TUMELO COAL MINES (PTY) LTD

HYDROLOGICAL IMPACT ASSESSMENT

Ref No.: LWES 873

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EXECUTIVE SUMMARY

Letsolo Water and Environmental Services cc, hereafter referred to as Letsolo, was appointed to update the Hydrological Impact Assessment Report for Tumelo Colliery, owned and operated by Tumelo Coal Mines (Pty) Ltd.

Tumelo Colliery is an existing underground coal mine with an approved Mining Right, Environmental Management Program and Water Use License. It is understood that construction of the operations commenced in 2008 however, Tumelo Colliery was later placed under care and maintenance at the end of February 2014. Activities recently resumed during the first quarter of 2019.

This report outlines the current hydrological characteristics as well as proposed upgrades on the storm water management measures for Tumelo Colliery, where the management of clean and dirty systems were assessed. This report is based on the 3C's of storm water management (Control, Collect and Contain) and intends to achieve the following:

- Storm water is controlled by separating clean and dirty water runoff thus protection of water resources from pollution;
- Collection of contaminated water is made possible by the dirty water management facilities in the mining footprint; and
- Contaminated water is contained in a Pollution Control Dam (PCD). This is achieved by ensuring that the dirty footprint is managed as small as possible.

For this assessment, the principal Act of relevance is National Water Act, Act 36 of 1998 (NWA) which provides for the protection, usage, development, conservation, management and control of the country's water resources in an integrated manner. The Act provides the legal basis, upon which to develop tools and means to give effect to the protection of water resources. The study was conducted in line with the requirements of the NWA as well as the Best Practice Guidelines (BPG) for the Protection of Water Resources and "Regulation 704" as published in Government Gazette, Volume 408, No 20119 of June 1999 (Also known as General Notice 704, 04 June 1999).

The following findings were made:

- There are no significant changes on surface infrastructure that is required to support the amendment of current authorisations;
- The mining area consists of both dirty water catchments and clean water catchment where no mining activities are taking place. Runoff from the clean water catchment can flow freely

back to the environment through a channel in order to minimise the amount of water contained in the PCD;

- Water management facilities like cut-off trenches which are located downstream of the dirty water catchments serve the purpose of ensuring that dirty water is directed towards the PCD;
- A PCD is properly located at the most downstream point. The PCD is designed as a rectangle for ease of conceptualization and is designed with walls of less than 5 m height to comply with the National Water Act (NWA, Act 36 of 1998);
- The existing PCD is designed to hold a 1:100 years, 24-hour storm event. The 1:100 flood volume is 2 925m^3. The dam is designed and constructed to contain 3 200m^3 (excluding freeboard).

GLOSSARY

Catchment: In relation to a watercourse or watercourses or part of a watercourse, means the area from which any rainfall will drain into the watercourse or watercourses or part of a watercourse, through surface flow to a common point or common points.

Clean water: Water that complies with a negotiated standard.

Dirty water: Water that does not comply with a negotiated standard.

Groundwater: Water that occurs in the voids of saturated rock and soil material beneath the ground surface is referred to as groundwater and the body within which the groundwater is found is referred to as an aquifer.

Mitigation: Measures taken to reduce adverse impacts on the environment.

Passive management system: A management system that does not require external energy inputs (such as electrical power) or continuous operator attention for its continued successful operation.

Pollution: Pollution (in relation to a water resource) means the direct or indirect alteration of physical, chemical or biological properties of a water resource so as to make it –

(a) Less fit for any beneficial purpose for which it may reasonably be expected to be used; or

(b) Harmful or potentially harmful.

Rehabilitation: Return of disturbed land to a stable, productive and self-sustaining condition after taking into account beneficial uses of the site and surrounding land.

Residue deposits: Residue deposits include any dump, tailings dams, slimes dams, ash dump, waste rock dump, in-pit deposit and any other heap, pile or accumulation of residue.

Runoff: Surface runoff is defined as the water that finds its way into a surface stream channel without infiltration into the soil and may include overland flow, return flow, interflow and base flow.

Stockpile: includes any heap, pile, slurry pond and accumulation of any substance where such substance is stored as a product or stored for use at any mine or activity.

Seepage: The act or process involving the slow movement of water or another fluid through a porous material like soil, slimes or discard.

Watercourse: Watercourse means –

a) a river or spring;
b) a natural channel in which water flows regularly or intermittently;
c) a wetland, lake or dam into which, or from which, water flows; and
d) any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its beds and banks. (National Water Act, 1998 (Act 36 of 1998)).

Water system: includes any dam, any other form of impoundment, canal, works, pipeline and any other structure or facility constructed for the retention or conveyance of water.

LIST OF ABBREVIATIONS

GNR	General Notice Regulation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MPRDA	Mineral and Petroleum Resources Development Act, 28 of 2002
NEMA	National Environmental Management Act, 107 of 1998
NWA	National Water Act, 36 of 1998
PCD	Pollution Control Dam
SWMP	Storm Water Management Plan

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1. INTRODUCTION

Letsolo Water and Environmental Services cc, hereafter referred to as Letsolo, was appointed to update the Hydrological Impact Assessment Report for Tumelo Coal Mines (Pty) Ltd. Tumelo Colliery is an existing underground coal mine with an approved Mining Right (MP 30/5/1/2/2/10115MR), Environmental Management Program and water use license (License No. 24090831).

