APPENDIX E: HYDROLOGICAL STUDY

PILANESBERG PLATINUM MINE (PPM): PLANT EXPANSION PROJECT- HYDROLOGY STUDY

Pilanesberg Platinum Mine

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BASIS OF REPORT

EXECUTIVE SUMMARY

SLR Consulting (Africa) (Pty) Ltd (SLR) has been appointed by Pilanesberg Platinum Mine (Pty) Ltd (PPM) to undertake a Technical Specialist Surface Water Study to support an Environmental Impact Assessment (EIA) for the expansion of the PPM's processing facilities. PPM proposes to expand the existing mineral processing facilities located on the farms Witkleifontein 136 JP and Tuschenkomst 135 JP located north of the Pilanesberg in the North West province.

The monthly rainfall at the site has been estimated by taking a linearly weighted average of the monthly data from the three rain gauges and the mean annual precipitation (MAP) for the site is estimated to be 592mm.

For the purposes of utilising daily rainfall for stormwater dam (SWD) sizing, the nearest station with the least patched data (meaning it has least amount of daily rainfall data that was estimated by averaging the surrounding stations and more of the actual measurements) was therefore taken to be Pilanesberg station (0548165_W).

Evaporation data is based on records from Department of Water and Sanitation (DWS) operated station reference A2E021, which is located approximately 25km north east of the current operation with Symon's Pan (S-Pan) evaporation record length of length of 15 years from 1970 until 1986. A mean annual evaporation (MAE) based on S-Pan is 1532 mm.

Comparison of the design storms / depth duration frequency (DDF) estimates against the daily rainfall data analysed from the Pilanesberg rain gauge shows that the 1:50 year and 1:100 year 24 hour DDF estimates are 151.5mm and 169.2mm respectively which are close to the largest 1 day rainfall event recorded in 78 year, which was 145.8mm.

The project site is located in the west of the secondary catchment A2 (Crocodile) within Quaternary Catchment A24D upstream of Bierspruit Dam. PPM is located between two non-perennial water course systems, into which potential runoff from the study area drains, either to the west into the Motlhabe or to the east into the Wilgespruit. The PPM plant and proposed project are located in the catchment of the Motlhabe. Both these watercourses eventually end in the Bierspruit Dam at the outflow from the quaternary catchment A24D.

A network of thirteen surface water sampling points is monitored for water quality as required by the water use license. They are situated along the non-perennial Motlhabe, Wilgespruit and Manyedime rivers, and some of their tributaries. Of these 13, two were selected for understanding the PPM plant expansion pre-project water quality, namely SW9 and SW13. Three dirty water containment facilities were also selected namely SWD1, SWD2 and SWD5. The available water quality data indicates exceedances of several parameters. It is not possible to isolate the contributions from the waste rock dump and the plant in terms of water quality at this site, however, Exigo attributed the water quality impacts to the waste rock dump. Consideration of exceedances from process water dams and surface water monitoring sites indicates minor similarities between these which can be interpreted that there is minimal cross contamination between process water and surface water resources near the PPM plant expansion area. Temporal comparison of the various sampling sites is complicated by the unavailability of consistent water quality information due to the non-perennial nature of streams, which are often dry during some sampling periods. However, a surface water monitoring point (SW5) located on the Motlhabe River, downstream of PPM's operations has lower sulfate levels when compared to SW13 located immediately downstream of PPM's waste rock dump and plant.

The existing stormwater management measures will be used as the project is located within existing footprints. The existing Tuschenkomst stormwater management system within the 2007 report covers the PPM Plant, the Tuschenkomst pits and the tailings system.

The proposed infrastructure is located within the following existing stormwater management areas:

- The PPM plant additional components (milling and floatation section, the hydrometallurgical plant) are in the current plant footprint;
- The sewage treatment plant upgrade and the waste facility are located in existing services,

- Community initiative infrastructure are located i.e. the crusher and brickyards are also located in an already impacted site.

A dynamic daily time step model was developed using 66 years of daily rainfall data to understand the impacts of climatic extremes and estimate capacity requirements for the SWD using the GoldSim simulation software. The daily rainfall data was selected from 1914 to 1980. The water use for the SWD sizing was provided by Exigo and considered.

Considering that the minimum abstraction/ pump out for reuse (10^{th} percentile), the annual maximum storm water volumes with a capacity of 45 000 m^3; the SWD spills 30 times in 8 years of the 66 year simulation period. At the average and 75^{th} percentile abstraction rates, the SWD will spill 4 times in the 66 year simulation period, which still does not comply with the GN704 Regulations.

Based on the design parameters discussed above, the current capacity of the SWD pumped for reuse at an abstraction rate that is at least $200m^3/d$ is adequate with a minimum risk of annual spillage of a 1:50 year chance. At the higher pump out rates, a capacity of approximately 45 $000m^3$, would be adequate. This excludes the 0.8m freeboard and excludes any permanent water storage below the inlet for the pump.

The current recommended SWD capacity is sufficient for the proposed plant upgrades, only if the withdrawal rate of the SWD is maintained above a200 m^3/hr rate to avoid spillage. Alternatively the PCD capacity can be adjusted to accommodate even the lowest withdrawal pump rate to a 56 000 m^3 capacity.

Water for the proposed project would be sourced from PPM's existing Magalies Water allocation.Currently, the reuse of water is prioritised i.e. the treated sewage water must all be used for dust suppression, the Tuschenkomst open pit excess water contained and pumped for reuse in the plant and tailings decant and seepage water reused at the plant.

The disturbed sub-catchment by the plant and TSF footprint is approximately 0.4% of the quaternary catchment. With the plant expansion, it is not anticipated to change as most of infrastructure is in existing areas. The plant site dirty catchment covers an area of $0.47km^2$, approximately 16% of catchment MLT-2 and less than 0.1% of Quaternary Catchment A24D.

Potential cumulative impacts that may arise from the PPM plant expansion project could be linked to water quality. Surface water may collect contaminants such as hydrocarbons, salts, and metals from numerous sources at the mine and beyond. At elevated concentrations these contaminants can be harmful to humans and livestock if ingested directly. However the operation of storm water management measures would reduce the potential cumulative impacts. As indicated, the current water quality indicates existing contamination from mining activities and the water quality already exceeding the baseline levels. Without mitigation these impacts maybe detrimental rendering water not suitable for other uses (livestock watering within standards).

As long as the proposed plant remains within the serviced and disturbed area and relevant mitigation measures implements, the PPM plant expansion is not anticipated to result in major impacts that the current status.

The studies such as the water balance and storm water management can be revised and updated as per requirements of licences and as mining continues for the life of mine (LoM) until determination of closure liabilities of the PPM Mine. Provided with the water quality results and discussions in the report, it is recommended that an immediate downstream location is established closer to the PPM plant to be able to separate the impacts of the PPM plant and the waste rock dump. Furthermore, a study can be conducted by PPM to trace the actual source of pollutants on site, this may require marker parameters and large water quality dataset if statistical methods are to be utilised.

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ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
AMSL	Above Mean Sea Level
DDF	Depth-Duration-Frequency
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
GN 704	Government Notice 704
HEC-RAS	Hydrologic Engineering Centres – River Analysis System
LOM	Life of Mine
MAP	Mean Annual Precipitation
MAE	Mean Annual Evaporation
MAR	Mean Annual Runoff
mcm	Million Cubic Meters
PrSciNat	Professional Natural Scientist
PCD	Pollution Control Dam
PPM	Pilanesberg Platinum Mine (Pty) Ltd
SACNASP	South African Council for Natural Scientific Professions
SANRAL	South African National Road Agency
SAWS	South African Weather Service
Tc	Time of Concentration
UPD	Utilities Programme for Drainage
WMA	Water Management Area
WR2005	Water Resources of South Africa 2005 Study
WULA	Water Use License Application
SWD	Storm water Dam
TWQG	Target Water Quality Range
SOG	Soaps, oil and grease
SCS	Soil Conservation Service
CN	Curve Number

1. INTRODUCTION

SLR Consulting (Africa) (Pty) Ltd (SLR) has been appointed by Pilanesberg Platinum Mine (Pty) Ltd (PPM) to undertake a Technical Specialist Surface Water Study to support an Environmental Impact Assessment (EIA) for the expansion of the PPM's processing facilities. PPM proposes to expand the existing mineral processing facilities located on the farms Witkleifontein 136 JP and Tuschenkomst 135 JP located north of the Pilanesberg in the North West province.

This surface water study was undertaken by a suitably qualified and experienced Hydrologist registered with the South Africa Council for Natural Scientific Professions (SACNASP) as a Professional Natural Scientist (Pr.Sci.Nat.) in the field of Water Resources Science and the CV is appended to the report (Appendix A).

1.1 PROJECT DESCRIPTION

PPM is a platinum and chrome mining and mineral processing operation located to the north-west of the Pilanesberg National Park in the North West Province. In broad terms the existing PPM operation comprises an open pit mine (West Pit and East Pit), temporary and permanent waste rock dumps (WRDs), a mineral processing plant complex, a tailings storage facility (TSF) and support services and infrastructure.

PPM proposes to expand the existing PPM mineral processing operations to incorporate:

- a hydrometallurgical plant for the extraction of platinum group metals (PGMs) and base metals; and
- a UG2 milling and flotation circuit to process ore from the Sedibelo Platinum Mine (SPM) operation.

In addition, the following is planned:

- upgrading of the existing sewage treatment plant; and
- relocation of the waste storage and handling facility from inside the plant to an area outside the plant.

Furthermore, a number of community based initiatives have been established at the mine. These have been included in this report at the request of the DMR. They include:

- an aggregate crusher and brick making project;
- a nursery;
- a vegetable garden and composting area; and
- a car wash.

It is expected that the proposed project will extend the life of PPM's processing facility beyond the life of mine.

The PPM project area (the site) is situated 2km north of the Pilanesberg National. The site is bounded to the east by Tushenkomst Pit, to the north and west by light bushveld and farmland.

1.2 LEGISLATION

National Water Act (Act No. 36 of 1998), Government Notice 704 (Government Gazette 20119 of June 1999) (hereafter referred to as GN 704), was established to provide regulations for the use of water for mining and related activities aimed at the protection of water resources. Regulations 4, 5, 6, 7 and 10 of the GN704 are applicable in this study and are summarised below:

- Regulation 4 which defines the restrictions for the locality of mine working and infrastructure. Any residue deposit, dam, reservoir together with any associated structure or any other facility should be situated outside the 1:100 year flood-line. Any underground or opencast mining, prospecting or any other operation or activity should be situated or undertaken outside of the 1:50 year flood-line. Where the flood-line is less than 100 metres away from the watercourse, then a minimum watercourse buffer distance of 100 metres is required for infrastructure and activities;

- Regulation 5 which restricts the use of residue or substance which causes or is likely to cause pollution of a water resource, it may not be used in the construction of any dams, impoundments or embankments or any other infrastructure;
- Regulation 6 which describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated to ensure conveyance of flows of a 1:50 year recurrence event. Clean and dirty water systems should not spill into each other more frequently than once in 50 years. Any dirty water dams should have a minimum freeboard of 0.8m above full supply level.
- Regulation 7 which describes the measures which must be taken to protect water resources. All dirty water or substances which may result in pollution should be prevented from entering a water resource (by spillage, seepage, erosion etc.) and ensure that water used in any process is recycled as far as practicable.

In addition to the GN 704 regulations, the Department of Water and Sanitation (DWS) Best Practice Guidelines (BPG) for the mining industry have been consulted namely:

- BPG G1: Storm Water Management;
- BPG A4: Pollution Control Dams; and
- BPG G3: Water Monitoring Systems.

1.3 SCOPE OF WORK AND REPORT STRUCTURE

The study included the following:

- Baseline Hydrology – Section 2 presents a review and analysis of various sources of rainfall and evaporation data. The section also presents the baseline hydrology of the site and surroundings including topography, watercourse network and catchment delineation;
- Water quality - Section 3 presents a review of the available water quality information for the watercourses on site and surroundings;
- Stormwater management measures - Section 4 presents a summary of the existing details relating to stormwater management infrastructure in the Processing Plant area;
- Storm Water Dam (SWD) Sizing - Section 5 presents a daily time step water balance model (as per BPG A4) for the SWD (i.e. capacity vs pump out rate), to ensure annual probability of spillage is <1:50 as per GN704 regulations;
- Impact Assessment – Section 6 presents a qualitative assessment of the impacts of the project on the baseline surface water environment, a range of mitigation measures to minimise impacts, and recommendation on monitoring; and
- Conclusions and Recommendations - Section 5 presents the summary, conclusions and any further work recommended.

Most of the sections in this report have been compiled following review of available reports and received information from other consultants namely:

- SRK, April 2007 Surface Water Aspects for the Pilanesberg Platinum Mine (Report No 371373/1);
- Metago, June 2011. Surface Water Assessment for the Amendment of the Pilanesberg Platinum Mine EMP Closure Objectives (B007-21); and

- AGES (Pty) Ltd. 26 April 2012. PPM Individual and Integrated Environmental Site Water Balances (G12/014-2012-04-26).

2. BASELINE HYDROLOGY

2.1 INTRODUCTION

In order to inform impact assessments and the surface water management implications from the PPM plant expansion, understanding of baseline hydrology is required. This section presents a comprehensive review of various information sources and defines the baseline climatic and hydrological conditions of the site and surroundings.

The baseline information discussed in this section includes the rainfall, evaporation, design storm rainfall, catchment hydrology including watercourse network, topography, vegetation, previous stormwater management plans and floodlines.

Figure 2-1 illustrates the location of the study area relative to the river systems and quaternary catchment boundary.

2.2 CLIMATE

2.2.1 Rainfall

Rainfall for the site was considered from various sources including the information from the South African Weather Services (SAWS) and the Department of Water and Sanitation (DWS) and documented in the Water Resources of South Africa 2012 Study (WR2012). The WR2012 GIS maps show that the mean annual precipitation (MAP) at the site is likely to be in the region of 500 - 600mm and within the influence of the elevated topography of the Pilanesberg which increases total rainfall. No records of rainfall recorded at the site are available and as such rainfall data from the following sources was reviewed to characterise rainfall patterns at the site:

- The Daily Rainfall Extraction Utility programme (Version 1.4, 2019);
- Exigo database (from the period 2009 /2010 period until 2018); and
- Water Resources of South Africa 2012 Study (WR2012[1]).

