impact will be temporary and will cease shortly after the dirty water management infrastructure is in place.

Irreplaceable loss of resources

The impacts are likely to be temporary as high flows will wash sediments out of river systems. There will likely to be no irreplaceable loss of resources.

13.6.2 Impacts due to construction related pollution

Alternatives applicable

Impacts due to construction related pollution are applicable to the following activity alternatives:

- Mining option (Activity Alternative A1)

Impacts due to construction related pollution are applicable to the following process alternatives:

- Open Cast (Process Alternative P3a)
- Underground (Process Alternative P3b)

Impact assessment

During the construction phase a significant number of vehicles will be driving around the site. In addition to this, fuels are stored on site and chemicals are used during normal construction activities. This may result in the following impacts:

- If the construction vehicles are poorly maintained hydrocarbon spills could cause pollution if washed off roads by storm water.
- Vehicle wash bays are a common source of hydrocarbon pollutants.
- Leaks from fuel depots could result in surface water pollution.
- Spillage and unsafe storage of chemicals could result in surface water contamination.

The affected areas will be the entire construction site. Spillage impacts will be short-term and will cease after the completion of construction. If soils have become contaminated, this will leach out over a prolonged period.

Mitigation

Mitigation of the impacts should include the following:

- All construction vehicles should be well maintained and inspected for hydrocarbon leaks weekly.
- Wash bay discharge water should flow through an oil separator.
- Fuel depots and refuelling areas should be bunded.
- Chemicals should be stored in a central secure area.
- Regular toolbox talks on the responsible handling of chemicals should be undertaken.

Cumulative impact

There are potential sources of hydrocarbon pollutants in the study area. Hydrocarbons are currently not measured in the rivers. It is recommended that hydrocarbon pollutants be measured at least once a quarter in water quality monitoring locations.

Irreplaceable loss of resources

The impacts are likely to be temporary as high flows will wash sediments and hydrocarbon pollution out of river systems. There will likely to be no irreplaceable loss of resources.

13.7 Impacts During the Operational Phase

13.7.1 Impacts due to contaminated water discharge

Alternatives applicable

Impacts due to contaminated water discharge are applicable to the following activity alternatives:

- Mining option (Activity Alternative A1)
- No-go option (Activity Alternative A2)

Impacts due to contaminated water discharge are applicable to the following process alternatives:

- Open Cast (Process Alternative P3a)
- Underground (Process Alternative P3b)

Impact assessment

Some of the study area should be considered as dirty areas. These areas include the opencast operations, the hards and ROM stockpiles, and any pollution control dams. Storm water and seepage generated from these dirty areas will likely be contaminated and have a detrimental effect on the water quality in the local streams, the Grootspruit and the Grootspruit tributary. These impacts will be most acute during the dry season when stream flows are low.

The colliery must undertake to comply with Government Notice 704 of the South African National Water Act (Act 36 of 1998). This act limits discharges of contaminated water from mining related activities to less than once in 50 years on average. Storm water from dirty areas must be routed to a dirty water management system, in accordance with Government Notice 704 of the National Water Act (Act 36 of 1998).

Should a legal discharge occur as a result of extreme rainfall conditions, the Grootspruit and the Grootspruit tributary, and the local streams should have enough capacity to dilute poor quality water. The impacts from extreme rainfall conditions should be low and will last for a short duration.

Mitigation

Mitigation of the impacts must include the following:

- Contaminated shallow seepage and storm water run-off must be collected and routed to a lined pollution control dam. The pollution control dam must be sized in accordance with Government Notice 704 of the South African National Water Act.
- The pollution control dam water levels must be constantly monitored. Steps and procedures must be put in place to manage situations where excess water builds up in the pollution control dam.
- The pollution control dam must be operated empty as far as practicable and cannot fulfil the same role as a water storage dam, unless specifically designed to fulfil both purposes.

- Water reuse from the pollution control dam must be maximised.

Cumulative impact

The impacts resulting from contaminated water discharges in accordance with Government Notice 704 of the South African National Water Act, Act 36 of 1998 will result in short-term water quality deterioration in the Grootspruit and the Grootspruit tributary.

Irreplaceable loss of resources

The impacts are likely to be temporary as high flows will wash sediments and salts out of river systems. There will likely to be no irreplaceable loss of resources.

13.7.2Impacts due to leaking or burst dirty water pipes

Alternatives applicable

Impacts due to leaking or burst dirty water pipes are applicable to the following activity alternatives:

- Mining option (Activity Alternative A1)
- No-go option (Activity Alternative A2)

Impacts due to leaking or burst dirty water pipes are applicable to the following process alternatives:

- Open Cast (Process Alternative P3a)
- Underground (Process Alternative P3b)

Impact assessment

Water pipes may transport polluted water between the pollution control dam and other facilities on the proposed colliery. If any of these pipes burst, significant quantities of poor-quality water could be pumped into the environment.

Mitigation

Mitigation of the impacts should include the following:

- It is preferable to run the dirty water pipelines through areas already serviced by dirty water systems where possible.
- Pipelines should be subjected to frequent patrols. An efficient system of reporting should be available to allow the immediate tripping of pumps should a leak be found.

Cumulative impact

The impacts resulting from leaking or burst dirty water pipes will result in water quality deterioration in the Grootspruit and the Grootspruit tributary.

Irreplaceable loss of resources

The impacts are likely to remain in the medium term (a few seasons) until salts are leached from the temporary as high flows will wash sediments out of river systems. There will likely to be no irreplaceable loss of resources.