Tumelo Colliery was placed under care and maintenance at the end of February 2014. Activities have only recently resumed in the first quarter of 2019.

Tumelo Colliery is accessed via the D2539 just south of the Hendrina Power Station. The access road is approximately 3km in length, tarred and in fair condition. Internal vehicle movement at Tumelo Colliery is via a series of paved and unpaved roads. No additional haul or access roads are associated with the project.

The underground mining activities adopted at Tumelo Colliery have lesser impacts on surface water resources when compared to opencast activities. However, due to the need of support services which are be located on the surface, it is necessary to ensure that reasonable mitigation measures are in place.

1.1. Purpose of this study

The approved environmental authorisations for Tumelo addressed the underground mining (bord-and-pillar) of the reserves associated with the No. 2 Seam. Upon further assessment of the resource, Tumelo now intends to amend the mine plan to include the partial pillar extraction of the No. 2 Seam. (Generally known as “stooping”).

During this phase of minng, coal will be extracted from the existing underground mine, leaving behind an open space known as a stope. This method is used when the rock is sufficiently strong not to collapse into the stope, although in most cases artificial support is also provided.

The intended change of the mining plan constitutes a change in the approved Mine Work Programme and Tumelo therefore must obtain the Minister’s consent in terms of Section 102 of the Mineral and Petroleum Resources Development Act, Act No. 28 of 2002 (MPRDA) prior to effecting the change.

The Hydrological Assessment is required to predict and quantify the potential impacts on surface water resources as well as to recommend reasonable mitigation measures. This assessment is fundamental to the discipline of environmental management and is a requirement of the environmental authorizations. There is a need to understand the future impact of a proposed / current activity and to then determine whether the management measures applied to that activity are appropriate or whether they should be modified.

Hydrological Assessment is done to ensure that:

- Effect is given to the objectives of the NWA.
- The hydrological regime applicable to the project is understood.
- Systems are in place to enable effective management of impacts on the water resources.
- There is consistency and sustainable implementation of water management hierarchy at the proposed facilities that have a potential to impact on the water resource.
- Management measures are proposed from results of the Hydrological impact assessment.

1.2. Background information (Cabanga, 2019)

The Mining Right Area includes various portions of the farm Boschmanskop 154 IS and extends over an area of approximately 462.2117 Ha.

Underground mining of the No. 2 Seam is undertaken using mechanised board-and-pillar methods. The No. 2 seam is accessed via a box-cut decline positioned slightly upslope of the Boschmanskop Dam. Coal is conveyed to the surface where it is crushed and screened on site before being trucked off site.

Overburden from the construction of the existing boxcut has been stockpiled on site for reuse during decommissioning and closure. Tumelo's processing activities are limited to crushing and screening thus no additional mine residue facilities are anticipated.

Product coal will continue to be transported off-site by truck to nearby power stations (local market) and/or the nearby Forzando North Colliery (International market).

Water for domestic and potable purposes is sourced from the onsite borehole as per the approved IWUL, License No.: 24090831. Water is treated on site for consumption purposes.

Process water requirements are limited to that of dust suppression and for use underground by the continuous miners. Water for dust suppression purposes is abstracted directly from the PCD. Water found in the underground workings is pumped to the existing PCD on surface which has a design capacity of 3,200 m^3, excluding freeboard. Once settled the water within the PCD is pumped to the Erikson Dam with a storage capacity of 140 m^3 for use underground.

Sewage from the administrative complex and change houses are managed via a system of septic tanks. From here the water is pumped to a self-contained sewage treatment plant, with a capacity of $10m^3$/day. Treated effluent from the plant is disposed into the PCD for re-use.

Ancillary infrastructure on site includes the administrative complex, change houses, parking area, workshop, stores, weighbridge, wash bay and water reticulation for potable water supply (JoJo tanks). These will continue to be utilised for the life of mine. Diesel storage facilities (1 x $23m^3$ tank) are located at the workshop and are appropriately bunded.

1.3. Date and season of the site investigation

The site visit was conducted in October 2019. The site investigation made allowance for the following:

- Record of the current state of mine operations;
- Identification of areas that may be hydrologically affected by the re-instatement of the mining activity and proposed partial pillar extraction;
- Logging of areas of interest for mapping purposes;
- Identification of nearby streams; and
- Characterisation of tributaries in terms of their perennial or non-perennial nature.

1.4. Site Location

The mining area is located approximately 5.5km south east of Pullens Hope in Mpumalanga Province.

1.4.1. Regional setting

Infrastructure associated with the Tumelo Colliery is situated on Portions 6, 10 and 14 of the farm Boschmanskop 154 IS. The regional setting is illustrated in Figure 1-1 below. Direction and distance from site to the nearest towns are as follows:

- Pullens Hope 5.5km North
- Hendrina 15km South East
- Middelburg 35km North East

1.4.2.Municipal Demarcation

Tumelo is situated in the Steve Tshwete Local Municipality (MP313) which forms part of the greater Nkangala District Municipality, situated in the Mpumalanga Province.