Daily rainfall records from the nearest SAWS rain gauges were obtained from the Daily Rainfall Extraction Utility program (V1.4), which was developed by the Institute for Commercial Forestry Research (ICFR) in conjunction with the School of Bio-resources, Engineering and Environmental Hydrology at the University of KwaZulu-Natal. A summary of the nearest rain gauges with reliable records is presented in Table 2-1.

Table 2-1: Summary of Rainfall Stations from the Daily Rainfall Extraction Utility.

Station name	SAWS number	Longitude	Latitude	Altitude (m)	Location from Site	MAP (mm)	Start	End	Years
Pilanesberg POL)	0548165_W	27.108	-25.242	1271	19.1km South-South-East	578	1 Jan 1914	31 Dec 1986	73
Saulspoort	0548280_W	27.175	-25.158	1102	20.5km South-	646	1 Jan	31 Dec	35

[1] Water Resources of South Africa, 2012 Study (WR2012). http://waterresourceswr2012.co.za/

Station name	SAWS number	Longitude	Latitude	Altitude (m)	Location from Site	MAP (mm)	Start	End	Years
					East		1965	1999	
Klipkuil	0547362_W	26.7083	-25.025	105	31.9km West	510	1 Jan 1923	30 June 1966	44

The monthly rainfall at the site has been estimated by taking a linearly weighted average of the monthly data from the three rain gauges as presented in Table 2-2 below. By this method, the MAP for the site is estimated to be 592mm, which is towards the upper end of the range of values shown on the WR2012 map (500-600mm).

Table 2-2: Average Monthly Rainfall

Month	Pilanesberg (Pol)	Saulspoort	Klipkuil	Site
January	115.8	123.1	97.2	112.0
February	88.2	86.9	88.0	87.7
March	84.8	91.6	78.8	85.1
April	37.3	44.1	34.5	38.7
May	15.1	15.2	10.6	13.6
June	6.3	2.8	8.4	5.8
July	5.1	0.6	8.3	4.7
August	7.7	5.8	3.3	5.6
September	12.9	16.7	12.0	13.9
October	47.7	48.9	43.6	46.8
November	78.1	75.9	64.0	72.6
December	104.6	115.2	97.0	105.6
Total	**603.5**	**627.0**	**545.7**	**592.1**

For the purposes of utilising daily rainfall for a storm water dam (SWD) sizing, the nearest station with the least patched data (meaning it has least amount of daily rainfall data that was estimated by averaging the surrounding stations and more of the actual measurements) was therefore taken to be Pilanesberg station (0548165_W).

A review of the daily rainfall records from Pilanesberg rain gauge illustrates that the maximum rainfall depth within 1 day between 1908 and 1986 was 145.8mm; several other high rainfall depths are presented in Table 2-3.

Table 2-3: Five Greatest Depths of Rainfall Recorded (Pilanesberg Rain Gauge)

Date	Rainfall (mm)
05/03/1945	145.8
22/04/1951	94.0
27/01/1955	98.5
05/01/1976	121.5
19/03/1976	126.0

A review of the wettest multi-day periods recorded are presented in Table 2-4, which shows the maximum depth of rain falling over consecutive days ranging from 1 to 30 days. As can be seen, the greatest depth of rain falling within a 30 day period was 406.9mm.

Table 2-4: Maximum/ Wettest Period Recorded On Consecutive Days

No of consecutive days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Rainfall depth in mm	145.8	180.3	182.3	184.3	204.5	228.0	232.5	235.5	249.8	255.6	273.9	273.9	281.5	283.5	284.8

No of consecutive days	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Rainfall depth in mm	291.8	298.5	314.5	322.6	330	332.2	344.5	359.5	375.2	381	399.3	399.3	406.9	406.9	406.9

2.2.2 Evaporation

Evaporation data is based on records from DWS operated station reference A2E021, which is located approximately 25km north east of the current operation with Symon's Pan (S-Pan) evaporation record length of length of 15 years from 1970 until 1986. S-Pan evaporation was converted to open water evaporation using evaporation coefficients from WR1990[2]. The evaporation records show a mean annual evaporation (MAE) of 1286mm, which will be adopted for the site.

Table 2-5 presents the average monthly evaporation adopted for the site.

Table 2-5: Average Monthly Evaporation Adopted for the Site

Month	S-Pan Evaporation (mm)	A-Pan Evaporation (mm)	Conversion Factors	Lake Evaporation (mm)
January	170.5	197.9	0.84	143.2
February	127.6	147.4	0.88	112.3
March	134.5	150.9	0.88	118.4
April	98.3	119.3	0.88	86.5
May	83.8	98.5	0.87	72.9
June	67.7	82.2	0.85	57.5
July	68.6	92.8	0.83	56.9
August	99.8	139.7	0.81	80.8
September	138.4	182.0	0.81	112.1
October	179.0	210.2	0.81	145.0
November	178.7	201.5	0.82	146.5
December	185.5	203.2	0.83	154.0
Total	**1 532.2**	**1 825.7**	**N/A**	**1 286.2**

[2] Surface Water Resources of South Africa 1990 - Volume 1 Appendices. WRC Report 298/1.1/94

2.3 DESIGN STORMS

Design storm estimates for various return periods and storm durations were sourced from the Design Rainfall Estimation Software for South Africa, developed by the University of Kwazulu Natal in 2002 as part of a WRC project K5/1060 (Smithers and Schulze, 2002)[3]. The software extracts the storm depth-duration-frequency (DDF) data for the six closest rainfall stations to the site (25° 6' S; 26° 59' E) and was used to interpolate DDF data for the project area. The Smithers and Schulze method of DDF rainfall estimation is considered more robust than previous single site methods. WRC Report No. K5/1060 provides further detail on the verification and validation of the method.

A summary of the input stations is presented in Table 2-6.

Table 2-6: Summary of Weather Stations Used For Generating Rainfall DDF for the Site

Station Name	SAWS Number	Record Length (years)	MAP (mm)
Pilanesberg-POL	0548165_W	79	623
Saulspoort	0548280_W	38	611
Mahobieskraal	0547831_W	32	630
Syferfontein	0547526_W	41	641
Klipkuil	0547362_W	45	560
Middelkop	0587139_W	49	650

Table 2-7 presents DDF rainfall estimates that were derived from the Smithers and Schulze method based on data taken from the six nearest rain stations which have similar mean annual precipitations and altitudes.

Table 2-7: Storm Depth-Duration-Frequency (DDF) Rainfall for Project Site

Duration (hours and days)	Rainfall Depth (mm)						
0.08	9.9	13.6	16.2	18.7	22	24.6	27.2
0.167	14.7	20.2	24	27.7	32.7	36.6	40.4
0.25	18.5	25.5	30.3	35	41.3	46.1	51
0.5	23.4	32.3	38.3	44.3	52.2	58.4	64.6
0.75	26.9	37.1	44	50.9	60	67	74.1
1	29.6	40.9	48.5	56.1	66.2	73.9	81.8
1.5	34	46.9	55.7	64.4	76	84.8	93.9
2	37.5	51.7	61.5	71	83.8	93.6	103.5
4	44.3	61	72.5	83.8	98.8	110.4	122.1
6	48.8	67.2	79.9	92.3	108.9	121.6	134.5
8	52.2	72	85.5	98.8	116.6	130.2	144.1
10	55.1	76	90.2	104.2	123	137.3	152

[3] Smithers, J.C. and Schulze, R.E., 2002. Design rainfall and flood estimation in South Africa. WRC Project No. K5/1060. Water Research Commission, Pretoria, RSA. 155 pp

Duration	Rainfall Depth (mm)						
12	57.5	79.3	94.2	108.9	128.4	143.5	158.7
16	61.6	85	100.9	116.6	137.6	153.6	170
20	65	89.6	106.4	123	145.1	162	179.3
24	67.9	93.6	111.2	128.4	**151.5**	**169.2**	187.3
2d	69.5	95.9	113.9	131.6	155.2	173.4	191.8
3d	78.6	108.3	128.6	148.6	175.3	195.8	216.7
4d	85.6	118	140.1	161.9	191	213.4	236.1
5d	91.5	126.1	149.8	173.1	204.1	228	252.3
6d	96.6	133.1	158.1	182.7	215.5	240.7	266.3
7d	101.1	139.4	165.5	191.3	225.6	252	278.9

Comparison of the DDF estimates against the daily rainfall data analysed from the Pilanesberg rain gauge (Table 2-4), shows that the 1:50 year and 1:100 year 24 hour DDF estimates are 151.5mm and 169.2mm respectively which are close to the largest 1 day rainfall event recorded in 78 year, which was 145.8mm.

2.4 HYDROLOGICAL SETTING

2.4.1 Introduction

South Africa is divided into 9 water management areas (WMAs) in line with the National Water Resource Strategy 2[4] (NWRS 2) boundary readjustments proposition from the previous 19 WMAs; which have been published in the Government gazette number 40279 of 19/09/16 (Notice no 1056 , DWS, 2016), managed by their own water boards. Each of the WMAs is made up of quaternary catchments which relate to the drainage regions of South Africa. This section presents a review of catchment information from various sources.

2.4.2 Regional Hydrology

The project area falls within the Limpopo WMA (formerly Crocodile West and Marico WMA) with the major rivers being the Crocodile River. All runoff from the project area is eventually drained north into the Limpopo River.

The project site is located in the west of the secondary catchment A2 (Crocodile) within Quaternary Catchment A24D upstream of Bierspruit Dam at the outlet of the catchment. The WR2012 study presents the hydrological parameters for the quaternary catchment as summarised in Table 2-8 :

Table 2-8: Catchment Characteristics for Quaternary Catchment A24D

Catchment Name	Catchment Area (km^2)	Mean Annual Runoff (MAR) in mcm	Mean Annual Evaporation(MAE) in mm	Mean Annual Precipitation (MAP) in mm
A24D	1328	19.72	1850	600

[4] Department of Water and Sanitation, 2013. National Water Resource Strategy, Second Edition, June 2013.

2.4.3 Local Hydrology

PPM is located between two water course systems, into which potential runoff from the study area drains, either to the west into the Motlhabe River to the east into the Wilgespruit which are both non-perennial. The PPM plant and proposed project are located in the catchment of the Motlhabe. Both these watercourses eventually end in the Bierspruit Dam at the outflow from the quaternary catchment A24D the Bierspruit, joining the Crocodile River near Thabazimbi at the outlet of the quaternary catchment A24F.

The watercourses have a relatively flat grade with the exception of the watercourses originating at the catchment divide in the Pilanesberg mountain range, which are extremely steep through the mountainous area before flattening at the foot of the range.

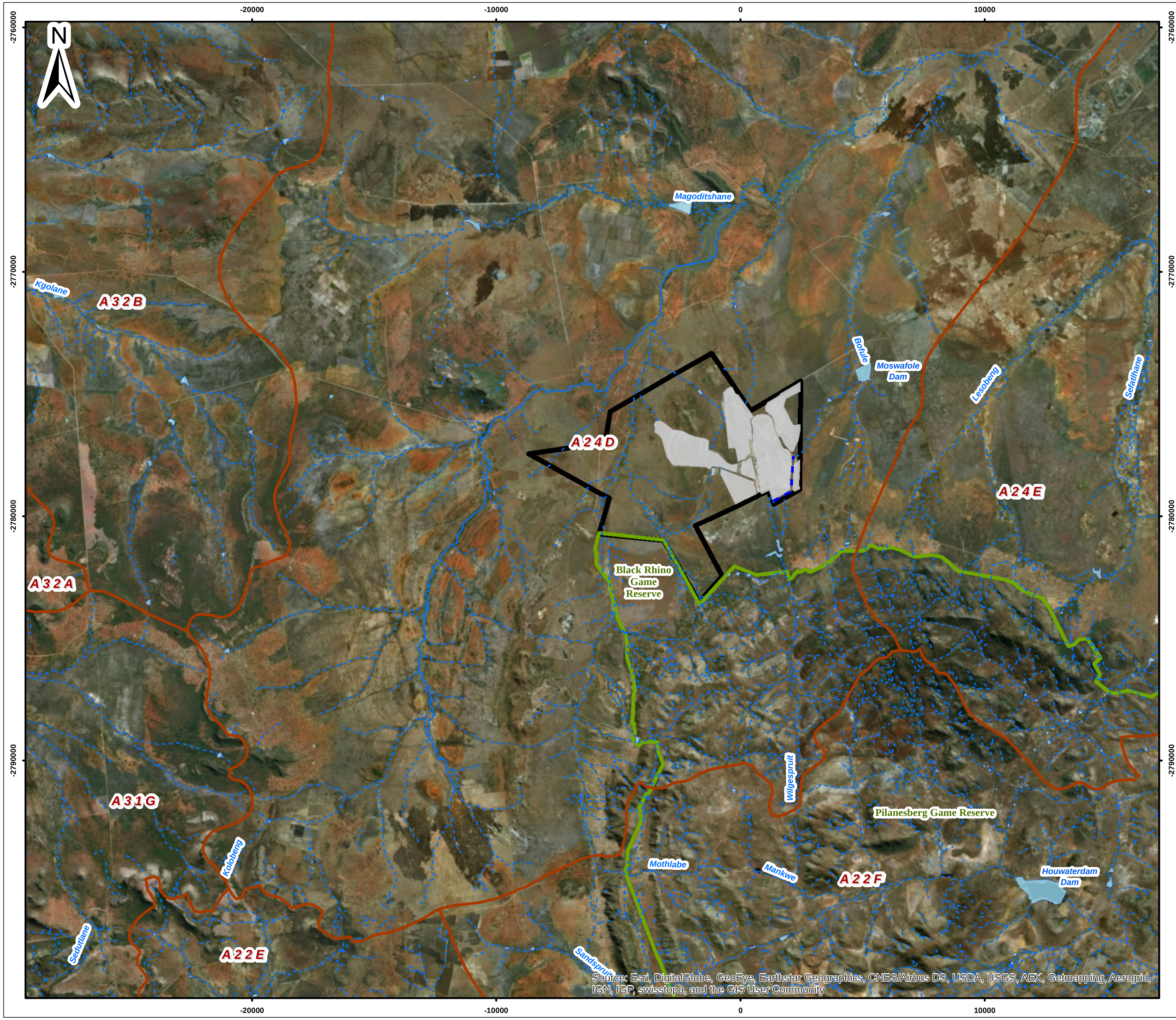
Most of the source catchment / headwaters of the Motlhabe River are from the Pilanesberg both in the vicinity of the site and further to the south-west. The Motlhabe River flows on the west of the site and to the north to a confluence with the Kolobeng River, close to the town of Motlhabe River approximately 8km north-west of the site. The Motlhabe River has a total catchment area of 146.0km^2 upstream of the confluence with the Kolobeng River, following which the Kolobeng River continues in a north-easterly direction to a confluence with the Bofule River of which the Wilgespruit is a tributary.