13.7.3 Loss of catchment yield

Alternatives applicable

Impacts due to loss of catchment yield are applicable to the following activity alternatives:

- Mining option (Activity Alternative A1)
- No-go option (Activity Alternative A2)

Impacts due to loss of catchment yield are applicable to the following process alternatives:

- Open Cast (Process Alternative P3a)
- Underground (Process Alternative P3b)

Impact assessment

During the operational phase storm water generated from the proposed mining areas and pollution control dams must be considered as dirty and must be collected in the dirty water system. This water would have contributed to the flow into the Grootspruit and the Grootspruit tributary and in the local wetlands. The impounding of this water will result in a small reduction in the yield of the catchment.

If surface subsidence occurs above the underground workings, this will reduce the yield of the Grootspruit and the Grootspruit tributary and the local wetlands. Run-off from this area would have contributed to the flow in these streams. This water will be intercepted and lost from the surface water system to evaporation and infiltration. These potential losses are quantified in Table 17.

TABLE 17: LOSS OF CATCHMENT YIELD (% OF MAR)*

Parameter	Opencast area	Dirty areas reporting to the PCDs	Underground area (if surface subsidence occurs over full area)
Total catchment loss	80 012 m^3/yr	51 615 m^3/yr	90 485 m^3/yr
Impact on Grootspruit	0.4%	0.5%	0.5%
Impact on Grootspruit tributary	18.1%	9.6%	20.6%
Impact on wetlands in Grootspruit*	0.4%	0.5%	0.5%
Impact on wetlands in Grootspruit tributary*	18.1%	9.6%	20.6%

** Note: MAR is mean annual run-off.*
*** Note: The wetlands considered are those within the catchment boundaries shown in Figure 3.*
Refer to Figure 3 on page 13 for stream locations.

Mitigation

As is best practice, dirty areas should be minimised. This will have the dual benefit of smaller dirty water management systems and reduction in catchment yield loss.

The loss of catchment yield due to underground subsidence can be mitigated by preventing subsidence and surface cracking. The mine must commit to adhering to suitable surface subsidence safety factors. The areas where surface subsidence may occur are shown in Figure 10.

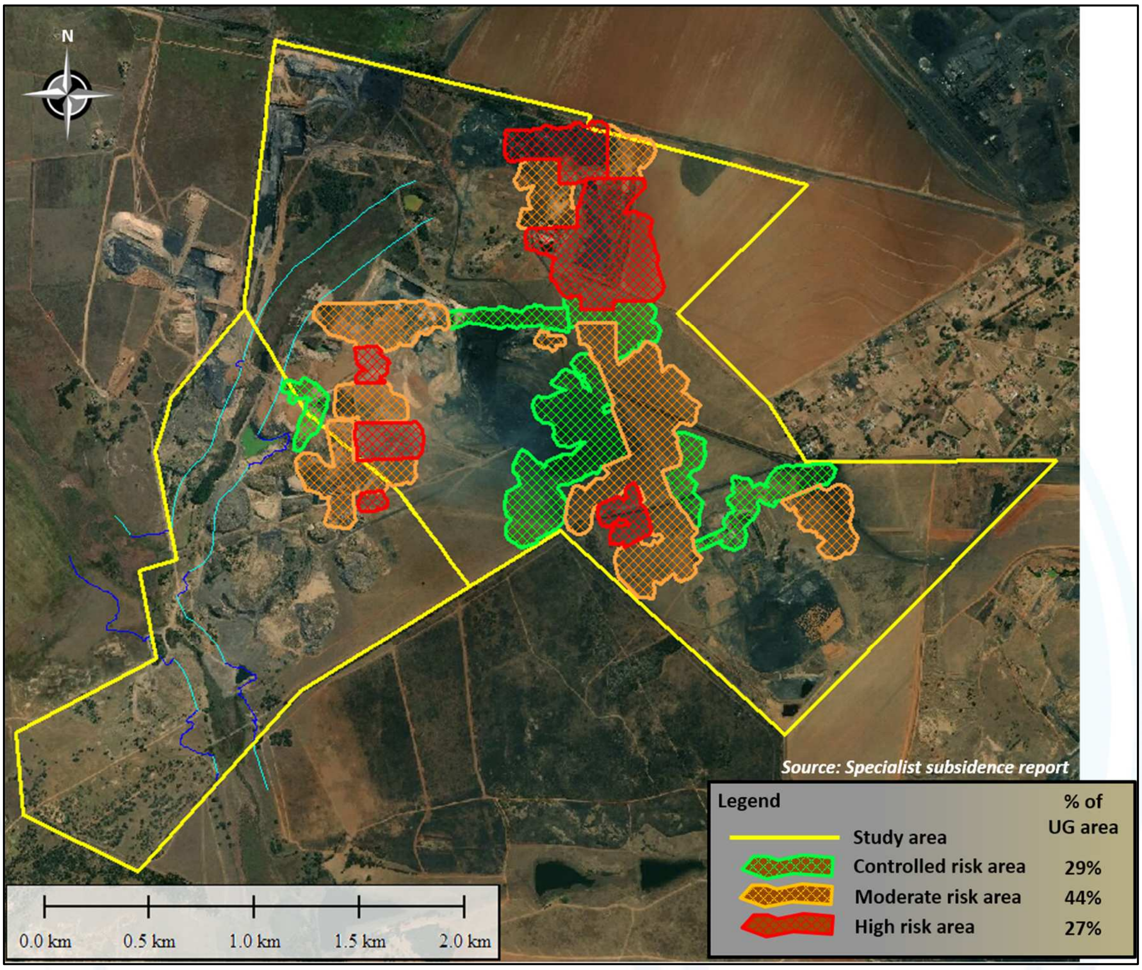

FIGURE 10: AREAS WHERE SURFACE SUBSIDENCE MAY OCCUR

Cumulative impact

The impact on the Grootspruit and the Grootspruit tributary and the local wetlands will be small.