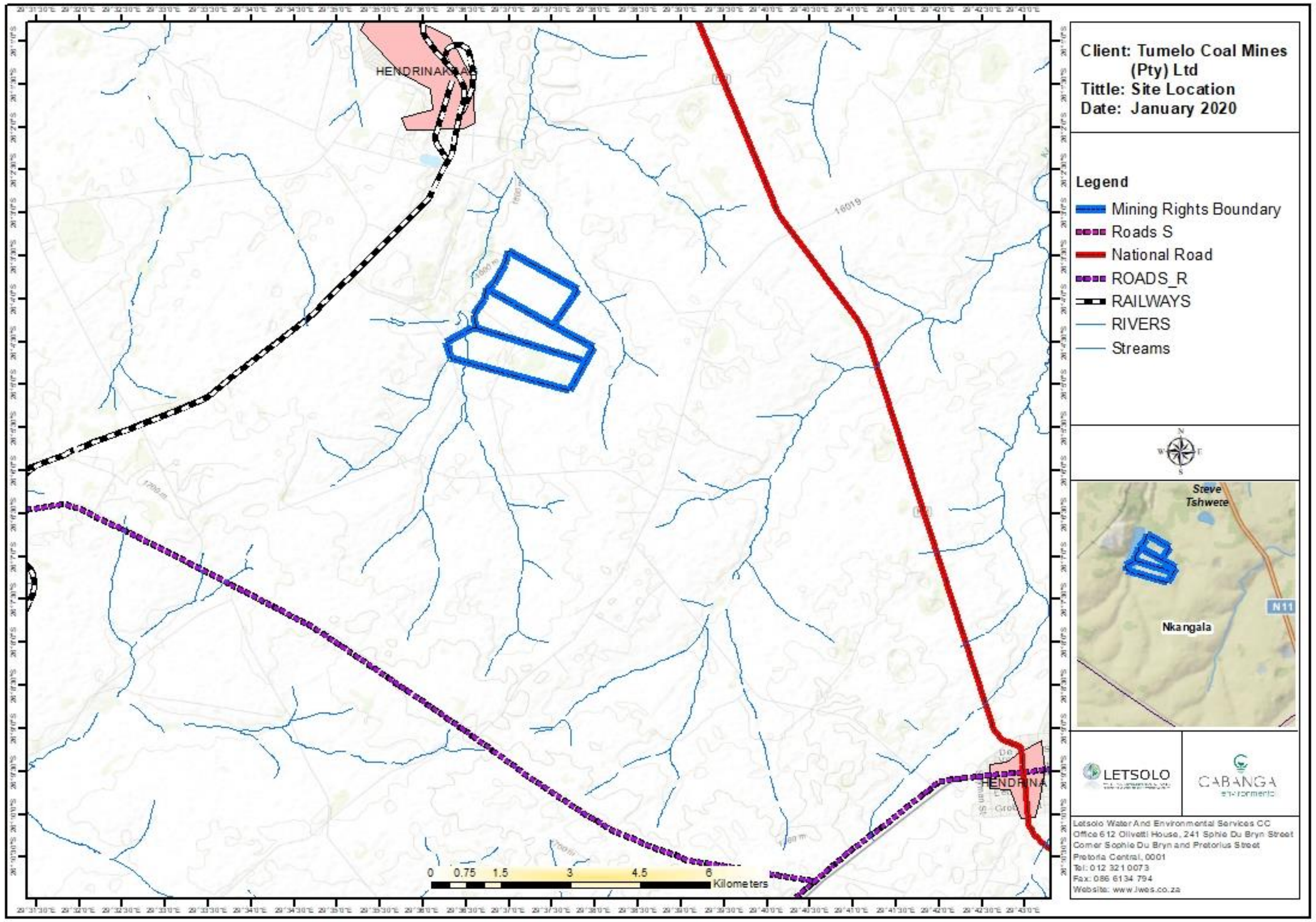


Figure 1-1: Site Location Map

1.5. Specialist Expertise

(a) Details of the specialist who prepared the report;

Details of the specialist who prepared this report are summarised as follows:

Surname	: Phalane
First Names	: Ishmael Letsolo
Specialty	: Hydrology
Entity	: Letsolo Water and Environmental Services
NQF Level 5	: Baccalaureus Technologiae: Civil Engineering
Professional Registration	: Engineering Council of South Africa Reg No. 201480763
	: Water Institute of South Africa
	: Institute of Directors of South Africa

(b) The expertise of the specialist to compile a specialist report including a curriculum vitae can be summarised as follows;

Mr Phalane has more than 16 years' experience in the field of Hydrological Engineering (Hydraulics, Water Quality and Quantity). Over the years Mr Phalane gained valuable experience in the implementation of the National Water Act, 1998 (Act 36 of 1998), National Water Resource Strategy, implementation of the General Authorizations as well as Water Use License Authorizations.

Mr Phalane has extensive experience in Hydrological Impact Assessment for Environmental Impact Assessments (EIA's), Environmental Management Program Reports (EMPR's), Site Management Plans, Water Balance Calculations, Mine Closure Applications and Water Conservation/Demand Management Principles.

Mr Phalane was appointed as a Technical Manager by the Department of Water and Sanitation (DWS) during the Revision of Government Notice 704 (GN704) for the period starting on the 10th of January 2013 and ending on the 31st of December 2013.