The Wilgespruit headwaters are from the Pilanesberg and flows in a northerly direction towards the site (east of the site) and through a flow diversion channel around the south of Tuschenkomst Pit. Furthermore it passes through the site flowing towards to a confluence with the Bofule River approximately 2.5km north east of the site. The Wilgespruit comprises a catchment area of 56.4 km^2 upstream of the confluence with the Bofule River. A further 4km downstream (north-west) of the Bofule-Kolobeng rivers confluence, the Kolobeng River flows into the Bierspruit Dam.

A review of reservoirs in the Wilgespruit and Bofule catchments indicates that there are no major dams present, although a number of small farm dams have been identified. The most significant of these dams is the Moswafole dam located at the confluence of the Wilgespruit and Bofule rivers. It is understood that the Moswafole dam is a “breached” dam (SRK, 2007). Its designation as a dam is consequently not accurate since its ability to store water is at present compromised.

The project site infrastructure (plant and tailings areas) is located in the headwaters of two tributaries of the Motlhabe River. The tailings dam has been designed as a valley tailings dam between to hills at the top of the catchment. Tailings catchment has an area of 2.6km^2 shows the affected area of the structure. Nodes MLT-1 and MLT-2 (SRK, 2007) which have areas of 6.2km^2 and 2.8km^2 respectively show the area that the plant has impacted on the most. Both tributaries report to the Motlhabe River before it joins the Kolobeng River.

The regional and local hydrology setting is presented in Figure 2-1 and Figure 2-2.



Legend

- Quaternary Cathments
- Perennial Rivers
- Non-Perennial Rivers
- Wilgespruit River Diversion
- Dams
- Pilanesberg Platinum Mine Mining Right Area & Related Infrastructure
- Pilanesberg National Park (including Black Rhino Game Reserve)

0 1 000 2 000 3 000 Meters

Scale: 1:150 000 @ A3

Projection: Transverse Mercator
Datum: Hartebeeshoek, LO27

PILANESBERG PLATINUM MINES (PTY) LTD

Regional Hydrology

SLR

SLR Consulting (Africa) (Pty) Ltd
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Legend

- Approved Infrastructure
- Proposed Infrastructure Changes
- Existing Community-Based Projects
- Non-Perennial Rivers
- Wilgespruit River Diversion
- Dams

Storm Water Management System

- Clean Water Controls
- Dirty Water Controls

0 100 200 300 400 500 600 700 Meters

Scale: 1 : 20 000 @ A3
Projection: Transverse Mercator
Datum: Hartebeeshoek, Lo27

PILANESBERG PLATINUM MINES (PTY) LTD

Local Hydrology

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2.5 TOPOGRAPHY

The topography of the site is characterised by elevations of between 1100 and 1120 metres above sea level (m amsl) with a general slope of 1-3%. The location of the mine is approximately 5km from the foot of the Pilanesberg where the peaks rise up to 1687 m amsl. The PPM site is located between several hills, with the highest hill located to the north of the tailings facility which rises up to 1 266 m amsl.

2.6 VEGETATION

As detailed in the Metago (Metago, 2011[5]) report, with the exception of the Pilanesberg, the lower catchments of the Motlhabe and Wilgespruit including the site feature a less dense bushveld and thornveld with agriculture and grazing. The upper catchments within the Pilanesberg on the other hand, are associated with more dense vegetation cover.

2.7 SOIL

The soils consist of a sandy clay surface layer which is dispersive and erodible while deep clays and weathered rock are encountered thereafter (SRK, 2007).

2.8 FLOODLINES

Several flood studies have been undertaken for watercourses in and around the PPM mine as detailed in SLR, 2013[6] study summarised below:

1. Flood modelling for discrete stretches of the Manyedime, the Motlhabe and its tributaries was undertaken by Metago Environmental Engineers (Pty) Ltd in July 2010. The modelling used peak flows which were estimated by SRK using both the Rational and SCS Methods. Peak flows for the 1:100 year event of between 17.0 and 31.1m^3/s were estimated in the Mothlabe tributary in the vicinity of the Tuschenkomst WRD, and 46.6m^3/s within the Manyedime watercourse at a location 4.65km north of the mineral rights abandonment area.
2. Flood modelling of the Wilgespruit and Bofule watercourses as they flow through the site was undertaken initially by SRK in 2007[7] and subsequent modelling was undertaken by Peen & Associates in June 2011. Peen & Associates estimated peak flows within the Wilgespruit for a range of return period events concluding that a flow of 274m^3/s would be expected during a 1:100 year event. No independent review of Peen & Associates or SRK's work has been undertaken as part of this study although, for comparison, SRK estimated a flow of 193m^3/s for approximately the same location in the Wilgespruit.

The flood-lines are presented in Figure 2-3.

---

[5] Metago, June 2011. Surface Water Assessment for the Amendment of the Pilanesberg Platinum Mine EMP Closure Objectives.
[6] SLR, 2013. Tuschenkomst Open Pit Extension (Sedibelo West) Stormwater Management Plan (B007-19)
[7] SRK Consulting, Surface Water Aspects for the Pilanesberg Platinum Mine prepared in April 2007 SRK Project Number 371373/1

2.9 WATER BALANCE

A site wide water balance was undertaken by AGES[8] in 2012 and was an update to the SRK, 2007 water balance. From the water balances, it is understood that water is sourced from Magalies Water Board (MWB), where PPM has an allocation of 24.2ML/d (24 200 m^3/d). PPM only uses 8ML/day (8 000m^3/day) of this allocation.

Water for the proposed project would be sourced from this existing allocation. Water at PPM is recycled and reused in the process. Where make-up water is required to supplement process water, the design requirements are as follows:

- Additional UG2 milling and flotation circuit: approximately 39 000 m^3/month (1,3 Ml/day); and
- KELL process: approximately 2 670 m^3/month (0,089 Ml/day).

The reuse of water is prioritised i.e. the treated sewage water must all be used for dust suppression, the Tuschenkomst open pit excess water to be contained and pumped for reuse in the plant and tailings decant and seepage water will be reused at the plant.

---

8 AGES Pty Ltd, 2012. PPM Individual and Integrated Environmental Site Water Balances Technical Report (G12/014-2012-04-26)

Legend

- Approved Infrastructure
- Proposed Infrastructure Changes
- Existing Community-Based Projects
- 100 Year Floodlines (SRK 2007)
- 100 Year Floodlines (Metago July 2010)
- 100 Year Floodline (Peen & Associates)
- Non-Perennial Rivers
- Wilgespruit River Diversion

0 100 200 300 400 500 600 700 Meters

Scale: 1 : 20 000 @ A3
Projection: Transverse Mercator
Datum: Hartebeesthoek, Lo27

PILANESBERG PLATINUM MINES (PTY) LTD

Floodlines and Diversion

SLR Consulting (Africa) (Pty) Ltd
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3. WATER QUALITY ASSESSMENT

This section of the report presents a review of water quality reports provided from Exigo Sustainability (Pty) Ltd (Exigo)[9] and a summary of key findings pertinent to the PPM Plant expansion area only.

3.1 WATER QUALITY MONITORING PROGRAMME

Exigo is appointed by PPM to analyse and interpret the quality of water at the Pilanesberg Platinum Mines and surrounding area. The monitoring is conducted in accordance with a previously proposed monitoring programme and requirements of the water use license (Reference number: 03/A24D/ACGU/2037) issued on 10 October 2013.

The Exigo monitoring reports and database were provided to SLR to summarise water quality records from the period 2009 /2010 period until 2018. Of relevance to this study the water monitoring included sample collection points for surface water, storm water dam, sewage treatment and process water areas.

A network of thirteen surface water sampling points is monitored for water quality. They are situated along the non-perennial Motlhabe, Wilgespruit and Manyedime rivers, and some of their tributaries. Of these 13, two were selected for understanding the PPM plant expansion current water quality namely SW9 and SW13. Three dirty water containment facilities were also selected namely SWD1, SWD2 and SWD5. The selected water monitoring locations relevant to this project have been presented in Table 3-1 and shown in Figure 3-1.

Table 3-1: Surface Water Sampling Locations Relevant to the PPM Plant Expansion Project

Monitoring site	Description of Sampling Location	GPS coordinates (WGS84)		Monitoring Frequency	Monitoring Records (Yrs.)
		Latitude	Longitude		
SW9	Surface Water River- Non-perennial tributary joining Mothlabe River from east (downstream from TSF, RWD & SWD2)	-25.0907	26.96635	Chemical- Monthly	2009-2012 & 2017
SW13	Surface Water River- Non-perennial tributary joining Mothlabe River from east (downstream from SWD1 & PPM Waste Rock Facility)	-25.0848	26.9902	Chemical- Monthly	2017 & 2018
SWD1	Plant Storm Water Dam (Below Plant and Main Admin office)	-25.1023	26.98835	Chemical- Monthly SOG- Monthly	2009-2018
SWD2	TSF Storm Water Dam (Below TSF RWD)	-25.09378	26.96742	Chemical- Monthly SOG- Monthly	2009 - 2018

SOG = soap, oil and grease

[9] Exigo Sustainability Pty Ltd, 2018. Bi-Annual Water Monitoring Report Pilanesberg Platinum Mines January 2018 - June 2018

3.2 WATER QUALITY GUIDELINES

The water quality guidelines that are used for interpretation were determined from the land use and current water use namely:

- SANS 241 (2015), Drinking Water – Edition 2.
- Department of Water Affairs and Forestry (now Department of Water and Sanitation (DWS)), 1996. South African Water Quality Guidelines (second edition), Volume 3: Industrial use - Target Water Quality Range (TWQR).
- DWS, 1996. South African Water Quality Guidelines (second edition), Volume 5: Agricultural Water Use: Livestock Watering - Target Water Quality Range (TWQR).
- Wastewater limit values applicable to discharge of wastewater into a water resource (GN 1191; GG20526, 1999).
- Integrated water use licence (IWUL) licence number 03/A24D/ACGU/2037.
- Baseline water quality.

The DWS, Volume 5: Agricultural Use: Livestock Watering (1996), were selected considering that the water is from time to time consumed by livestock, owned by members of the surrounding communities. The water quality from dirty water containment facilities is compared to the target water quality ranges (TWQR) for DWS, Volume 3: Industrial Use (1996).

Water quality of surface water monitoring points were also compared to baseline data in order to determine if the mining or any other activities had an adverse effect on the water quality of each respective sampling point. Developments at the mine commenced during 2009. During May 2018, baseline values were re-calculated as the 95th percentile values of all available water quality data from before 2009.

However, surface water quality results from before 2009 were limited to four samples taken at SW3 in 2008 and considered for 95th, 75th and average baseline values. SW3 is located upstream from PPM mining activities on the non-perennial Motlhabe River at location latitude -25.12490 and longitude 26.94233 (WGS84).

3.3 WATER QUALITY RESULTS

The summary of surface water quality results for the sites relevant for the PPM Plant expansion project as detailed in Table 3-1 are presented in this section.

The specific water quality criteria evaluated and accompanying test results are included in Appendix A.

The exceedances are presented in Table 3-2 and site monitoring water quality results are detailed in Appendix A and present the following:

- The water quality at SW9 was within the Target Water Quality Range (TWQR) for Agricultural Use: Livestock Watering (1996) on most sampling periods except for nitrite N (NO_2-N) and electrical conductivity (EC) which were above the TWQR in 2009;
- When compared to the baseline and the WUL quality specifications, SW9 exceeds these for several parameters as listed in Table 3-2. The exceedance for pH was only once in 2017 with the pH reading of 8.9 compared to the WUL limit of 8.8;
- SW13 only complied with the TWQR for Livestock Watering at all times except once when it exceeded DWS TWQR once for TDS in April 2018. However when compared to the baseline and WUL quality specifications, samples exceed several parameters. It is not possible to isolate the contributions from

the waste rock dump and the plant in terms of water quality at this site, however, Exigo attributed the water quality impacts to the waste rock dump; and

- The available data at both sites indicate potential impacts from the current mining activities.

It can be argued that the baseline is for a different river (Mothlabe), therefore, the trends in water quality at theses selected surface water monitoring locations become of importance. However, the sites are dry for most of the year and having a consistent water quality results database is not possible.

Additionally, considering that the watercourses from which the samples were collected are non-perennial the exceedances could be attributed to washed off contaminants from the rainy season. Where sampling in the dry season is done from pools of water which would have undergone evaporation, concentrating of elements would occur.

It should be ensured that the stormwater management measures are fully operational to contain dirty runoff from site and no spillages are experienced from the dirty water storage dams even after storm events.