Irreplaceable loss of resources

If surface subsidence occurs over the underground mining areas, surface water losses over the underground mining areas will be permanent. The permanent losses related to the opencast and dirty areas are likely to be temporary until these areas are rehabilitated.

13.7.4 Impacts due to wash bays and workshops

Alternatives applicable

Impacts due to wash bays and workshops are applicable to the following activity alternatives:

- Mining option (Activity Alternative A1)
- No-go option (Activity Alternative A2)

Impacts due to wash bays and workshops are applicable to the following process alternatives:

- Open Cast (Process Alternative P3a)
- Underground (Process Alternative P3b)

Impact assessment

Organic and nutrient pollution may result from the wash bays and workshop areas. These areas should be bunded and all water should be contained, collected and routed to an appropriate treatment facility. Impacts are likely to be low and will last during the life of the colliery.

Mitigation

Mitigation of the impacts should include the following:

- All drains that collect the wash water and storm water must be maintained regularly. These should be free of debris and silt.
- All diversion canals, trenches and conduits must be designed to convey run-off from a 50-year design storm.
- The wash bays and workshops must be equipped with oil separators to remove hydrocarbons from wash down water.

Cumulative impact

There are potential sources of hydrocarbon pollutants in the study area. Hydrocarbons are currently not measured in the rivers. It is recommended that hydrocarbon pollutants be measured at least once a quarter in water quality monitoring locations.

Irreplaceable loss of resources

The impacts are likely to be temporary as high flows will wash sediments and hydrocarbons out of river systems. There will likely to be no irreplaceable loss of resources.

13.7.5 Impacts due to vehicle fleet-related pollution

Alternatives applicable

Impacts due to vehicle fleet-related pollution are applicable to the following activity alternatives:

- Mining option (Activity Alternative A1)
- No-go option (Activity Alternative A2)

Impacts due to vehicle fleet-related pollution are applicable to the following process alternatives:

- Open Cast (Process Alternative P3a)
- Underground (Process Alternative P3b)

Impact assessment

During the operational phase, a significant number of vehicles will be driving around the site. In addition to this, fuels are stored on site and chemicals are used during normal operational activities. This may result in the following impacts:

- If the vehicles are poorly maintained hydrocarbon spills could cause pollution if washed off roads by storm water.
- Vehicle wash bays are a common source of hydrocarbon pollutants.
- Leaks from fuel depots could result in surface water pollution.
- Spillage and unsafe storage of chemicals could result in surface water contamination.

The affected areas will be the entire expansion area. Impacts will be medium term and will cease after the cessation of mining. If soils have become contaminated, this will leach out over a prolonged period.

Mitigation

Mitigation of the impacts should include the following:

- All vehicles should be well maintained and inspected for hydrocarbon leaks weekly.
- Wash bay discharge water should flow through an oil separator.
- Fuel depots and refuelling areas should be bunded.
- Chemicals should be stored in a central secure area. Regular training on the responsible handling of chemicals should be undertaken. If contract plant is being used, responsible handling of chemicals and vehicle maintenance should be a key performance objective of the plant contractor.

Cumulative impact

There are potential sources of hydrocarbon pollutants in the study area. Hydrocarbons are currently not measured in the rivers. It is recommended that hydrocarbon pollutants be measured at least once a quarter in water quality monitoring locations.

Irreplaceable loss of resources

The impacts are likely to be temporary as high flows will wash sediments and hydrocarbons out of river systems. There will likely to be no irreplaceable loss of resources.

13.7.6 Impacts due to the discharge of treated water

Alternatives applicable

Impacts due to the discharge of treated water are applicable to the following activity alternatives:

- Mining option (Activity Alternative A1)
- No-go option (Activity Alternative A2)

Impacts due to the discharge of treated water are applicable to the following process alternatives:

- Open Cast (Process Alternative P3a)
- Underground (Process Alternative P3b)

Impact assessment

During the operational phase, a water treatment plant may discharge up to 3 Ml/days into the tributary of the Grootspruit:

- Wet season baseflows will be significantly increased above their normal flows while treatment plant is operational. This is considered a positive impact.
- However, the flows are likely to be inconsistent and binary so surface water ecosystems will not be able to depend on this water. The flows will therefore provide similar value as storm water flows provide.
- The water quality is reported to be compliant with the resource water quality objectives, as shown in Table 9, so the water quality will be an improvement on the water quality in the Grootspruit tributary and the Grootspruit.

The affected areas will be the Grootspruit Tributary downstream of the discharge point and the Grootspruit. Impacts will cease after the treatment plant stops operating.

Mitigation

The impacts are positive, so no mitigation is required.

Cumulative impact

The impact on the Grootspruit and the Grootspruit tributary and the local wetlands will be significant, particularly in the dry season.

Irreplaceable loss of resources

There will likely to be no irreplaceable loss of resources.

13.8 Impacts During the Decommissioning Phase of the Project

13.8.1 Impacts due to the removal of surface infrastructure and rehabilitation

Alternatives applicable

Impacts due to removal of surface infrastructure and rehabilitation are applicable to the following activity alternatives:

- Mining option (Activity Alternative A1)
- No-go option (Activity Alternative A2)

Impacts due to removal of surface infrastructure and rehabilitation are applicable to the following process alternatives:

- Open Cast (Process Alternative P3a)
- Underground (Process Alternative P3b)

Impact assessment

During the decommissioning phase, most impacts will be associated with the removal of surface infrastructure, final pit closure and removal and rehabilitation of the ROM stockpiles and the hards dump. Haul roads will be removed, as will berms and diversion trenches.

During this process, short-term impacts will be moderate, as heavy earthmoving machinery will disturb large areas. Previously vegetated areas may be disturbed which will increase erosion potential. These short-term impacts will give way to long-term benefits.