Mr Phalane was also part of the technical team assessing the Water Use License Applications on behalf of the Department of Water and Sanitation (Letsema Backlog Project). Specifically, to review Storm Water Management Plans (SWMP), Hydrological Impact Assessment Reports (HIAR), Water Quality Management Reports (WQMR), Integrated Water and Waste

Management Plans (IWWMP) and Section 27 Water Use Motivations. Mr Phalane also compiled the Record of Recommendation to be considered and approved by the Director General (DWS), on behalf of the Regional Director (DWS) (01 April 2013 – 31 March 2014).

Mr Phalane was part of the negotiation team during the transfer of Sand-Vet Government Water Scheme to Sand Vet Water User Association in 2001. In the field of Civil Engineering Mr Phalane gained valuable experience in calculation and analysis of hydrological data and liaison with different organizations in the private, governmental and international sectors, through negotiations with Irrigation Boards. He is practical and has the ability to, logically and strategically, resolve a problem and to work under pressure of a deadline.

As a director, Mr Phalane is involved in strategic decision making in line with the company's vision, mission and values to ensure long term sustainability of the company during the recession time and beyond by being competitive, by developing staff as well as personal development in top management.

1.6. Declaration of Independence:

I, Ishmael Phalane, act as the independent specialist in the environmental authorisation amendment processes for Tumelo Coal Mines (Pty) Ltd. I will perform the work relating to the environmental authorisation applications in an objective manner, even if this results in views and findings that are not favourable to the applicant.

I declare that there are no circumstances that may compromise my objectivity in performing such work. I have expertise in conducting the Hydrological Impact Assessment specialist study and report relevant to the environmental authorisation applications. I confirm that I have knowledge of the relevant environmental Acts, Regulations and Guidelines that have relevance to the proposed activity and my field of expertise and will comply with the requirements therein.

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 particulars furnished by me in this report are true and correct. I realise that a false declaration is an offence in terms of regulation 48 of the National Environmental Management Act, 107 of 1998 (NEMA) and is punishable in terms of section 24F of the Act.

Name of the specialist: Ishmael Phalane

Name of company: Letsolo Water and Environmental Services cc
Date: January 2020

2. LEGAL FRAMEWORK

2.1. National Water Act, Act 36 of 1998 (NWA)

The National Water Act (NWA) provides for the protection, usage, development, conservation, management and control of the country's water resources in an integrated manner. The Act provides the legal basis upon which to develop tools and means to give effect to the said activities.

2.1.1. GN 704 Regulations (GN 704 of 4 June 1999)

GN 704 contains regulations on use of water for mining and related activities aimed at the protection of water resources. The Regulations state that every person in control of a mine or activity must-

- Confine any unpolluted water to a clean water system, away from any dirty area; and
- Collect the water arising within any dirty area, including water seeping from mine operations.

Furthermore, GN 704 emphasizes that:

"4. No person in control of mine or activity may:

a) Locate or place any residue deposit, dam reservoir, together with any associated structure or any other facility within the 1:100 year floodline or within a horizontal distance of 100 meters from watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on waterlogged ground, or on ground likely to become water-logged, undermined, unstable or cracked;
b) Except in relation to a matter contemplated in regulation 10, carry on any underground or opencast mining, prospecting or any other operation or activity under or within 1:50 year floodline or within a horizontal distance of 100 meters from any watercourse or estuary, whichever is the greatest;
c) Place or dispose of any residue or substance which causes or is likely to cause pollution of a water resource, in the workings of any underground or opencast mine excavation, prospecting diggings, pit or any other excavation; or
d) Use any area or locate any sanitary convenience, fuel depots for any substance which causes or is likely to cause pollution of a water resource within the 1:50 year floodline of any watercourse or estuary."

"6. Every person in control of a mine or activity must –

(a) confine any unpolluted water to a clean water system, away from any dirty area;
(b) design, construct, maintain and operate any clean water system at the mine or activity so that it is not likely to spill into any dirty water system more than once in 50 years;
(c) collect the water arising within any dirty area, including water seeping from mining operations, outcrops or any other activity, into a dirty water system;
(d) design, construct, maintain and operate any dirty water system at the mine or activity so that it is not likely to spill into any clean water system more than once in 50 years; and
(e) design, construct, maintain and operate any dam or tailings dam that forms part of a dirty water system to have a minimum freeboard of 0.8 metres above full supply level, unless otherwise specified in terms of Chapter 12 of the Act.
(f) design, construct and maintain all water systems in such a manner as to guarantee the serviceability of such conveyances for flows up to and including those arising as a result of the maximum flood with an average period of recurrence of once in 50 years."

2.1.2. Best Practice Guidelines (BPGs – G1 Storm Water Management)

There are four primary principles that need to be applied in the development and implementation of a Storm Water Management Plan (SWMP).

- Clean water must be kept clean and be routed to a natural watercourse by a system separate from the dirty water system while preventing or minimising the risk of spillage of clean water into dirty water systems. This will limit the reduction in water flow to the receiving water environment/catchment (loss of water to the catchment) and thus increase the water available in the water resource to other users.
- Dirty water must be collected and contained in a system separate from the clean water system and the risk of spillage or seepage into clean water systems must be minimised. The containment of dirty or polluted water will minimize the impact on the surrounding water environment.
- The report must be sustainable over the life cycle of the mine and over different hydrological cycles and must incorporate principles of risk management. Infrastructure, such as those associated with waste management facilities, may have to remain after mine closure since management is required till such time that the impact is considered negligible and the risk no longer exists.
- The statutory requirements of various regulatory agencies and the interests of stakeholders must be considered and incorporated.