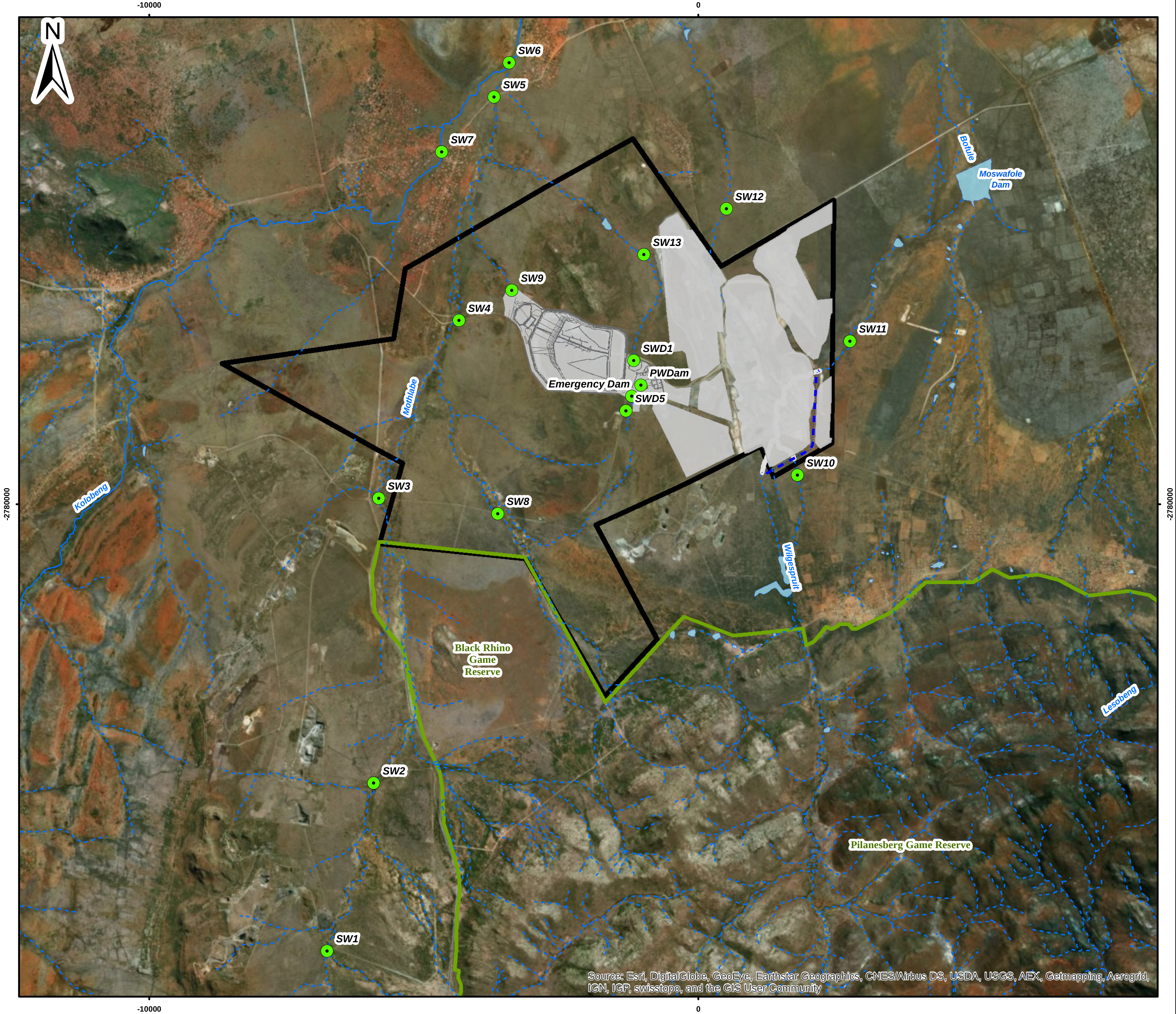
Dirty stormwater containment dams SWD1 and SWD2 historical results indicate that:

- The storm water dams, suspended solids concentration was above the DWS TWQR for industrial use;
- The WUL quality specifications are exceeded for nitrate and soap, oil and grease (SOG) and iron for both sites and then an additional chloride SWD2.

Consideration of exceedances presented in Table 3-2 and Table 3-3, the similarity in the water quality exceedances between the dirty water storages and the surface water monitoring sites is minor, this could be because there is minimal to no cross contamination.

Temporal comparison of the various sampling sites is complicated by the unavailability of consistent water quality information due to the non-perennial nature of streams, which are often dry during some sampling periods. Nonetheless, the water quality samples collected from SW9 and SW13 were compared to a downstream location (SW5) (location is shown in Figure 3-1), and using the water quality data and graphs plotted by Exigo (Bi-Annual Water Monitoring Report – June 2018) as presented in Figure 3-2 through to Figure 3-4. Considering the monitoring periods where sampling coincides and looking at the sulfate concentrations for comparison purposes, the following conclusions were drawn:

- 2017-02-20: The downstream location SW5 (175 mg/l) had higher sulfate concentration that the SW9 (110mg/l), and SW13 was dry;
- 2017-12-05: The dowsntream location SW5 had higher conentration (21.1mg/l) than the upstream location SW9 (5.8mg/l) located downstream of the TSF whilst at SW13 located downstream of the waste rock dump and plant catchments, had the highest concentratioin of sulfate (61mg/l); and
- 2018-04-10: SW13 had a much higher concentration (632mg/l) when compared top SW5 (6.9mg/l).



Legend

- Surface Water Monitoring
- Perennial Rivers
- Non-Perennial Rivers
- Wilgespruit River Diversion
- Dams
- Pilanesberg Platinum Mine Mining Right Area & Related Infrastructure
- Pilanesberg National Park (including Black Rhino Game Reserve)

0 1 000 Meters

Scale: 1:150 000 @ A3

Projection: Transverse Mercator
Datum: Hartebeeshoek, LO27

PILANESBERG PLATINUM MINES (PTY) LTD

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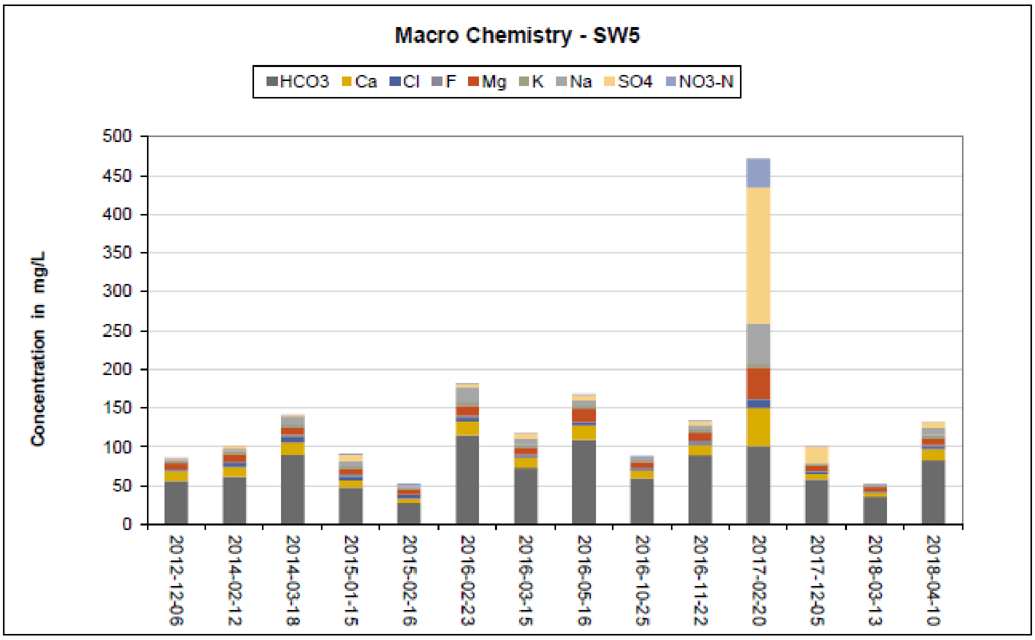

Figure 3-2: Water Quality Summary at SW5

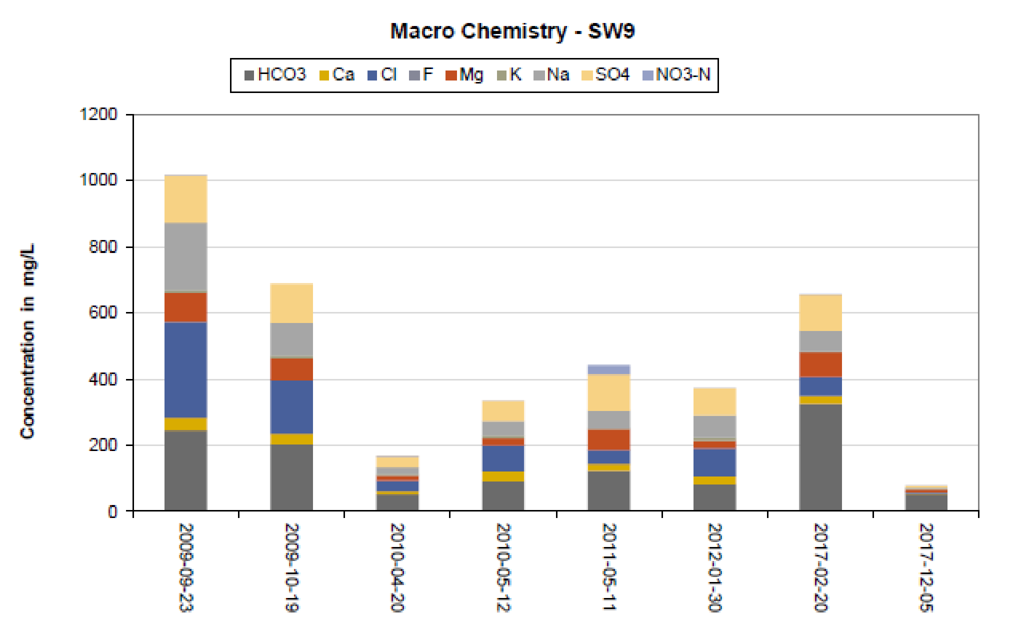

Figure 3-3: Water Quality Summary at SW9

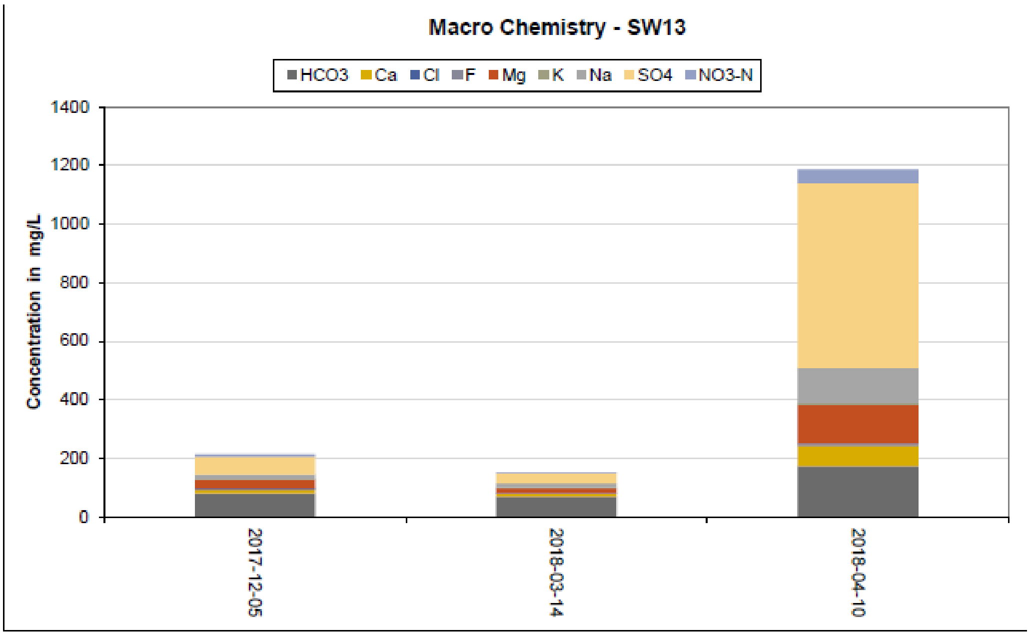

Figure 3-4: Water Quality Summary at SW13

Considering the results and discussions above, it is recommended that a sampling point is established downstream and closer to the PPM plant to be able to separate the impacts of the PPM plant and the waste rock dump. Furthermore, a study should be conducted by PPM to trace the source of pollutants on site.

Table 3-2: Summary of Exceedances of Surface Water Sampling Sites

	Standard exceedance	2009	2010	2011	2012	2017
SW9	Baseline 95th	HCO_3,Ca,Cl,Mg,K,Na,NO_3-N, CO_3, EC, TDS, Alkalinity, Total Hardness	HCO_3,Ca,Cl, Mg, K, Na, NO_3-N, CO_3, EC, TDS, Alkalinity, Total Hardness	HCO_3,Ca,Cl,Mg,Na,NO_3-N, CO_3, EC, TDS, Alkalinity, Total Hardness	HCO_3,Ca,Cl,Mg,K,Na, NO_3-N, CO_3, EC, TDS, Alkalinity, Total Hardness	HCO_3,Ca,Cl,Mg,Na, NO_3-N,CO_3,EC,TDS, Alkalinity,Total Hard
	Baseline 75th	SO_4	K,NO_3-N			
	Baseline Average	SO_4		SO_4	SO_4	SO_4
	TWQR of DWAF, Volume 5 Livestock Watering (1996)	NO_2-N,EC				
	IWUL- Licence Nr : 03/A24D/ACGU/2037	Ca,Cl,Mg,Na,NO_2-N,NH_3-N,EC	Ca,Cl,Mg,Na,NH_3-N	Ca,Mg,Na,NO_3-N,NH_3-N	Ca,Cl,Mg,Na	Ca,Cl,Mg,Na,NH_3-N, pH,EC,Free Cl_2

	Standard exceedance	2017	2018
SW13	Baseline 95th	HCO_3, Mg, Na, NO_3-N, CO_3, EC, Alkalinity, Total Hardness	HCO_3,Ca,Mg,Na,SO_4,NO_3-N, CO_3, EC, TDS, Alkalinity, Total Hardness
	Baseline 75th	Ca	
	Baseline Average	TDS	
	TWQR of DWAF, Volume 5 Livestock Watering (1996)		TDS
	IWUL- Licence Nr : 03/A24D/ACGU/2037	Mg,NO_3-N,Free Cl_2,Al,Cu,Zn	Ca,F,Mg,Na,SO_4,NO_3-N, NH_3-N,EC,Al,Zn

Table 3-3: Summary of Exceedances of Dirty Water Containment Facilities

	Standard exceedance	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
SWD1	TWQR of DWAF, Volume 3 Industrial Use (1996)	SS	SS	SS	SS	SS	SS	SS	SS	SS, TDS	SS, TDS
	IWUL- Licence Nr : 03/A24D/ACGU/2037	Fe	Cl	NO_3-N		Cl, Fe	NO_3-N,SOG	SOG	Fe, SOG, Cl, NO_3-N	Fe, SOG, Na, NO_3-N	NO_3-N,SOG

	Standard exceedance	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
SWD2	TWQR of DWAF, Volume 3 Industrial Use (1996)	SS	pH, SS	pH, SS	pH, SS	pH, SS	pH, SS	EC, TDS, SS	SS	SS	SS
	IWUL- Licence Nr : 03/A24D/ACGU/2037	Cl, Fe	Cl	NO_3-N, Cl	Cl	Cl	NO_3-N, Cl, SOG	Cl	Cl, SOG	SOG, Fe	NO_3-N,SOG

4. STORMWATER MANAGEMENT MEASURES

4.1 INTRODUCTION

A review of existing stormwater management report undertaken by SRK[10] in 2007 as well as proposed site plans inform the stormwater management description for the PPM Plant expansion.

The existing Tuschenkomst stormwater management system within the 2007 report covers the PPM Plant, the Tuschenkomst pits and the tailings system. Furthermore, the proposed infrastructure is situated within existing (already designed and constructed) stormwater management measures as discussed in Section 4.3 below.

The aim of the stormwater management plan is to fulfil the requirements of the National Water Act (Act 36 of 1998) and more particularly, Government Notice 704 (as discussed in Section 1).