Mitigation

Apart from due diligence care while performing decommissioning tasks, no mitigation is necessary. Due diligence care includes the following:

- Plant should be well maintained to ensure that hydrocarbon spills are minimised.
- Existing roads should be used where possible.
- New disturbed areas should be minimised.

Cumulative impact

Topsoil stripping will add to sediment loads produced by erosion from upstream agricultural activities. While it occurs, the impact will be significant compared to upstream impacts of a similar nature. However, the impact will be temporary and will cease shortly after the dirty water management infrastructure is in place.

Irreplaceable loss of resources

The impacts are likely to be temporary as high flows will wash sediments out of river systems. There will likely to be no irreplaceable loss of resources.

13.8.2 Impacts due to the pit infilling and dump reshaping within the buffer zones

Alternatives applicable

Impacts due to pit infilling and dump reshaping within the buffer zones are applicable to the following activity alternatives:

- Mining option (Activity Alternative A1)
- No-go option (Activity Alternative A2)

Impacts due to pit infilling and dump reshaping within the buffer zones are applicable to the following process alternatives:

- Open Cast (Process Alternative P3a)
- Underground (Process Alternative P3b)

Impact assessment

During the decommissioning phase, the pits will be backfilled, and the dump side slopes will be reshaped to their final closure slopes. Two pits (voids V4 and V8) will be within the 100-year floodlines. One dump (dump D7) will be outside of the floodlines but withing the buffer zone. and the . These are shown in Figure 11. The closure design specifies that the void infilling is higher than the floodlines to prevent water from inundating the pit area after closure. This is desirable. It limits infiltration of clean water into the void backfill. The effect on the floodlines will be negligible and will be environmentally beneficial compared to allowing water to inundate the backfill.

The dump reshaping will likely be out of the 100-year floodline, or very close to the floodline. If the dump reshaping footprint is out of the 100-year floodline, it will have no effect on the floodline, despite it being in the 100 m GN 704 buffer zone. The clean water runoff from the dump will be an environmental benefit. There is no environmental detriment to reshaping the dump sides so that their footprint is within the 100 m GN 704 buffer, but outside the 100-year floodline.

Should the rehabilitated dump footprint encroach within the 100-year floodline slightly (<15 m), it will have no detrimental effects as flow velocities in this zone of the floodplain will be slow. Because of this, the floodline will be negligible altered and the risk of damage to the dump is small.

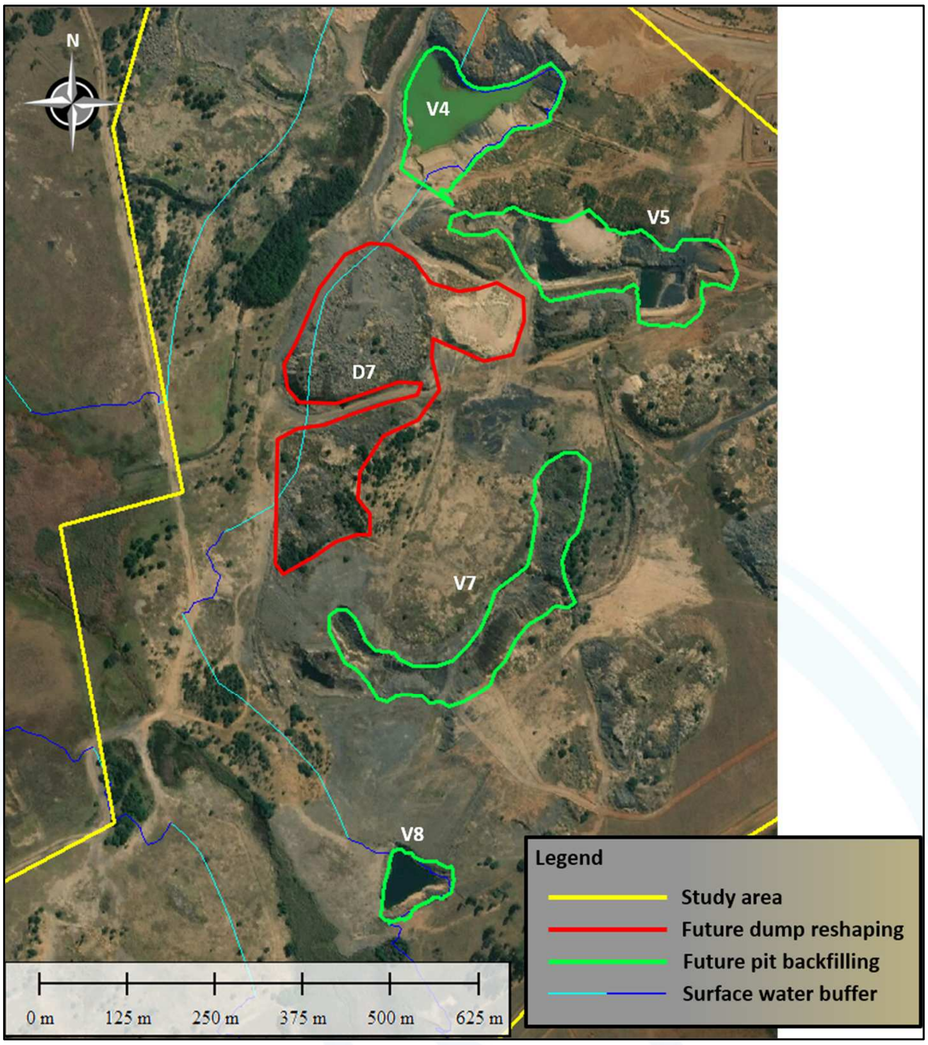

FIGURE 11: VOIDS V4, V8 AND DUMP D7

Mitigation

The reshaped footprint should remain outside of the 100-year floodline where possible. However, small concessions (<15 m) are acceptable. Should these concessions be used, the lower 1 m of the dump should be reinforced with rock cladding (60% coverage) with a d_{50} of 200 mm.