3. METHODOLOGY

The following sub-sections provide a description of the methodologies used for:

- Flood calculations;
- Impact Assessment;
- Water Balance.

3.1. Methodology for flood calculations

Flood calculation methods were applied for the sizing clean and dirty water catchments as well as to determine if existing infrastructure can manage to collect, convey and contain contaminated water.

The common Hydrological Method applied was the Rational Method. This method is highly dependent of field observations data. To determine the flood volumes following the rational method the following needs were considered:

- Run-off coefficient;
- Slope;
- Vegetation; and
- Permeability.

The Rational method was selected as the most reliable method for site specific flood calculations, based on the size of the catchment as well as the reliability of input data. The Rational method is based on a simplified representation of the law of conservation of mass. Rainfall intensity is an important input in the calculations; because uniform aerial and time distributions of rainfall must be assumed.

Field observation data were used to calculate the Runoff Coefficient.

The runoff coefficient (c) represents the integrated effects of infiltration, evaporation, retention, flow routing, and interception; all of which affect the time distribution and peak rate of runoff. The runoff coefficient is the variable of the Rational method, least susceptible to precise determination and requires judgment and understanding on the part of the designer. This coefficient differs from site to site as it depends on site conditions, as observed during the site visit. The conditions that have an impact on the runoff coefficient are slope, vegetation cover and permeability.

3.2. Methodology for Impact Rating

An aspect and impact matrix were used to assist in identifying potential interactions between environmental and social receptors and project activities. Where interactions were deemed likely, the interactions were further rated to determine if impacts could potentially be created which should be further investigated during the specialist investigation phase. The matrix made provision for the identification of potential interactions for all phases of the project (either positive or negative).

The identification of potential impacts also made provision for the identification of potential:

- Direct impacts – interactions and impacts which could be caused by an activity or action and occur at the same time and place (e.g. direct footprint of project infrastructure locations);
- Indirect impacts – interactions and impacts caused by an action and occur later in time or farther removed in distance, or which may cause an impact on another environmental or social receptor or component but are still reasonably foreseeable, e.g. soil erosion due to exposure of surfaces is the direct impact and siltation of surface water as a result of the erosion, is the indirect impacts; and
- Cumulative impacts - impact on the environment, which results from the incremental impact of the action when added to other past, present, associated and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Where cumulative impacts can be expected,

To ensure consistency, Similar Impact Rating Definitions were applied for current and future activities.

3.3. Impact Rating Definitions

Likelihood, duration, extent, magnitude, sensitivity and significant ratings should be based on the following scoring scheme:

Table 3-1: Likelihood:

1 = Unlikely	2 = Possible	3 = Likely	4 = Definite Likelihood
Low probability of occurrence with the implementation of management measures	Possible that impact may occur from time to time	Distinct possibility that impacts will occur if not managed and monitored	Impacts will occur even with the implementation of management measures

Table 3-2: Duration:

1 = Short term	2 = Medium Term	3 = Long Term	4 = Permanent
Possible to immediately or within a short period of time mitigate / immediate or fairly quick progress with management implementation <3 yrs	Impacts reversible within the Life of Mine +3 to 5 yrs	Impacts will only cease after the operational life +/- 5 yrs	Long term, beyond mine closure or irreplaceable

Table 3-3: Extent:

1 = Localised	2 = Confined to site	3 = Wider area of Influence	4 = National / International
Localised to specific area of activities	Confined to the site	The extent of the impacts will affect the wider area of Influence	Importance of the impact is of provincial or national importance

Table 3-4: Magnitude:

1 = Low	2 = Minor	3 = Moderate	4 = High
Minor deterioration Nuisance Will not cause any material change to the value or function of the receptor Emissions comply with legal limits Emissions contained within footprint	Moderate deterioration, partial loss of habitat / biodiversity/ social functions or resources, Emissions at times exceed legal limits Emissions reach outside project footprint	Reversible although substantial illness, injury, loss of habitat, loss of resources Notable deterioration of functions Impact on biodiversity Causes a change in the value or function of receptor but does not fundamentally affect its overall viability Emissions regularly exceed legal limits Emissions will affect the wider region	Mainly irreversible Causes a significant change in the environment affecting the viability, value and function of the receptors Substantial impact on biodiversity Death / loss of receptors Emissions do not comply with regulations, Extinction of Red List species

Table 3-5: Sensitivity:

1 = Low	2 = Moderate Low	3 = Moderate	4 = High
Areas already subjected to significant degradation Non-designated or locally designated sites/habitats Non-sensitive receptor with regards to the impact type (e.g. noise receptors) No vulnerable communities	Partially degraded area Sensitive receptors present Small number of vulnerable communities present	Regionally designated sites / habitats Regionally rare or endangered species Moderately sensitive receptor with regard to the impact type Some vulnerable communities present	Nationally or internationally designated sites/habitats Species protected under national or international laws / conventions High sensitivity with regard to the impact type High number of vulnerable communities present High dependency

Table 3-6: Significance

		Likelihood + duration + extent + sensitivity			
		Low (+ / -) ≤4	Minor (+/ -) 5 – 8	Moderate (+ / -) 9 – 12	High (+ / -) 13 – 16
Magnitude	Low (1)	Not significant	Not significant	Minor	Moderate
	Minor (2)	Not significant	Minor	Minor	Moderate
	Moderate (3)	Minor	Moderate	Moderate	High
	High (4)	Moderate	High	High	High

3.4. Methodology for Salt Balance

GCS Water and Environment (Pty) Ltd (GCS) was appointed in January 2018 to undertake a Water and Salt Balance Update study for Tumelo Colliery. No significant changes were noted as the mine had only recently resumed activities. The findings in the GCS report were verified and referred to in this report.