4.2 STORMWATER CLASSIFICATION

The following definitions from GN 704 are appropriate to the classification of catchments and design of storm water management measures at the PPM Plant expansion project:

- Clean water system: includes any dam, other forms of impoundment, canal, works, pipeline and any other structure or facility constructed for the retention or conveyance of unpolluted (clean) water;
- Dam: includes any settling dam, slurry dam, evaporation dam, catchment or barrier dam and any other form of impoundment used for the storage of unpolluted water or water containing waste (i.e. dirty water);
- Dirty area: means any area at a mine or activity which causes, has caused or is likely to cause pollution of a water resource;
- Dirty water system: this includes any dirty water diversion bunds, channels, pipelines, dirty water dams or other forms of impoundment, and any other structure or facility constructed for the retention or conveyance of water containing waste (i.e. dirty water); and
- Activity: means any mining related process on the mine including the operation of washing plants, mineral processing facilities, mineral refineries and extraction plants; the operation and the use of mineral loading and off-loading zones, transport facilities and mineral storage yards, whether situated at the mine or not; in which any substance is stockpiled, stored, accumulated, dumped, disposed of or transported.

Based on the mine layout and proposed expansion the catchment classification is presented in Table 4-1.

Table 4-1: General Classification of Catchments at PPM

Classification	Areas	Treatment Technique
Clean	Undisturbed areas	Diverted dirty areas.
Dirty	PPM Tailings Facility Pits Plant RoM pad Stockpiles and waste rock dumps	Perimeter berms and trenches Contain in RWD and SWD and re-use.

[10] SRK Consulting, 2007. Surface Water Aspects for the Pilanesberg Platinum Mine (Report No 371373/1)

4.3 STORM WATER MANAGEMENT MEASURES

This study assumes that stormwater management measures recommended by SRK are adequate and have been implemented.

The PPM storm water management system is already in place and copes with storm water runoff events and the system fulfils the GN704 design requirements. In addition to the river diversions additional storm water control structures were proposed to divert clean water runoff away from plant infrastructure areas before being contaminated. The control of dirty water runoff from areas is being contained and reused as far as possible. Furthermore, diversion channels have been sized to divert runoff up to a 1:100 year return period with dirty water dams being sized to contain a 1:50 year runoff volume before spillages in the natural environment will be accepted.

The proposed infrastructure is located within the following existing stormwater management areas:

- The PPM plant additional components (milling and floatation section, the hydrometallurgical plant) are in the current plant footprint;
- The sewage treatment plant upgrade and the waste facility are located in existing services; and
- Community initiative infrastructure are located i.e. the crusher and brickyards are also located in an already impacted site.

The current PPM operations have 5 SWD on site that sufficiently manages the storm water throughout the year. Water from the SWD during summer months is used as water supply for dust suppression and thus water consumption during the rainy season can be reduced during flood periods.

In conclusions, no new stormwater infrastructure will be required as project components are within existing stormwater management systems. However, the existing diversion channel system around the proposed PPM plant expansion is summarised in the section below

4.3.1 Diversion Channels

As previously stated, this study assumes that stormwater management measures recommended by SRK are adequate and have been implemented. SRK (2007) recommended that a series of clean water diversion channels (presented in Figure 4-1) were installed around the dirty water areas including:

- Clean water diversion channels around TSF (TK-C-5 and TK-C-6) and processing plant area (TK-C-1); and
- Dirty water interception channel around the southern boundary of the plant area (TK-D-1).

The diversion at node TK-C-1 is a clean storm water diversion channel and has been put in place to divert the clean water runoff from the hill that lies behind the plant area. Once the diversion has reported past the plant it discharges back into one of the Motlhabe River's tributaries.

The clean water diversion at node TK C-2 is the formalizing of the natural river watercourse that route past the south western edge of the plant. A clay berm was constructed between the river and the plant to prevent the watercourse encroaching onto the plant area.

The clean water diversions at nodes TK-C-5 and TK-C-6 have been put in place to divert clean water runoff from the two adjacent hills that drain towards the proposed tailings dam area. The tailings dam has not been designed to cater for additional runoff from the external catchment draining onto it; therefore the two diversions are critically important from a safety point of view.

The plant is serviced by a dirty water diversion channel along the southern boundary of the plant which is shown at node TK-D-1. The diversion channel needs to collect the runoff from the plant area and discharge it into pollution control dam at the end of the channel to prevent ground contamination.

A summary of SRK's recommended sizes for these channels is presented in Table 4-2. All channels were sized to convey the 1:100 year event.

Table 4-2: Recommended Channel Sizes (SRK, 2007)

Channel	Catchment Type	Catchment Area (km^2)	Design Flow (m^3/s)	Depth (m)	Bottom Width (m)	Side Slope (1:x)		Channel Gradient
						Left	Right	%
TK-C-1	Clean	0.21	2	0.75	0.50	2	4	1.66
TK-C-2	Clean	1.53	19	1.00	0.50	70	2	1.28
TK-C-5	Clean	0.23	4	1.00	0.50	5	2	0.63
TK-C-6	Clean	0.72	5	1.00	0.50	2	20	0.30
TK-D-1	Dirty	0.47	11	1.50	1.50	0	0	1.28

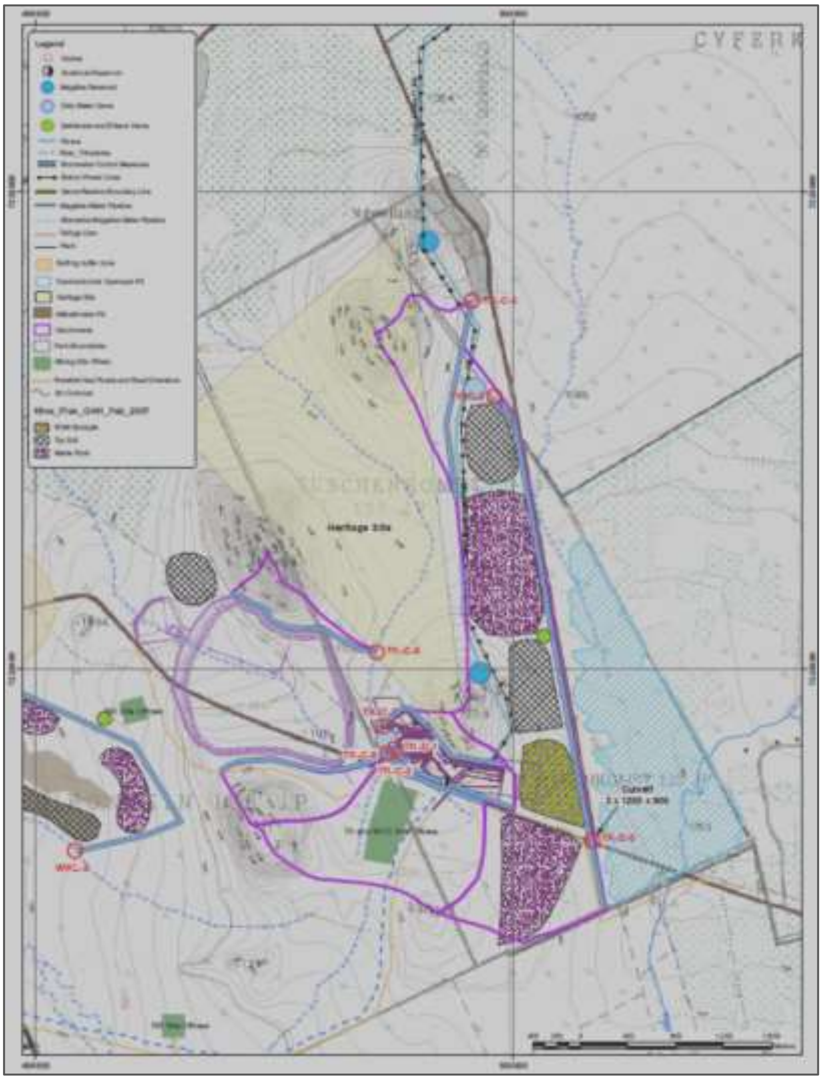

Figure 4-1: Stormwater Control measures in the PPM plant Area (extract from SRK Report, April 2007)

4.3.2 Storm Water Dam (SWD)

SRK (2007) recommended that dirty stormwater from the processing plant area collected within the above mentioned drainage channel TKD1 and conveyed to a SWD. The SWD was designed to contain a 1:50 year storm runoff of approximately 45 000m^3 and has a 0.5m thick clay liner to prevent ground water contamination. The water from dam is re-used as part of the plant makeup water as far as possible. A daily time step sizing of the SWD undertaken is presented in Section 5 to confirm these dimensions and make necessary recommendations.

4.4 IMPACTS ON MAR

The SRK, 2007 report estimated the runoff details the MAR for the catchments of the rivers that may be disturbed by mining operations.

The catchment area for catchment A24D is 1 262km^2 which has a MAR of 15.53 x 10^6 m^3/annum. The disturbed sub-catchment by the plant and TSF footprint is approximately 0.4% of the quaternary catchment. The MAR of the catchments affected by the PPM Plant expansion are detailed in Table 4-3.

Table 4-3: The MAR of the disturbed catchments

Sub-Catchment*	Area (km^2)	MAR (x 10^6 m^3/annum)	% of A24D MAR
Plant and offices sites (MLT-2)	2.8	0.03	0.19
Tailings facility (MLT-3)	2.6	0.03	0.19

*The codes in brackets refer to the names of catchment nodes as presented in the SRK 2007.

With the plant expansion, it is not anticipated to change as most of infrastructure is in existing areas.

As indicated in Table 4-2, the plant site dirty catchment covers an area of 0.47km^2, approximately 16% of catchment MLT-2 and less than 0.1% of Quaternary Catchment A24D.

5. SWD SIZING

The existing SWD dimensions are presented in Section 4.3.2 and it was required that the capacity be confirmed in line with the DWS Best Practice Guideline (BPG) A4 for Pollution Control Dams (DWS, 2007) and the Regulation 704.

5.1 DESIGN STANDARDS

The BPG (A4) requires that the determination of the size of the PCD (SWD in our case) so as to only spill once in 50 years and requires the application of a continuous model (not a single event) at an appropriate (preferable daily) time step. Furthermore, Regulation 6 of GN 704 requires the capacity requirements of dirty water systems to be designed “so that it is not likely to spill into any clean water system more than once in 50 years”.

A water balance approach has been adopted which takes into account daily runoff, evaporation and water re-use associated with the processing plant’s process water dam as a pump out rate.

5.2 DESIGN METHODOLOGY

A dynamic daily time step modelling was developed using 66 years of daily rainfall data to understand the impacts of climatic extremes and estimate capacity requirements for the SWD using the GoldSim simulation software. The daily rainfall data was selected from 1914 to 1980 which is 66 year record which as much as possible, excluding records with gaps for periods before or after this record length.

Withdrawal /pumping rates for the SWD for uses at the plant were supplied by the client (through Exigo), covers the period January 2016 until December 2018. The data is summarised to provide the minimum (10th percentile), average, the 75th percentile, 95th percentile and maximum. This was to understand the sensitivity of the model to the pump rates, as well and how the storage requirements change and compare to the current design capacity. The pump out rates is as presented in Table 5-1:

Table 5-1: SWD design pump out rates

Statistic	Pumping rate (m^3/hr)
10th Percentile	53
Average	133
75th Percentile	182
95th Percentile	233
Maximum	247

5.2.1 Rainfall Runoff Model

A daily rainfall runoff model was used to quantify the volumes of storm water running off the plant area into the SWD. The rainfall runoff model is based on the Soil Conservation Service (SCS) method to estimate the portion of the rainfall which infiltrates or runs off of each catchment type each day of the simulation. This method requires the allocation of a parameter, known as a Curve Number (CN), to the various surfaces in a catchment, from which percentage daily runoff can be calculated. The CN value is altered to account for the daily variation in the catchment soil moisture budget.

The following catchment parameters presented in Table 5-2 were used for rainfall runoff modelling.

Table 5-2: Summary of plant catchments characteristics

Catchment	Footprint Area (Ha)*	SCS Curve Number (CN)*
RoM Pad and Plant – Gravel Roads	25.85	88
Plant Impermeable	7.05	98
Plant disturbed soil and vegetation cover	14.1	86
Total Stormwater Catchment	47	-
SWD Footprint	3	-

*Estimated from measures from google earth for the SWD and estimates proportions of the 0.47km^2

The current SWD has the following parameters:

- SWD area (m^2) 30 000
- Volume (m^3) 45 000
- Depth (m) 1.5

5.3 DESIGN ASSUMPTIONS

The key variables and assumptions for the dynamic water balance model constitute the following:

- Daily rainfall data recorded at the Pilanesberg (Pol) station detailed in Section 2.2;
- For analysis of results, a "hydrological year" is assumed to run from 1st August to 31st July, thereby capturing the entire wet season within one "hydrological year";
- Monthly average lake evaporation data calculate from rainfall data obtained from the DWS operated station reference A2E021 is used as presented in Section 2.2 and evaporation losses from the SWD are estimated on a daily basis by multiplying the daily average open water evaporation rate by the surface area of the dam;
- Stormwater catchments contributing water to the SWD are characterised in terms of rainfall runoff from the following:
  - Plant and associated infrastructure into the Plant SWD; and
  - Rainfall onto the SWD surface.
- The return water system pumps water out of the dam for re-use at the plant whenever water is available. The total pump out rates for reuse from the SWD are utilised top define different scenarios;
- The dams is modelled, assuming vertical sides for simplicity;
- The water balance assumes a dam capacity of the current (45 000m^3), and the dam will likely spill at low water usage; and
- The 66 year annual maximum series for the SWD is statistically analysed by the Generalized Extreme Value distribution, to allow estimation of the maximum SWD with an annual probability of occurrence of 1:50 (2%), which is used to inform the capacity requirements of the SWD ensuring compliance with GN 704.

5.4 RECOMMENDED SWD DESIGN CAPACITY

The summary of the PCD sizes based on the storm water runoff catchments (470 000 m^2) obtained from the Generalized Extreme Value distribution for the 1:50 year event are presented in Table 5-3 and also presented in Figure 5-1 together with the maximum spill volumes from the recorded daily spills.