Cumulative impact

Dump reshaping and rehabilitation will have a positive impact on the runoff water qualities in the Grootspruit tributary. Pit infilling and reshaping will have a positive impact on the water volumes and qualities in the Grootspruit tributary.

Irreplaceable loss of resources

The impacts are likely to be permanent.

13.9 Impacts After the Closure Phase of the Project

13.9.1 Impacts due to pit decant

Alternatives applicable

Impacts due to pit decant are applicable to the following activity alternatives:

- Mining option (Activity Alternative A1)
- No-go option (Activity Alternative A2)

Impacts due to pit decant are applicable to the following process alternatives:

- Open Cast (Process Alternative P3a)
- Underground (Process Alternative P3b)

Impact assessment

The groundwater study has indicated that decant may occur from the mine workings.

After the colliery is closed, contaminated water management becomes passive. Groundwater inflows and recharge through the rehabilitated spoils may create decant from the opencast and underground workings. This decant will be driven by rainfall recharge through the rehabilitated surface and groundwater inflows. The decant water quality is likely to be poor and will contaminate the Grootspruit and the Grootspruit tributary. Decant flows will likely be seasonal and volumes will be dependent on the quality of rehabilitation done and the degree of surface subsidence. Poor rehabilitation will increase the decant volumes. The water quality is likely to remain poor in the long term (>20 years). Eventually as pollutants are leached out of the workings and natural stratification occurs, the seepage water quality will improve.

Mitigation

Mitigation of the impacts should include the following:

- The rehabilitation work should strive to minimise recharge and maximise run-off.
- A final void could be optimised to evaporate excess pit water if approved by the Department of Water Affairs.
- Where feasible, materials likely to produce the highest amounts of pollution should be replaced in sections of the pit where they will be permanently flooded, thus preventing oxidation of these materials.
- Should passive mitigation measures not be suitable, active alternatives can be considered such as some form of treatment, prior to release.
- The planned mining method and the commitment to adhering to appropriate safety factors must be made by the mine to prevent surface subsidence.
- Methods to stop or reduce decant volumes could include sealing some areas of the mine workings or leaving some areas unmined to act as a barrier to decant.

- Methods to improve the decant water quality could include flooding of the mining areas, where practical, to reduce oxygen ingress. Routing seepage through lime pits can also improve the water quality if the flows are low enough.

Cumulative impact

If the quality of rehabilitation is good and the void can balance the inflows, the cumulative impacts will be negligible. The same will apply if no surface subsidence occurs over the underground areas. Should decant occur, the impacts resulting from pit or underground workings decant will result in long term water quality deterioration in the Grootspruit and the Grootspruit tributary. The impacts resulting from pit decant are likely to result in water quality deterioration in the Grootspruit and the Grootspruit tributary. If this water is treated to discharge standards and released, then impacts will be positive as clean water will feed the natural river systems.

Irreplaceable loss of resources

The impacts are likely to be long term (>20 years) unless this water is treated. If the water is treated, the impacts will be negligibly negative to positive, and there will likely to be no irreplaceable loss of resources.

14. MONITORING REQUIREMENTS

Surface water quality monitoring must be conducted on the both the Grootspruit and its tributary. The recommended monitoring locations are shown in Figure 12. The mine currently monitors the recommended points as well as additional points. This is considered acceptable. The monitoring frequency must be monthly or more frequently if desired. The water quality samples must be analysed by an accredited laboratory.

Parameters to be sampled must include the following. It must be noted that the current sampling being done includes all these parameters:

- Total Dissolved Solids
- Suspended Solids
- Nitrate as N
- Chlorides as Cl
- Total Alkalinity as $CaCO_3$
- Fluoride as F
- Sulphate as SO_4
- Total Hardness as $CaCO_3$
- Calcium Hardness as $CaCO_3$
- Magnesium Hardness as $CaCO_3$
- Calcium as Ca
- Magnesium as Mg
- Sodium as Na
- Potassium as K
- Iron as Fe
- Manganese as Mn
- Conductivity at 25° C (mS/m)
- pH-Value at 25 ° C (pH Units)
- Turbidity (NTU)
- Aluminium as Al