This water balance (WB) calculations were conducted in line with the Best Practice Guidelines, BPG G2. According to the BPG G2, the purpose of the Water Balance includes:

- WB serves as the most important and fundamental tool for water management;
- It provides the information for defining & driving water management strategies;
- Auditing and assessment of the water reticulation system, with the focus on water usage and pollution sources. This includes identifying and quantifying points of high-water consumption or wastage, as well as pollution sources. Seepage and leakage points can also be identified and quantified when the balances are used as an auditing and assessment tool.
- It assists with design of storage systems and management tool for simulation and evaluation of alternative strategies and minimises the risk of spillage.

4. CURRENT INFRASTRUCTURE OVERVIEW

As shown in Figure 4-1 below, the following infrastructure was observed on site:

- Access and haul roads;
- Workshop area including stores, fuel storage and waste management areas;
- Administrative complex including change house and lamproom;
- Sewage package plant;
- Crushing and Screening Plant;
- Weighbridge
- Coal stockpile area (RoM);
- Clean and dirty water diversion drains;
- Pollution control dam (PCD);
- Overburden stockpile;
- Erickson Dam;
- Electricity Substation; and
- Pump station.

Figure 4-1: Overview of current mine infrastructure

5. HYDROLOGICAL ANALYSIS

In order to recommend the corrective storm water management measures, it is important to understand the hydrological characteristics of the study area. The Hydrological analysis is simplified in the paragraph below.

5.1. Water Management Area (WMA2)

The water management areas were revised in line with Government Gazette No. 35517, Regulations 547 of 20 July 2012. The study area falls within Water Management Area 2 (WMA2) - Olifants. The Olifants Water Management Area was previously Water Management Area 4. The WMA2 lies in the north-eastern part of South Africa (*National Water Resources Strategy*, 2013). The Water Management Area hosts five (5) major rivers, namely the Elands, Wilge, Steelpoort, Letaba and Olifants. The mine site falls within the Olifants river catchment.

5.2. Quaternary Catchment B12B

A catchment or water shed is derived from the topographical landscape. It is sectioned by a water divide, a high land separating two or more water systems. A quaternary catchment is the land and water surface area that contributes to the discharge at the system outlet. Tumelo Colliery falls in the Olifants catchment under the B12 tertiary drainage region of the Bronkhorstspruit River, within the B12B quaternary drainage region (Figure 5-1).

5.1. Sensitive Surface Water Resources

The Woestaleenrpruit flows in an easterly direction and discharges into the Boschmaskop Dam which is located north-west of the mine infrastructure area.