Table 5-3: Summary PCD capacity for various pump-out rates (scenarios)

Scenario	Pump out Rate (m3/hr)	SWD Capacity Requirements (1:50) m^3	Depth of design SWD volume (m)	Spillage Occurrences
10th percentile	43	56 791	1.9	30 times
Average	133	48 748	1.6	4 times
75th Percentile	183	45 645	1.5	4 times
Recommended	200	44 427	1.5	None
95th Percentile	233	44 473	1.5	None
Maximum	247	44 950	1.5	None

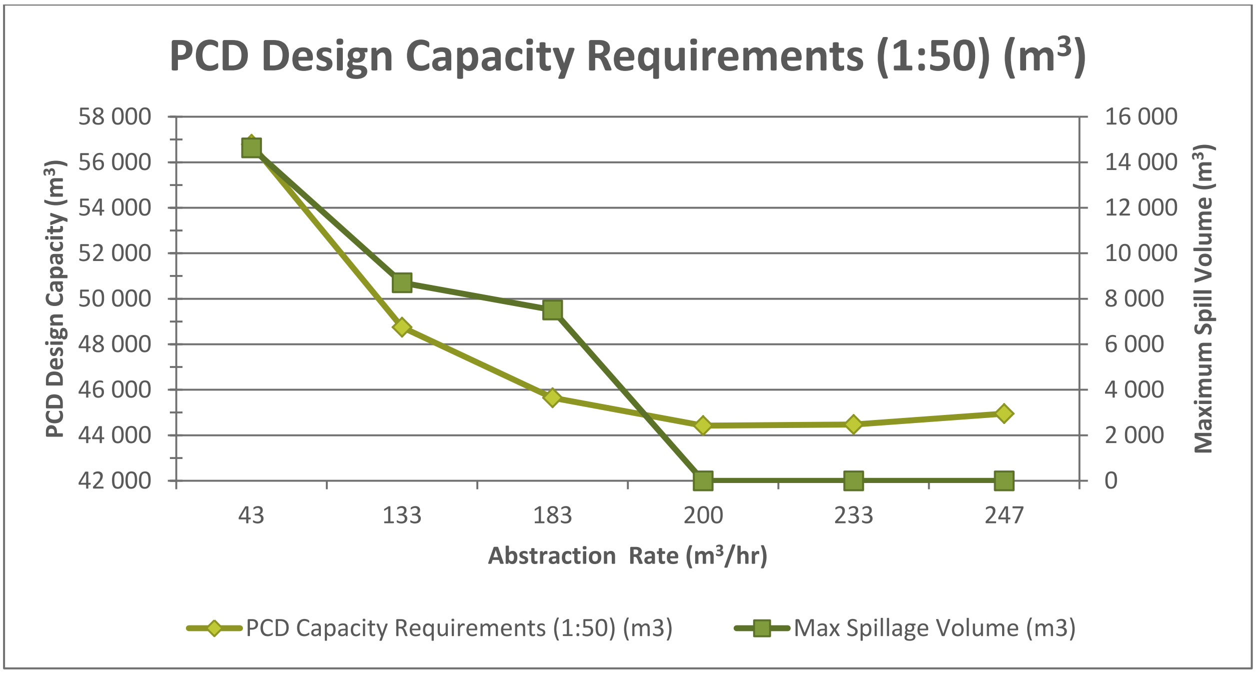

Figure 5-1: Graph Showing Changes In PCD Design Capacity Requirements with Abstraction Rates and Maximum Spill Volumes

Considering that the minimum abstraction/ pump out for reuse (10th percentile) and the annual maximum storm water volumes with a capacity of 45 000 m^3; the SWD spills for approximately 30 times in 8 of the 66 year simulation period. At the average and 75th percentile abstraction rates, the SWD will spill 4 times in the 66 year simulation period, which still does not comply with the GN704 Regulations.

Based on the design parameters discussed above, the current capacity of the SWD pumped for reuse at an abstraction rate that is at least 200m^3/d is adequate with a minimum risk of annual spillage of a 1:50 year chance. At the higher pump out rates, a capacity of approximately 45 000m^3, would be adequate. This excludes the 0.8m freeboard and excludes any permanent water storage below the inlet for the pump.

The current recommended SWD capacity is sufficient for the proposed plant upgrades, only if the withdrawal rate of the SWD is maintained above a 200 m^3/hr rate to avoid spillage. Alternatively the PCD capacity can be enlarged to accommodate even the lowest withdrawal pump rate to a 56 000 m^3 capacity.

A trade-off study and optimising the pump vs dam capacity does not form part of this scope of work.

6. IMPACT ASSESSMENT

Informed by the mine plan layout, baseline hydrology, design specifications for the storm water management measures and the water balance results (providing an indication of there being no increase in allocated water demands from Magalies Water), the potential impacts of the proposed activities on surface water receptors as well as the sensitivity of the surface water resources are discussed in this section and presented along with a summary of mitigation measures.

Considering that this project focuses on expansion of existing mineral processing facilities, impacts are assessed cumulatively, in that the assessment takes into account the currently impacted environment covered by mining facilities. However, the impacts of the various (surrounding/neighbouring) mining activities in the wider region have not been cumulatively assessed in this report.

6.1 IMPACT IDENTIFICATION

The existing impacts include the following:

- Reduced availability to downstream/down-gradient water users due to changes in water quantity or flow regime;
- Reduced availability of water to downstream/downgradient water users due to changes in water quality;
- Reduced availability of water to surrounding water users due to physical obstruction from mine infrastructure (open pits, residue deposits etc.);
- Deterioration to the aquatic ecosystem due to contaminants contained in releases from the mine (indirectly via seepage or via overflow);
- Scouring effect on River banks and bed due to releases from the mine (clean water diversions, storm water drains, road culverts etc.);
- Increased erosion from areas of exposed soils; and
- Increased risk of flooding due to changes in catchment hydrology.

Water quality assessments (Section 3) already present evidence of baseline water quality impacts from current mining activities when compared to the baseline at selected sampling sites (SW9 and SW13) downstream of proposed plant extension.

Considering that the plant expansion infrastructure will be within existing footprints, no new impacts and the majority of the identified impacts will be localised and low to moderate.

6.1.1 Impact Description

The impacts of the anticipated major activities on the surface water resources have been identified for the three main stages of the project namely the construction, operation and closure phases and presented in Table 6-1.

Table 6-1: Summary of Project Activities, Interaction and Potential Impacts to Surface Water Resources

Project Activities	Interaction	Impact description
Construction		
Initial earthworks associated with site clearing, stripping and stockpiling of soil resources, preparations and construction of new surface infrastructure (new waste storage area) as well as transport movement in and out of site with material and workers on site.	Water quality	Deterioration of water quality as a result of the following: • Clearing the surface and site preparations, for the mine infrastructure will result in exposure of soil surfaces to erosion factors. Rainfall events result in the runoff from exposed areas carrying increased sediment. • Uncontrolled spills of contaminants such as fuel and oils, and subsequent washing away of these into the surface water resources. • Loosened soil surface from vehicular movements exposes the soil to erosion factors and potentially washed off with runoff.
	Water quantity	• A reduction of runoff water quantity to the surface water resources system almost negligible as the existing activities already reduced the catchment area for runoff by almost 0.4 % to the A24D quaternary catchment. Proposed infrastructure will be in existing dirty catchments therefore there will be no additional catchment loss.

Project Activities	Interaction	Impact description
		• Water supply will remain the same as water requirements will not change.
Operation		
Development and operation of PPM processing facilities (the hydrometallurgical plant, milling and floatation plant) and other infrastructure (sewage treatment plant, waste storage facilities as well as the community based initiatives as presented in Section 1.1	Water quality	• Deterioration of water quality as a result of contaminated stormwater runoff from operational areas containing potential pollutants such as oils, solvents, paints, spills of operational chemicals, fuels and waste materials and contaminated discharge from the SWD into the catchment when extreme events do occur.
	Water quantity	• Informed by the project description, water supply will remain the same as water requirements will not change and current water allocation from Magalies Water Board is adequate.
Decommissioning and Closure		
Caseation of the mining and the removal and demolition of surface infrastructure and rehabilitation	Water quality	• Removal and handling of hazardous waste offsite and waste storage facilities, damage to waste handling facilities resulting water quality deterioration
Removal of surface infrastructure and rehabilitation	Water quantity	• With adequate rehabilitation and closure some of the catchment is returned to a self-sustaining system and therefore the contributing runoff catchment's return of natural drainage patterns as a result of freely draining topography

6.2 IMPACTS RATING

Based on a review of the project description and activities in previous section the proposed infrastructure will be located within exiting PPM processing infrastructure footprints already serviced by storm water management measures and existing mitigation measures.

The potential unmitigated impacts (unrealistic worst-case scenario), and residual impacts of the project after considering the design mitigation measures proposed within this report are qualitatively assessed in this section and presented in Table 6-2

Table 6-2: Qualitative Impact Assessment

Issue	Description	Severity	Duration	Spatial Scale	Consequence	Probability	Significance
Construction							
Impact on Baseline Surface Water Quality – Unmitigated	Without mitigation deterioration of water quality as a result of the runoff from exposed areas and loosened soil from vehicular movement carrying increased sediment, uncontrolled spills of contaminants such as fuel and oils, and subsequent washing away of these into the surface water resources.	Without mitigation, the project could have a moderate impact on the quality of surface water resources which are already impacted. (M)	Impacts could be long term as operation of the plant will go beyond the life of mine (M)	Water quality impacts will be within the site boundary especially in the rainy season (L)	Medium	Even without mitigation the likely chance of impacting the quality of surface water resources during the normal course of operations is low (L)	Low
Impact on Baseline Surface Water Quality - Mitigated	A stormwater management plan is already in place and covering the proposed infrastructure. It was designed in line with GN704 regulations to ensure that dirty water is conveyed in channels (sized for 1:100 year flows) to plant SWD sized not to discharge or spill into clean water more frequently than once in 50 years. Clean storm water is diverted away from dirty areas.	Considering the mitigation measures discussed within this report, the mine will have a low severity of the impact the quality of surface water resources. (L)	The impacts of the mine will continue for the construction phase (L)	Any impacts would be localised within the holding facilities. (L)	Low	Probability of impacts is unlikely as mitigation measures are designed for extreme events. (L)	Low.

Issue	Description	Severity	Duration	Spatial Scale	Consequence	Probability	Significance
Impact on catchment runoff Unmitigated	Without considering any mitigation measures or water management measures, the collection of stormwater and physical alteration of drainage lines may reduce catchment area for runoff to the non-perennial watercourses on site and water requirements also straining available water resources.	The project area is small compared to the current catchment with existing activities already reduced the catchment area for runoff by almost 0.4 % to the A24D quaternary, there will be no additional catchment loss and water requirements will not change the severity is low. (L)	Impacts could last the project life and beyond until catchment is restored (M)	Impacts could affect only the local catchments as drainage is non perennial (L)	Low	Reduction in catchment runoff flows is likely, especially in the rainy season (L)	Low
Impact on catchment runoff mitigated	The proposed stormwater management measures are already in place and remain in place throughout the project as such; collection of stormwater will continue with the project and may still reduce baseline flows into the water resources systems	The project area is small compared to the catchment and the severity of reduction in runoff flows is low. (L)	Impacts could last the project life and beyond until catchment is restored (M)	Impacts could affect only the local catchment to a small extent (L)	Low	Reduction in catchment runoff flows is likely , especially in the rainy season (L)	Low

Issue	Description	Severity	Duration	Spatial Scale	Consequence	Probability	Significance
Operation and decommissioning							
Impact on Baseline Surface Water Quality – Unmitigated	Without considering stormwater the project could cause deterioration of water quality pollution of water resources through potential spillage, leaching and seepage of chemical contaminants and contaminated discharge of dirty water systems into the catchment when extreme events do occur.	Without mitigation, the project could have a moderate impact on the quality of surface water resources which are already impacted. (M)	Impacts could be long term (M)	Water quality impacts will be within the site boundary especially in the rainy season (M)	Medium	Without mitigation there could be a likely chance of impacting the quality of surface water resources. (M)	Medium
Impact on Baseline Surface Water Quality - Mitigated	A stormwater management plan to ensure that dirty water is conveyed in channels (sized for 1:100 year flows) to plant SWD sized not to discharge or spill into clean water more frequently than once in 50 years. Clean storm water is diverted away from dirty areas.	Considering the mitigation measures discussed within this report, the mine will have a low severity of the impact the quality of surface water resources. (L)	The impacts of the mine will continue for the construction phase (L)	Any impacts would be localised within the holding facilities. (L)	Low	Probability of impacts is unlikely as mitigation measures are designed for extreme events. (L)	Low.

Issue	Description	Severity	Duration	Spatial Scale	Consequence	Probability	Significance
Impact on catchment runoff - Unmitigated	Without considering any mitigation measures or water management measures, the collection of stormwater and physical alteration of drainage lines may reduce catchment area for runoff to the non-perennial watercourses on site and water requirements also straining available water resources.	The project area is small compared to the current catchment with existing activities already reduced the catchment area for runoff by almost 0.4 % to the A24D quaternary, there will be no additional catchment loss water requirements will not change the severity is low. (L)	Impacts could last the project life and beyond until catchment is restored (M)	Impacts could affect only the local catchments as drainage is non perennial (L)	Low	Reduction in catchment runoff flows is likely, especially in the rainy season (L)	Low
Impact on catchment runoff - Mitigated	The proposed stormwater management measures are already in place and remain in place throughout the project as such; collection of stormwater will continue with the project and may still reduce baseline flows into the water resources systems	The project area is small compared to the catchment and the severity of reduction in runoff flows is low. (L)	Impacts could last the project life and beyond until catchment is restored (M)	Impacts could affect only the local catchment to a small extent (L)	Low	Reduction in catchment runoff flows is likely , especially in the rainy season (L)	Low

Issue	Description	Severity	Duration	Spatial Scale	Consequence	Probability	Significance
Closure							
Impacts on water quality - no mitigation	Without considering the waste handling procedures, the caseation of the mining and the removal and demolition of surface infrastructure and rehabilitation could result in potential accidental spillages and damage to waste handling facilities resulting water quality deterioration.	Without mitigation, the project could have a moderate impact on the quality of surface water resources (M)	The low impacts of the mine will be for a short term (L)	Impacts could be downstream beyond the site boundary as several tributaries drain form the site (M).	Medium	Without mitigation there could be a likely chance of impacting the quality of surface water resources (M)	Medium
Impact on Baseline Surface Water Quality - Mitigated	Mitigation measures recommended for the management of accidental spills and the use of accredited removals if implemented will reduce and manage the impacts.	Considering the mitigation measures discussed within this report, the mine will have a low severity of the impact the quality of surface water resources. (L)	Impacts will last for the project life and would be reversible over time (L)	Any impacts would be localised within the holding facilities. (L)	Low	Probability of impacts is unlikely as mitigation measures are designed for extreme events. (L)	Low.
Impact on catchment runoff mitigated	At closure, the objective will be to rehabilitate all remaining facilities to establish a functionality that eliminates or materially reduces the need for dirty water systems	The project area is small compared to the catchment and the severity of reduction in runoff flows is low. (L)	Impacts could last the project life and beyond until catchment is restored (M)	Impacts could affect only the local catchment to a small extent (L)	Low	Reduction in catchment runoff flows is likely , especially in the rainy season (L)	Low

6.3 MITIGATION MEASURES AND MONITORING PLAN

Mitigation by design measures developed to ensure legislative and design standards compliance have been discussed in detail throughout the report, and a summary of these measures and additional mitigation measures recommended to further reduce any residual impacts on both surface water drainage quality and quantity is presented in this section.