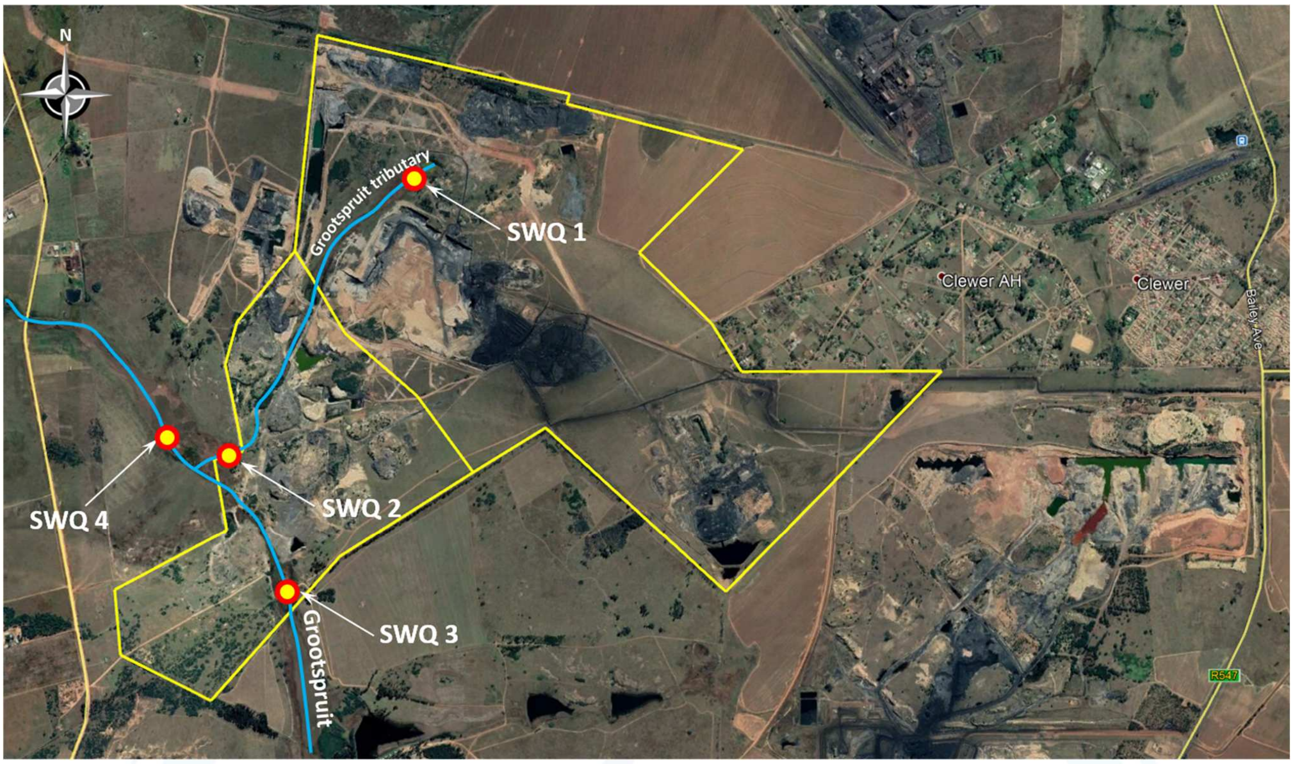

FIGURE 12: RECOMMENDED MINIMUM MONITORING LOCATIONS

15. RIVER DIVERSION REINSTATEMENT

A river 280 m long diversion is located between the coordinates listed below:

Start: 25°54'49.896"S, 29°4'45.048"E

End: 25°54'56.052"S, 29°4'41.268"E

Prior to the construction of the diversion channel, the original channel appears to have been poorly-defined and would likely have been a valley bottom wetland without a channel. The diversion channel collects and concentrates the flow of the Grootspruit tributary. This robs the wetland of surface water.

For this reason, the original valley bottom wetland morphology should be reinstated.

Concentrating the flow in a small channel reduces the availability of water for plant growth and therefore less water will be lost from the Grootspruit tributary. The channel therefore slightly increases the yield of the Grootspruit tributary. However, this is unnatural and should not be used as an argument for keeping the diversion channel.

16. CONCLUSIONS

Elandsfontein colliery is an operational colliery with significant development within the mining rights area.

The mining rights area is in quaternary catchment B20G. The mining rights area is located just west of Clewer and approximately 15km west, south west of Emalahleni. Elandsfontein is an operational colliery with significant development within the mining rights area.

A small tributary of the Grootspruit flows in a south westerly direction through the mining rights area. Its confluence with the Grootspruit is just to the west of the mining rights area. The Grootspruit flows from south to north along the western boundary of the mining rights area before turning west to meet the Saalklapspruit, approximately 5 km west of the mining right area.

The Grootspruit and its tributary floodplains are highly impacted by mining related activities and poorly constructed/informal road crossings. Both rivers are marked as perennial streams on the 50 000 topo sheets.

The Elandsfontein mining operations occur on both sides of Grootspruit tributary along most of its length. The upper reaches are dammed with pollution control and water supply dams. The natural tributary has a poorly defined water course but is generally heavily reeded. The lower reaches have been modified and the stream is canalised for roughly half its length.

The proposed open cast and underground operation will create significant impacts if unmitigated. Mitigation will reduce these impacts significantly. In general, full compliance with GN 704 will result in very low impacts during the operational phase.

Post closure mine workings decant has the potential to create high long-term impacts on the Grootspruit and its tributary. If this decant water is treated and released, the impacts are likely to become positive.

17. ASSUMPTIONS, UNCERTAINTIES AND GAPS IN KNOWLEDGE

The floodline delineation assumes that the survey provided is a true reflection of the surface topography. This survey was compiled by a third party and provided for floodline delineation.

The post mitigation impact assessment scores assume that mitigation measures will be implemented as recommended in this document. Should these mitigation measure not be implemented, the post mitigation scores may no longer be valid.

The impact assessment assumes that the mine is in full compliance with GN 704 of the South African national Water Act, act 36of 1998.

18. REFERENCES

- Middleton, B.J. and Bailey, A.K., *Water Resources of South Africa*, 2005 study (WR2005), 2009. WRC Report No TT 382/08.
- Midgley, D.C., Pitman, W.V., Middleton, B.J., *Surface Water Resources of South Africa*, 1990. WRC Report No 298/1.1/94, Volume 1.

Appendix A: Declaration of Independence

As the specialist compiling the surface water specialist study, I declare that to the best of my knowledge and belief:

1. I have no vested interests in Elandsfontein Colliery or stand to benefit in any way from the mining activities at the colliery.
2. There are no contraventions of any applicable code of professional conduct in relation to my specialist study.

Appendix B: CV of specialist who prepared the report

Curriculum Vitae - Bruce Randell

EDUCATION AND QUALIFICATIONS

PR Eng

BSc (Civil Engineering) University of Witwatersrand, Johannesburg, 1996
PhD, University of Witwatersrand, Johannesburg, 2002
MDP, Unisa SBL, Johannesburg, 2007
Microsoft Certified Professional (TCP/IP) – NT4, 1998

EXPERIENCE SUMMARY

Water Resources Engineer with over 18 years' experience in mostly mining and heavy industrial projects.