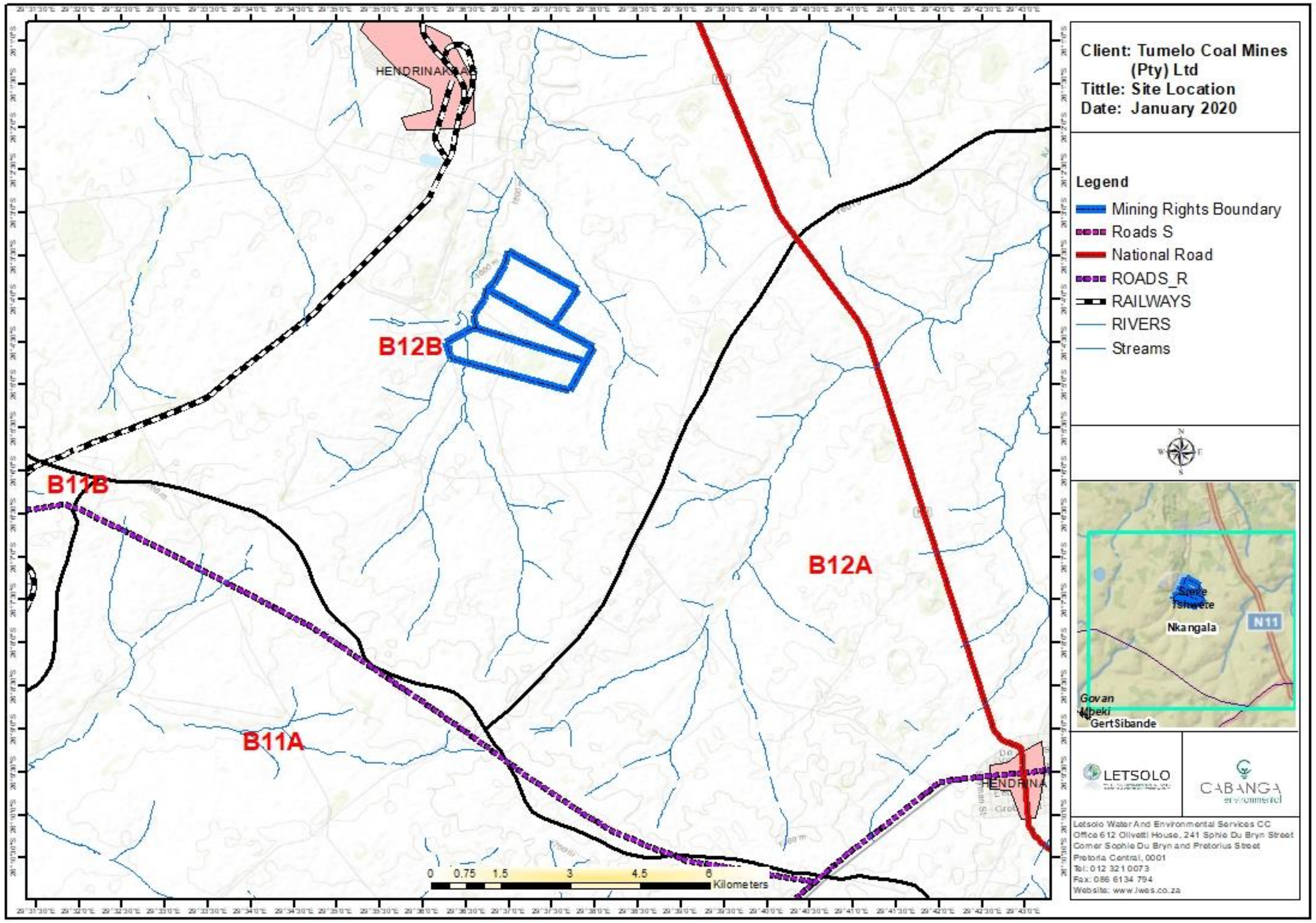


Figure 5-1: Quaternary Catchments

5.2. Rainfall and evaporation

The Department of Water and Sanitation as well as the South African Weather Services were consulted for rainfall and evaporation data. Data used was validated with the Water Research Commission to eliminate uncertainties. The DWS rainfall station used is B1E003 and the SAWB rainfall station used is 0479369 (Hendrina). Data dating back from May 1979 and ending on May 2019 was used. Rainfall and evaporation data from June 2019 onwards was unverified and therefore excluded from this study.

Mean Annual Precipitation (MAP) is representative of the average rainfall that occurs over an area during any given year. The site MAP is estimated at 729 mm.

As in the case of rainfall and runoff it is also necessary to analyze the Mean Annual Evaporation (MAE) based on A-Pan Evaporation Calculation Method. Data for evaporation is measured at dams and mostly stations that are operated by DWS; and these stations provide such data. Gross annual evaporation ‘A’ pan evaporation for the study area is 1,552mm/a.

Table 5-1 below provides details on the Rainfall and Evaporation data for the study area.

Table 5-1: Rainfall (MAP) and Evaporation (MAE) data

Description	Rainfall (mm)	Evaporation (mm)
January	118	170
February	72	129
March	77	137
April	29	109
May	22	95
June	4	71
July	5	76
August	3	112
September	27	124
October	109	178
November	122	176
December	141	175
Annual	**729**	**1552**