The existing stormwater management measures will be used as this project is located within existing footprints. In all phases, infrastructure associated with the proposed project will be constructed, operated and maintained so as to comply with the provisions of the National Water Act (36 of 1998) and Regulation 704 (4 June 1999) or any future amendments thereto. These include the following:

- Separation of clean from dirty water systems;
- Dirty water is contained in systems that allow the reuse and/or recycling of this dirty water.

It is understood that there will be no increased water demand above the mine's allocation due to the proposed project and the reuse of water is prioritised i.e. the treated sewage water must all be used for dust suppression, the Tuschenkomst open pit excess water contained and pumped for reuse in the plant and tailings decant and seepage water reused at the plant.

Vehicles or plant equipment servicing should be undertaken within suitably equipped facilities, either within workshops, or within bunded areas, from which any storm water is conveyed to a pollution control dam, after passing through an oil and silt interceptor.

Any substances which may potentially pollute surface water should are stored within a suitably sized bunded area and where practicable covered by a roof to prevent contact with rainfall and/or runoff. Should an accidental spill occur, a spill of a processing chemical is generally not significant providing that the spill is identified promptly and cleaned up. Without intervention, 'clean' storm water can become contaminated by runoff from dirty plant areas. Reducing the impact of such a discharge is reliant on sound design and good housekeeping measures being maintained throughout the life of the mine

In the construction, operation and decommissioning phases the mine will ensure that all mineralised wastes and non-mineralised wastes are handled in a manner that they do not pollute surface water and managed offsite by accredited contractors.

Effective monitoring is necessary to ensure that any impact is rapidly identified so that it can be addressed.

6.4 CUMMULATIVE IMPACTS

There are a number of existing surface water pollution sources at the mine, particularly in the unmitigated scenario. Surface water may collect contaminants such as hydrocarbons, salts, and metals from numerous sources (PPM Mine and surrounding mines). At elevated concentrations these contaminants can be harmful to humans and livestock if ingested directly and possibly even indirectly through contaminated vegetation, vertebrates and invertebrates (impacts on biodiversity have not included in this study). An increase in activity on site is likely to have a minor contribution to cumulative impacts. The operation of storm water management measures minimises the potential cumulative impacts. Water quality monitoring indicates exceedances of several parameters expected to be due to mining activities. Without mitigation these impacts may render water not suitable for human uses (livestock watering within standards).

Natural drainage across the project sites is via sheet flow and/or non-perennial tributaries. The current MAR impacts as presented in Section 4.4 indicate a disturbed sub-catchment by the plant and TSF footprint is approximately 0.4% of the Quaternary Catchment A24D. There will be no additional disturbed catchment from this proposed project therefore the impacts will not be altered.

6.5 MONITORING

A monitoring programme is an essential tool to identify any risks of potential impacts as they arise and to assist in impact management plans by assessing if mitigation measures are operating effectively. Monitoring should continue throughout the life of the mine.

Ensure that monitoring is implemented to cover all mining activity areas as in the current monitoring plan and analytical suites for water quality analysis (see Appendix A).

Reporting on the above monitoring should continue as per the current WUL.

Accidental spillages and overflows should be reported as and when they occur to the relevant authorities.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

The baseline conditions of the site and surroundings including rainfall, evaporation, depth duration frequency rainfall events, topography, soils types and land cover have been provided.

The available water quality data at selected surface water monitoring sites indicate the impacts the current mining activities already have on the surface water baseline quality. Several parameters exceed the DWS South African Water Quality Guidelines TWQR for agriculture uses and industrial uses, the water use licence requirements and baseline (pre 2009). It is not possible to isolate the contributions from the waste rock dump and the plant in terms of water quality at this site, however, Exigo attributed the water quality impacts to the waste rock dump. Consideration of exceedances from process water dams and surface water monitoring sites indicates minor similarities between these which can be interpreted as that there is minimal cross contamination between process water and surface water resources near the PPM plant extension area. An attempt for like for like (temporal) comparison the various sampling sites, is somehow complicated by the unavailability of consistent water quality information due to the non-perennial nature of streams, which are often dry during some sampling periods. However, a downstream location SW5 located on the Motlhabe River has lower sulfate levels than SW13 associated downstream of waste rock dump and plant. Considering that the watercourses from which the samples were collected are non-perennial the exceedances could be attributed to the washed off contaminants in the first rains of the season or when these are in the dry season, samples could be from stagnant water which would have undergone evaporation, thereby concentrating the elements.

The existing stormwater management measures will be used as this project PPM expansion is located within existing footprints.

A dynamic daily time step model was developed using 66 years of daily rainfall data to understand the impacts of climatic extremes and estimate capacity requirements for the SWD using the GoldSim simulation software. The daily rainfall data was selected from 1914 to 1980. The water use for the SWD sizing was provided by Exigo and considered.

Considering that the minimum abstraction/ pump out for reuse (10th percentile), the annual maximum storm water volumes with a capacity of 45 000 m^3; the SWD spills 30 times in 8 years of the 66 year simulation period. At the average and 75th percentile abstraction rates, the SWD will spill 4 times in the 66 year simulation period, which still does not comply with the GN704 Regulations.

Based on the design parameters discussed above, the current capacity of the SWD pumped for reuse at an abstraction rate that is at least 200m^3/d is adequate with a minimum risk of annual spillage of a 1:50 year chance. At the higher pump out rates, a capacity of approximately 45 000m^3, would be adequate. This excludes the 0.8m freeboard and excludes any permanent water storage below the inlet for the pump.

The current recommended SWD capacity is sufficient for the proposed plant upgrades, only if the withdrawal rate of the SWD is maintained above a 200 m^3/hr rate to avoid spillage. Alternatively the PCD capacity can be adjusted to accommodate even the lowest withdrawal pump rate to a 56 000 m^3 capacity.

It is understood that there will be no increased water demand with the proposed PPM plant expansion project and the reuse of water is prioritised i.e. the treated sewage water must all be used for dust suppression, the Tuschenkomst open pit excess water contained and pumped for reuse in the plant and tailings decant and seepage water reused at the plant.

The disturbed sub-catchment by the plant and TSF footprint is approximately 0.4% of the quaternary catchment. With the plant expansion, it is not anticipated to change as most of infrastructure is in existing areas. The plant site dirty catchment covers an area of 0.47km^2, approximately 16% of catchment MLT-2 and less than 0.1% of Quaternary Catchment A24D.

Potential cumulative impacts that may arise from the PPM plant expansion project could be linked to water quality. Surface water may collect contaminants such as hydrocarbons, salts, and metals from numerous sources (PPM mine and surrounding mines). At elevated concentrations these contaminants can be harmful to humans and livestock if ingested directly. However the operation of storm water management measures would reduce the potential cumulative impacts although some residual ones are evident in the water quality. The current water quality indicates existing contamination from mining activities and the water quality already exceeding the baseline levels.

The current water quality indicates existing contamination from mining activities and the water quality already exceeding the baseline levels. Without mitigation these impacts maybe detrimental rendering water not suitable for other uses (livestock watering within standards).

As long as the proposed plant remains within the serviced and disturbed area and relevant mitigation measures implements, the PPM plant expansion is not anticipated to result in major impacts that the current status.

7.2 RECOMMENDATIONS

The water balance and storm water management plan must be reviewed and updated throughout the life of the mine and operations until determination of closure liabilities for the PPM Mine.

Provided with the water quality results and discussions in the report, it is recommended that an immediate downstream location is established closer to the PPM plant to be able to separate the impacts of the PPM plant and the waste rock dump. Furthermore, a study can be conducted by PPM to trace the actual source of pollutants on site, this may require marker parameters and large water quality dataset if statistical methods are to be utilised.

C Makamure	**Kevin Bursey**	**Kevin Bursey**
(Report Author)	(Project Manager)	(Reviewer)

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APPENDIX A: WATER QUALITY RESULTS

The water quality results obtained from Exigo

[a] Livestock Watering (1996)

[b] Licence No: 03/A24D/ACGU/2037

Site name	Date	HCO_3	Ca	Cl	F	Mg	K	Na	SO_4	NO_3-N	NO_2-N	NH_4-N	NH_3-N	o-PO4 as P	CO_3	pH	EC	TDS	Alka-linity	Total Hard	free - Cl_2	free - CN	Phenol	DO	Acidity
		mg/L $CaCO_3$				mg/L					mg/L N			mg/L	mg/L $CaCO_3$	pH	mS/m	mg/L	mg/L $CaCO_3$			mg/L		%	
SW9	2009-09-23	246	38	288.7	0.34	87.6	8.3	203.0	143.1	0.45	247.00		0.04	<0.025	1.3	7.8	165	918	247	456					
SW9	2009-10-19	203	33	160.1	0.31	67.7	6.9	98.7	118.5	<0.057	<0.005		0.04	<0.025	5.6	8.5	99	610	208	362					
SW9	2010-04-20	52	9	31.9	<0.183	15.0	5.4	21.3	31.8	0.77	0.21		<0.015	<0.025	0.5	8.0	35	147	53	84					
SW9	2010-05-12	92	30	77.7	0.24	21.6	9.0	43.6	60.9	0.41	0.18		0.40	<0.025	1.2	8.2	66	299	93	164					
SW9	2011-05-11	122	22	42.8	0.69	62.0	2.7	52.9	110.1	27.42	1.85		0.04	<0.025	5.8	8.7	84	396	128	309					
SW9	2012-01-30	83	24	83.8	0.22	23.8	9.1	67.6	80.4	0.57				<0.025	3.0	8.6	68	341	87	157					
SW9	2017-02-20	325	25	57.1	0.51	74.6	2.1	61.4	110.0	2.14	0.24	0.091	0.02	<0.005	21.8	8.9	88	572	347	368	0.10	<0.01	<0.02		
SW9	2017-12-05	52	4	2.5	0.47	8.9	2.2	2.2	5.8	0.84	0.09	0.167	<0.005	<0.005	0.2	7.6	10	62	52	46	0.20	<0.01	<0.01		
Baseline (95th Percentile)		63	13	8.7	3.18	7.0	5.9	8.0	157	0.41	N/A	N/A	1.02	N/A	0.10	7.37	15	268	63	60	N/A	N/A	N/A	N/A	N/A
75th Percentile (Baseline)		62	12	7.6	2.57	6.8	5.3	8.0	134	0.37	N/A	N/A	0.70	N/A	0.10	7.25	15	225	62	57	N/A	N/A	N/A	N/A	N/A
Mean Value (Baseline)		54	11	6.5	2.05	5.9	5.0	6.9	78	0.30	N/A	N/A	0.49	N/A	0.07	6.83	14	196	54	53	N/A	N/A	N/A	N/A	N/A
TWQR of DWAF, Volume 5 [a]		N/A	1000	1500	2	500	N/A	2000	1000	100	100	N/A	N/A	N/A	N/A	N/A	150	1000	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WUL Quality Specifications [b]		**N/A**	**20**	**57**	**0.75**	**15**	**N/A**	**16**	**191**	**4**	**4**	**N/A**	**0.007**	**0.125**	**N/A**	**8.8**	**85**	**N/A**	**N/A**	**N/A**	**0.0002**	**0.001**	**0.03**	**7-8**	**N/A**

Site name	Date	Al	As	B	Cd	Cr	Cr(VI)	Co	Cu	Fe	Pb	Mn	Ni
		mg/L											
SW9	2009-09-23	<0.037	<0.01	<0.18	<0.007	0.011	<0.01	<0.003	0.008	0.006	<0.024	0.002	0.012
SW9	2009-10-19	0.006	<0.01	0.030	<0.001	0.107	<0.01	0.014	0.036	<0.006	0.020	<0.001	0.026
SW9	2010-04-20	0.008	<0.01	0.088	<0.001	0.010	<0.01	<0.002	0.026	0.037	0.030	0.006	0.021
SW9	2010-05-12	<0.006	<0.01	0.107	<0.001	<0.002	<0.01	<0.002	0.022	0.022	<0.01	0.004	0.015
SW9	2011-05-11	<0.006	<0.023	0.070	<0.001	<0.002	<0.01	<0.002	0.009	<0.006	<0.01	<0.001	<0.003
SW9	2012-01-30	<0.006					<0.01			<0.006		<0.001	
SW9	2017-02-20	<0.002	<0.006		<0.002	0.067	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002
SW9	2017-12-05	1.620	<0.006		<0.002	0.055	<0.002	<0.003	0.002	3.130	<0.004	0.083	0.008
Baseline (95th Percentile)		13.740	0.690	0.086	0.010	N/A	0.020	N/A	0.050	8.000	0.030	0.100	0.040
75th Percentile (Baseline)		8.700	0.690	0.068	0.010	N/A	0.020	N/A	0.050	8.000	0.030	0.100	0.040
Mean Value (Baseline)		5.445	0.690	0.068	0.010	N/A	0.020	N/A	0.050	8.000	0.030	0.100	0.040
TWQR of DWAF, Volume 5 [a]		5	1.0	5	0.01	N/A	1	1	0.5	10	0.1	10	1
WUL Quality Specifications [b]		**0.005**	**0.01**	**N/A**	**0.00015**	**0.007**	**N/A**	**N/A**	**0.0003**	**N/A**	**0.0002**	**0.180**	**N/A**