April 2011 to Present

iLanda Water Services CC, Johannesburg, South Africa

Water Resources Engineer, Owner

I started my own consulting practice as a specialist hydrologist, Water Resources Engineer and some Tailings Engineering. My water related work mainly involves water and salt balance determination and modelling. I am also involved in surface water specialist studies and impact assessments, water resources studies, floodline determination, audits and the design of weirs and other hydraulic infrastructure. My tailings related work includes tailings dam surveillance and audits and dam break analysis. I specialise in numerical modelling of tailings storage facility water balances and mine-wide water balance modelling. I predominantly use GoldSim as my modelling tool. I have experience on projects throughout South Africa, Africa and Indonesia.

November 2017 to July 2020

Geo Tail Projects (Pty) Ltd, Johannesburg, South Africa

Tailings Engineer, Director

My mine residue management involves some design work, tailings dam break analysis, tailings storage facility surveillance and auditing. I have experience on projects throughout South Africa, Lesotho and the rest of Africa on gold, copper, diamond, coal, nickel, iron ore and base metal operations.

Reason for leaving: Group restructuring. All my Geo Tail work will be done through iLanda Water Services CC.

January 2008 to March 2011

Golder Associates Africa (Pty) Ltd, Johannesburg, South Africa

Tailings Engineer, Resident Engineer

During my tenure within the tailings division I was involved in feasibility designs for tailings storage facilities and associated infrastructure in South Africa and the Democratic Republic of Congo. The designs included 2-D and 3-D design, drafting using AutoCAD, 3-D modelling, stability and freeboard analysis, surveillance and monitoring of operational tailings storage facilities, and water balance modelling. I completed detailed design projects where I designed silt traps, channels, storm water dams, underdrains and a penstock plug and reverse filter. During the final year of this period I was a resident Engineer on a 380 ha tailings storage facility construction project. My role included quality assurance on earthworks, reinforced concrete, roads, piping, building, structural steelwork, underdrains, and mechanical works. I was also required to do on-site design work, 3-D modelling, on-site drafting in AutoCAD, running of site meetings, client liaison, client representation and on-site document control.

Reason for leaving: Started iLanda Water Services CC.

August 2002 to December 2007

Golder Associates Africa (Pty) Ltd, Johannesburg, South Africa

Water Resources Engineer, Operations Manager

During the early part of this period my role and experience in Golder Associates Africa was similar to that in Wates, Meiring and Barnard (see next section) but became more involved in the development and running of various water balance models for a wide variety of mining and heavy industrial applications. GoldSim was extensively used for modelling, as was various other mainstream software packages. I was also extensively involved in undertaking surface water specialist studies and impact assessments for EIA projects.

During the latter part of this period my work experience was dominated by water balance modelling and specialist study inputs for EIA's. I was extensively involved in developing and marketing a new product line which included water balance modelling to satisfy the requirements of the ICMI Cyanide Code. My client base was predominantly mining clients with some heavy industrial clients.

My role as Operations Manager of the Surface Water and Closure Division included the management of a merger with another company and the resulting new satellite office. I was again involved in significant staff management – both hiring new staff and managing staff underperformance.

Reason for leaving: Expand engineering and Tailings Engineering skills.

June 2002 to July 2002

Wates, Meiring and Barnard, Johannesburg, South Africa

Water Resources Engineer

I worked for Wates, Meiring and Barnard (WMB) as a hydrologist and modeller. My experience included hydrological studies, flood peak calculation. I was also involved with setting up REMIS applications for data management, general software design and water quality modelling, particularly for mining related pollution control dams. I was also part of the team developing the ISP for the Olifants river catchment in South Africa.

Reason for leaving: Golder Associates bought out WMB in August 2002.

1996 to 2002

Stephenson and Associates, Johannesburg, South Africa

Water Resources Engineer

While reading for my PhD, I was involved with a number of consulting projects. Experience included stream flow modelling, stream flow measuring, software design, water hammer analysis and surge protection design. I was also involved in sediment surveying, sediment modelling, floodline analysis and design of flood protection and alleviation measures. I constructed and tested a number of scale models including river models, pump stations, ogee crests and off channel flood control structures. I also tested the material properties of GRP pipe.

PROJECT RELATED EXPERIENCE

Tailings storage facility water balance modelling:

Custom-built GoldSim models are developed to simulate the water balance around a tailings storage facility. Modelling usually includes return water dam sizing. Rainfall inputs are generally stochastic to allow for scenario analysis, long-term analysis or the statistical analysis for short-duration projects. Tailings storage facility water balances have been completed on mining projects throughout Africa and South Africa on gold, diamond, copper, coal, nickel, base metal, and iron ore mines. Industrial projects have also been completed on power stations (ash dams), iron and steel works.

Mine water balance modelling:

Custom built GoldSim water balance models are developed for scenario analysis and water management decision making purposes on both operational and management levels. Projects completed throughout Africa and South Africa on gold, copper, coal, nickel, and base metal mines.

Open cast pit water balance modelling:

Custom built GoldSim models are used to calculate pit water make in opencast operations, including pits that have concurrent excavation and rehabilitation. Modelling takes into account the dynamics of the working pit configuration and rehabilitation progress during the simulation period. Rainfall inputs are generally stochastic to allow for scenario analysis, long-term analysis or the statistical analysis for short-duration projects. Modelling typically involves final void sizing for closure planning. Projects completed throughout Africa and South Africa on gold, copper, diamond, iron ore, and coal (with concurrent rehabilitation).