Site name	Date	HCO_3	Ca	Cl	F	Mg	K	Na	SO_4	NO_3-N	NO_2-N	NH_4-N	NH_3-N	o-PO4 as P	CO_3	pH	EC	TDS	Alka-linity	Total Hard	free - Cl_2	free - CN	Phenol	DO	Acidity
		mg/L $CaCO_3$				mg/L					mg/L N			mg/L	mg/L $CaCO_3$	pH	mS/m	mg/L	mg/L $CaCO_3$			mg/L		%	
SW13	2017-12-05	79	13	5.9	0.29	29	3.0	14	61	9.20	0.10	0.07	<0.005	0.01	0.4	7.7	29	216	80	151	0.20	<0.01	<0.01		
SW13	2018-03-14	69	8	2.6	0.28	18	1.9	13	35	2.00	0.06	0.07	<0.005	<0.005	0.7	8.1	22	174	70	95					
SW13	2018-04-10	173	71	5.5	1.07	133	4.9	120	632	45.50	0.27	0.10	0.019	0.08	9.6	8.8	146	1196	183	724	<0.1	<0.01	<0.01		
Baseline (95th Percentile)		63	13	8.7	3.18	7.0	5.9	8.0	157	0.41	N/A	N/A	1.02	N/A	0.10	7.37	15	268	63	60	N/A	N/A	N/A	N/A	N/A
75th Percentile (Baseline)		62	12	7.6	2.57	6.8	5.3	8.0	134	0.37	N/A	N/A	0.70	N/A	0.10	7.25	15	225	62	57	N/A	N/A	N/A	N/A	N/A
Mean Value (Baseline)		54	11	6.5	2.05	5.9	5.0	6.9	78	0.30	N/A	N/A	0.49	N/A	0.07	6.83	14	196	54	53	N/A	N/A	N/A	N/A	N/A
TWQR of DWAF, Volume 5 [a]		N/A	1000	1500	2	500	N/A	2000	1000	100	100	N/A	N/A	N/A	N/A	N/A	150	1000	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WUL Quality Specifications [b]		**N/A**	**20**	**57**	**0.75**	**15**	**N/A**	**16**	**191**	**4**	**4**	**N/A**	**0.007**	**0.125**	**N/A**	**8.8**	**85**	**N/A**	**N/A**	**N/A**	**0.0002**	**0.001**	**0.03**	**7-8**	**N/A**

Site name	Date	Al	As	B	Cd	Cr	Cr(VI)	Co	Cu	Fe	Pb	Mn	Ni
		mg/L											
SW13	2017-12-05	0.069	<0.006		<0.002	<0.003	<0.002	<0.003	0.002	<0.004	<0.004	0.002	<0.002
SW13	2018-03-14	0.009			<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.001	<0.002
SW13	2018-04-10	<0.002	<0.006		<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002
Baseline (95th Percentile)		13.740	0.690	0.086	0.010	N/A	0.020	N/A	0.050	8.000	0.030	0.100	0.040
75th Percentile (Baseline)		8.700	0.690	0.068	0.010	N/A	0.020	N/A	0.050	8.000	0.030	0.100	0.040
Mean Value (Baseline)		5.445	0.690	0.068	0.010	N/A	0.020	N/A	0.050	8.000	0.030	0.100	0.040
TWQR of DWAF, Volume 5 [a]		5	1.0	5	0.01	N/A	1	1	0.5	10	0.1	10	1
WUL Quality Specifications [b]		**0.005**	**0.01**	**N/A**	**0.00015**	**0.007**	**N/A**	**N/A**	**0.0003**	**N/A**	**0.0002**	**0.180**	**N/A**

Site name	Date	HCO_3	Ca	Cl	F	Mg	K	Na	SO_4	NO_3-N	NO_2-N	NH_4-N	NH_3-N	o-PO4 as P	CO_3	pH	EC	TDS	Alka-linity	Total Hard	free - Cl_2	free - CN	Phenol	DO	Acidity
		mg/L $CaCO_3$	mg/L							mg/L N				mg/L	mg/L $CaCO_3$	pH	mS/m	mg/L	mg/L $CaCO_3$		mg/L			%	
SW5	2009-01-14	57	10	6.0	2.55	6.5	4.9	7.2	72.0	<0.20			<0.10		0.4	7.9	13	204	57						3.0
SW5	2009-03-19	49	12	<5	0.42	20.0	4.1	2.2	139.0	0.33			0.38		0.1	7.3	10	94	50						1.9
SW5	2011-01-11	74	12	1.6	2.28	8.7	4.3	8.0	4.4	0.13	<0.005		<0.015	0.13	0.7	8.0	17	85	75	67					
SW5	2011-03-17	73	11	2.7	2.14	5.6	3.0	13.9	2.0	0.28	0.11		0.05	0.47	0.5	7.8	15	82	73	50					
SW5	2012-01-31	34	7	<1.408	0.73	4.0	2.5	1.2	0.5	0.53				<0.02	0.2	7.9	10	36	34	33					
SW5	2012-11-14	58	11	<0.423	2.21	9.6	3.8	0.5	<0.04	0.81		0.134		0.04	0.7	8.1	17	63	59	66					
SW5	2012-12-06	56	12	<0.423	3.00	7.9	2.3	1.4	1.5	1.21		0.16		1.13	0.4	7.9	15	64	57	63					
SW5	2014-02-12	62	13	4.6	2.46	9.7	3.6	2.9	3.5	0.40	0.08	0.05	<0.005	<0.008	0.7	8.1	16	116	62	72	0.30	<0.01	<0.02		
SW5	2014-03-18	90	16	6.5	3.06	9.4	4.5	9.6	1.9	0.56	0.08	0.15	0.01	0.02	1.2	8.2	21	154	91	79	0.10	<0.01	0.03		
SW5	2015-01-15	48	9	5.2	2.46	7.0	3.5	6.9	7.7	1.85	0.10	0.06	<0.005	0.04	0.2	7.7	14	92	48	51	0.10	<0.01		68.8	
SW5	2015-02-16	29	5	5.0	0.22	6.0	2.9	1.7	0.4	2.34	0.14	0.05	<0.005	0.07	0.2	7.9	10	70	29	38	0.10	<0.01		39.2	
SW5	2016-02-23	115	19	3.4	3.80	12.0	5.5	19.4	3.9	0.54	0.21	0.82	0.04	0.00	1.0	8.0	27	136	116	95	0.10	<0.01			
SW5	2016-03-15	73	13	2.6	1.96	7.4	4.8	8.1	6.0	0.68	0.16	2.41	0.11	0.46	0.6	8.0	17	116	74	63	0.10	<0.01			
SW5	2016-05-16	109	19	3.6	1.18	16.8	4.4	6.3	7.2	0.98	0.22	0.14	<0.005	0.07	0.7	7.8	23	152	109	115	<0.1	<0.01	0.05		
SW5	2016-10-25	60	11	0.8	2.41	7.5	2.8	3.8	<0.141	1.15	0.20	0.12	<0.005	0.03	0.3	7.7	14	72	60	57	0.10	<0.01	<0.02	83.8	
SW5	2016-11-22	90	13	0.6	4.83	10.6	4.1	5.5	4.9	0.92	0.30	0.18	0.01	<0.005	1.1	8.1	16	108	91	76	<0.1	<0.01	<0.02	96.6	
SW5	2017-02-20	101	49	9.5	2.36	40.3	4.6	52.3	175.0	37.40	0.55	0.13	0.02	<0.005	4.3	8.7	80	580	106	289	0.10	<0.01	<0.02		
SW5	2017-12-05	58	7	3.4	0.80	6.1	2.7	1.0	21.1	0.56	0.09	0.07	<0.005	<0.005	0.1	7.4	10	74	58	43	0.20	<0.01	<0.01		
SW5	2018-03-13	36	6	0.9	0.30	5.6	2.1	1.6	<0.141	0.52	0.05	0.05	<0.005	<0.005	0.3	8.0	8	38	36	37					
SW5	2018-04-10	83	14	2.9	2.99	7.6	4.7	10.1	6.9	0.37	0.04	0.18	0.01	0.08	0.5	7.8	15	110	84	66	<0.1	<0.01	<0.01		
Baseline (95th Percentile)		63	13	8.7	3.18	7.0	5.9	8.0	157	0.41	N/A	N/A	1.02	N/A	0.10	7.37	15	268	63	60	N/A	N/A	N/A	N/A	N/A
75th Percentile (Baseline)		62	12	7.6	2.57	6.8	5.3	8.0	134	0.37	N/A	N/A	0.70	N/A	0.10	7.25	15	225	62	57	N/A	N/A	N/A	N/A	N/A
Mean Value (Baseline)		54	11	6.5	2.05	5.9	5.0	6.9	78	0.30	N/A	N/A	0.49	N/A	0.07	6.83	14	196	54	53	N/A	N/A	N/A	N/A	N/A
TWQR of DWAF, Volume 5 [a]		N/A	1000	1500	2	500	N/A	2000	1000	100	100	N/A	N/A	N/A	N/A	N/A	150	1000	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WUL Quality Specifications [b]		N/A	20	57	0.75	15	N/A	16	191	4	4	N/A	0.007	0.125	N/A	8.8	85	N/A	N/A	N/A	0.0002	0.001	0.03	7-8	N/A

Site name	Date	Al	As	B	Cd	Cr	Cr(VI)	Co	Cu	Fe	Pb	Mn	Ni
		mg/L											
SW5	2009-01-14			<0.07									
SW5	2009-03-19	13.320	0.002	<0.06	<0.01		<0.02		<0.05	20.000	<0.03	0.240	0.100
SW5	2011-01-11	0.066	<0.023	0.023	<0.001	0.012	<0.01	<0.002	0.044	0.060	0.020	0.008	0.016
SW5	2011-03-17	0.347	<0.023	0.088	<0.001	0.007	<0.01	0.002	0.005	0.117	0.010	0.010	<0.003
SW5	2012-01-31	0.060					<0.01			<0.006		<0.001	
SW5	2012-11-14	<0.003					<0.002			<0.003		<0.001	
SW5	2012-12-06	0.747	<0.007		0.001	<0.001	<0.002	<0.001	0.001	0.168	<0.004	<0.001	<0.001
SW5	2014-02-12	<0.003	<0.007		<0.001	<0.001	<0.002	<0.001	<0.001	<0.003	<0.004	<0.001	<0.001
SW5	2014-03-18	0.193	<0.007		<0.001	<0.001	<0.002	<0.001	<0.001	0.015	<0.004	<0.001	<0.001
SW5	2015-01-15	<0.003	<0.007		<0.001	<0.001	<0.002	<0.001	<0.001	<0.003	<0.004	<0.001	<0.001
SW5	2015-02-16	<0.003	<0.007		<0.001	<0.001	<0.002	<0.001	<0.001	<0.003	<0.004	<0.001	<0.001
SW5	2016-02-23	<0.002	<0.01		<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	0.529	<0.002
SW5	2016-03-15	0.811	<0.01		<0.002	<0.003	<0.002	<0.003	<0.002	0.528	<0.004	<0.001	<0.002
SW5	2016-05-16	<0.002	<0.01		<0.002	<0.003	<0.002	<0.003	<0.002	0.218	<0.004	<0.001	<0.002
SW5	2016-10-25	0.646	<0.01		<0.002	<0.003	<0.002	<0.003	<0.002	0.338	<0.004	<0.001	<0.002
SW5	2016-11-22	1.570	<0.01		<0.002	<0.003	<0.002	<0.003	<0.002	0.994	<0.004	<0.001	<0.002
SW5	2017-02-20	<0.002	<0.006		<0.002	0.004	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002
SW5	2017-12-05	4.510	<0.006		<0.002	0.032	<0.002	<0.003	<0.002	4.360	<0.004	0.102	<0.002
SW5	2018-03-13	0.011			<0.002	<0.003	<0.002	<0.003	<0.002	<0.004	<0.004	<0.001	<0.002
SW5	2018-04-10	0.265	<0.006		<0.002	<0.003	<0.002	<0.003	<0.002	0.565	<0.004	0.069	<0.002
Baseline (95th Percentile)		13.740	0.690	0.086	0.010	N/A	0.020	N/A	0.050	8.000	0.030	0.100	0.040
75th Percentile (Baseline)		8.700	0.690	0.068	0.010	N/A	0.020	N/A	0.050	8.000	0.030	0.100	0.040
Mean Value (Baseline)		5.445	0.690	0.068	0.010	N/A	0.020	N/A	0.050	8.000	0.030	0.100	0.040
TWQR of DWAF, Volume 5 [a]		5	1.0	5	0.01	N/A	1	1	0.5	10	0.1	10	1
WUL Quality Specifications [b]		0.005	0.01	N/A	0.00015	0.007	N/A	N/A	0.0003	N/A	0.0002	0.180	N/A

APPENDIX B: SUMMARY OF NEMA REGULATION (2017) APPENDIX 6

NEMA Regs (2014) - Appendix 6	Relevant section in report
Details of the specialist who prepared the report	Section 6 and Appendix C
The expertise of that person to compile a specialist report including a curriculum vitae	Appendix D.
A declaration that the person is independent in a form as may be specified by the competent authority	Appendix D.
An indication of the scope of, and the purpose for which, the report was prepared	Section 1.3
An indication of the quality and age of baseline data used for the specialist report	Section 2.2
A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 3 and Section 6
The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 2
A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used	Numerous methodologies discussed throughout the report
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 considering alternatives	Baseline hydrological conditions are discussed in Section 2
An identification of any areas to be avoided, including buffers	Flood-lines and buffers are discussed in Section 2
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;	Figure 2-3
A description of any assumptions made and any uncertainties or gaps in knowledge;	Limitations and further work are discussed in Sections 4.6 and 5.6.
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Alternatives are discussed within the EMP
Any mitigation measures for inclusion in the EMPr	Section 4, Section 5 and Section 6
Any conditions for inclusion in the environmental authorisation	N/A
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 6.5
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised and	Section 7
Regarding the acceptability of the proposed activity	Section 7
If the opinion is that the proposed activity 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	Various recommendations are made throughout the report, most notably Sections 4, 5 and 6.
A description of any consultation process that was undertaken during the course of carrying out the study	N/A
A summary and copies if any comments that were received during any consultation process	N/A
Any other information requested by the competent authority.	N/A

APPENDIX C: DECLARATION OF INDEPENDENCE

Declaration by the specialist

I, Kevin Bursey, declare that --

- I act as the independent specialist in this application;
- I do not have and will not have any vested interest (either business, financial, personal or other) in the undertaking of the proposed activity, other than remuneration for work performed in terms of the EIA Regulations, 2014;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Waste Act and NEMA, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Waste Act and NEMA, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I am aware that a person is guilty of an offence in terms of Regulation 48 (1) of the EIA Regulations, 2014, if that person provides incorrect or misleading information. A person who is convicted of an offence in terms of subregulation 48(1) (a)-(e) is liable to the penalties as contemplated in section 49B(1) of the National Environmental Management Act, 1998 (Act 107 of 1998).

Signature of the specialist

SLR Consulting (Pty) Ltd

Name of company

12 March 2019

Date

APPENDIX D: SPECIALIST CV

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