EIA surface water specialist studies and impact assessments:

I have conducted specialist surface water studies and impact assessments as part of small and large-scale EIA's and ESIA's. This involved baseline assessments, setup of surface water monitoring programs, general hydrology, hydraulics, hydraulic and hydrological modelling and impact assessments, reporting and attendance and presentations at open house/public meetings. Projects completed in the DRC, Mozambique and throughout South Africa on mining, heavy industrial, municipal and railway projects.

Flood peak and floodline calculation:

I have calculated floodlines on many river reaches in Mali, the DRC and throughout South Africa for housing developers, mining, industrial, municipal, and private clients. Large-scale floodlines have been completed for the entire Umhlatuze municipal area (Richards Bay, Empangeni and surrounds), and the Clover and Blesbokspruit (Benoni, Brakpan, Springs and Heidelberg).

Storm water management plans:

Storm water management plans (concept through to detailed design) have been completed on mining projects in the DRC, Lesotho and throughout South Africa on gold, diamond, copper, nickel, coal, base metal mines. Industrial projects completed throughout South Africa on chrome, steel plants, and aluminium smelters.

Pollution control dam sizing:

Pollution control dams are sized to comply with relevant legislation (e.g. Regulation 704 of the South African National Water Act). In the absence of legislative guidelines, the use of impact assessments on the receiving environment is to determine allowable releases and resultant dam sizing. Mining projects completed throughout Africa and South Africa on gold, diamond, copper, nickel, coal, base metal mines. Industrial projects completed throughout South Africa on power stations, chrome, steel plants, and aluminium smelters.

Tailings dam break analysis:

I have calculated tailings dam breach volumes, flows and floodlines for various typical failure scenarios on tailings dams. Mudflow analysis is performed using Flo2D. Water flow analysis is performed using Flo2D and HEC RAS.

Tailings storage facility surveillance:

In accordance with South African mines' Code of Practice, I conducted tailings storage facility surveillance on numerous mines' tailings storage facilities. I have been the competent person for the Lubambe Copper Mine TSF in Zambia for 3 years. While at Golder, I headed up the surveillance group within the division which consisted of five technical staff and one administrative staff member. I was directly involved in the surveillance of nine tailings dams on two mines. Three of the nine dams were dormant, while the remaining six were active. As part of my surveillance responsibilities I did stability reviews and analysis, freeboard analysis, attended quarterly meetings and inspections and completed annual audit reports and inspections.

Catchment studies and runoff modelling:

Applications include runoff into pollution control dams, diversion canals, silt traps and through various hydraulic structures. Models used include ACRU, WRSM2000, WR90, RAFFLER and purpose-built GoldSim models. I have completed various projects throughout South Africa and Africa.

Infrastructure design:

Detailed design of small dams, silt traps, storm water channels, dissipation structures, Parshall flumes, headwalls, weirs, underdrains, and penstock plugs and reverse filters. The designs included the compilation of tender documents and bills of quantities and construction drawings.

Tailings storage facility feasibility design:

I completed feasibility and bankable feasibility design of tailings storage facility complexes in South Africa and the DRC. This included the tailings storage facility, return water dams, underdrains, storm water channels and other related infrastructure. The designs included the compilation of tender documents and bills of quantities.

Water quality modelling:

The water quality modelling related to pollution control dams involves modelling conservative variables, taking into account the surrounding catchments, dam operating rules, plant inputs and hydrology associated with the system. Daily continuous modelling is used in conjunction with relevant regulations (e.g. Regulation 704 of the South African National Water Act) to formulate solutions for clients.
Water resource projects involve determining the likely impact of process and contaminated storm water discharges from mines and industry. Mining projects completed throughout Africa and South Africa on gold, copper, nickel, coal mines (discard dumps and in pit water quality). Industrial projects completed throughout South Africa on power stations, chrome and steel plants, aluminium smelters, oil producers. Water resource projects completed in the DRC and throughout South Africa. Major rivers include the Olifants and Tugela Rivers in South Africa.

IWMP baseline hydrology and impact assessments:

I have conducted baseline hydrological assessment of the rivers that flow past two paper mills. This included ACRU and other rainfall-runoff modelling. GoldSim was used to do continuous daily modelling of the impacts of effluent from these mills into the receiving waters.

Mine water balance modelling for ICMI Cyanide code compliance:

I developed probabilistic mine-wide water balance models for scenario analysis and water management decision making purposes - a requirement of the ICMI Cyanide code. The models have been extensively audited and accepted as suitable water balance models for ICMI Cyanide code compliance. Project locations include South Africa, Namibia, Ghana, Mali, and Guinea.

Auditing:

I have been involved in GN704, storm water management plan implementation and water use licence auditing for power stations mines and industrial sites. I have experience as a lead auditor and as a specialist in support of a lead auditor.

Flow measuring:

I was involved in flow measuring in the field using both propeller and electromagnetic flow meters in the DRC and throughout South Africa on both small (50 ℓ/s) and large rivers (10 m^3/s).

Sediment surveying and modelling:

I was involved in the sediment surveys that were conducted on the Katse and Muela dams that form part of the Lesotho Highlands Water Project. My experience includes mapping floor profiles using sonar equipment and calculating sediment volumes.

PUBLICATIONS

Prediction model for the Caledon River – presented at the 4th Biennial Congress of the African Division of the International Association of Hydraulic Research, Windhoek, Namibia, 2000. (Co author)

A review of conjunctive use and a proposed model – poster presented at the XXVII IAHR Congress, Graz, Austria, 1999. (Sole author)

Artificial recharge and conjunctive use – Groundwater Hydrology workshop, Bulawayo, Zimbabwe, 1997. (Sole author)