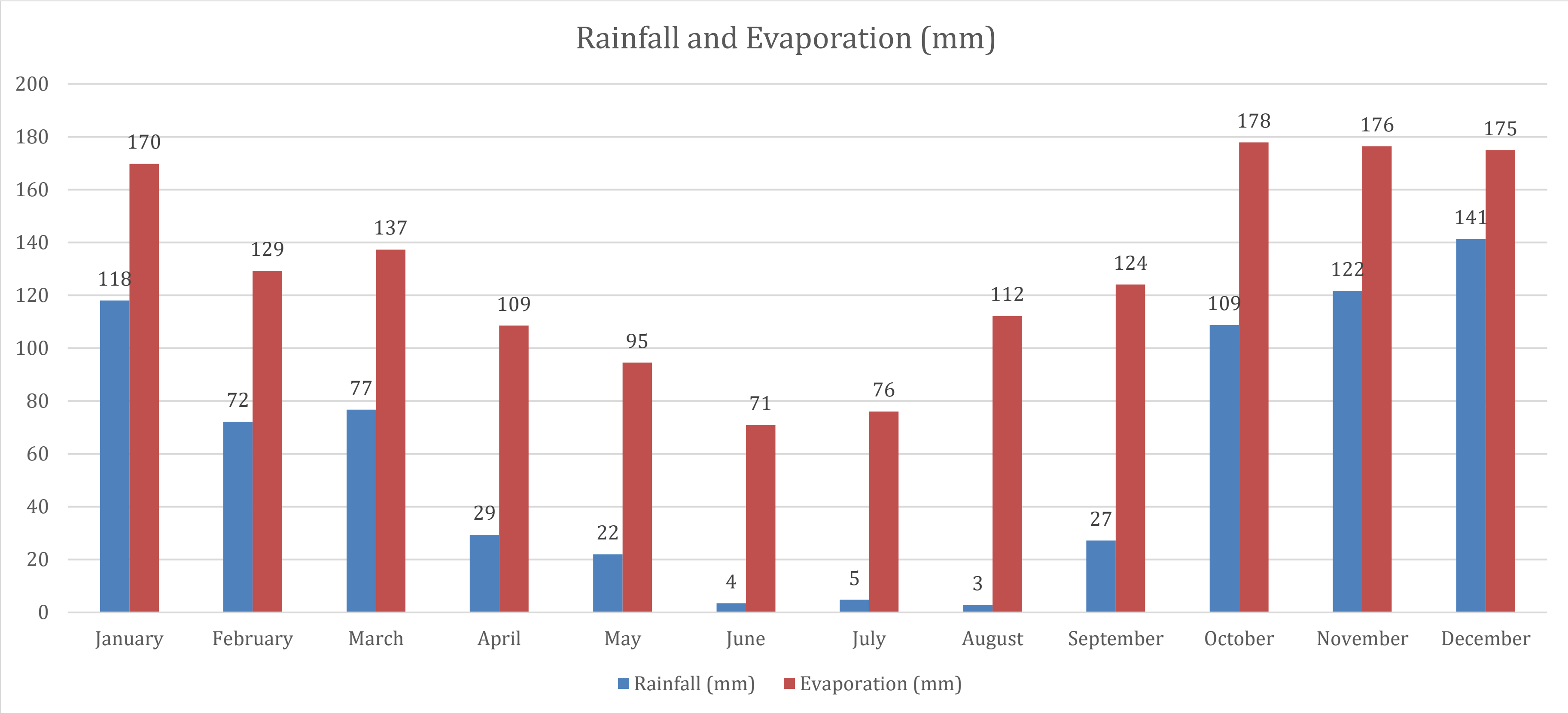


Figure 5-2: Rainfall and Evaporation data

5.3. Catchment Analysis

The present-day surface topography is of typical Highveld grassland with small undulations of hills and valleys. These valleys are mainly responsible for the erosion of the upper seams, and the relative sub outcrop positions of the upper seams are controlled by the present-day topography.

5.3.1. Site Delineated Catchment Areas

An effective catchment area of approximately 44km^2 was delineated for the study area. A catchment is an area of land that is drained by a river and its tributaries. Delineation is based entirely on topographic and river network information. The catchment boundary point on the river network is defined by applying GIS tools to an appropriate digital elevation model.

The process of delineation was conducted using existing digital elevation models (ASTER GDEM) and applicable GIS algorithms.

Site characteristics which influence the hydrological yield when applying the rational method are discussed for each site:

- Area of catchment

This refers to the footprint area for each catchment. This area was measured using the infrastructure layout.

- Length of longest watercourse

Survey data was used to delineate the hydrological path for each proposed area. This path is referred to as the Length of the longest watercourse.

- Average slope

Flat surfaces are associated with low peak flows and steep surfaces are associated with high peak flows. The slope was determined for each area in order to determine the peak flows.

- Mean Annual Runoff (MAR) (m^3/annum)

Water that used to flow to the environment prior to the mining activities being implemented will be managed as dirty water as storm water quality will be altered. This water will be stored in a PCD in order to reduce the potential impact on downstream water quality. The MAR was determined in order to quantify the reduction in hydrological yield and the impact on the receiving streams.

5.4. Hydrological Calculations

After the delineation of catchment areas, flood calculations were conducted based of the hydrological characteristics and flood calculation methods discussed below.

5.4.1.Hydrological calculation methodology

There are different hydrological calculation methods that can be used to calculate flows and drainage in South Africa, the most common being:

- Rational method
- Alternative Rational method
- Unit Hydrograph method
- Standard Design Flood (SDF) method
- Empirical method

5.4.1.1. Flood calculations for estimating the flood volumes at each facility

The runoff coefficient (c) represents the integrated effects of infiltration, evaporation, retention, flow routing, and interception; all of which affect the time distribution and peak rate of runoff. The runoff coefficient is the variable of the Rational method, least susceptible to precise determination and requires judgment and understanding on the part of the designer. This coefficient differs from site to site as it depends on site conditions, as observed during the site visit. The conditions that have an impact on the runoff coefficient are slope, vegetation cover and permeability. The runoff coefficient used for the flood calculations considered land cover onsite. The workshop area is mainly paved and other areas which includes the plant and Run of Mine stockpile had no vegetation cover. The incline shaft had a higher coefficient of 0.6 due to the steep slopes and paved access are. Rational method was used to determine the following:

- *Average slope (m/m):* The average slope has an impact on hydrological yield. Flat terrains yield lower flood volumes when compared with steep terrains.
- *Peak flow (m^3/s):* The peak flows were determined for the sizing of the dirty water collection channels.
- *Flood volume (m^3):* The peak volume was determined for the sizing of the existing PCD and underground sump.

Rational Method details are indicated in Table 5-2 and the summary of calculations in Table 5-3 below.

Table 5-2: Rational Method Flood Calculations

Drainage Area	Recurrence interval	Area (m^2)	Longest water course (km)	Ave slope (m/m)	Tc (hrs)	C - runoff coef.	Point intensity (mm/h)	Peak flow (m^3/s)	Flood vol (m^3)
Clean Catchment 1	2	36 820	0.253	0.04743	0.074	0.4	114.962	**0.94**	378
Clean Catchment 1	5	36 820	0.253	0.047431	0.074	0.4	156.543	**1.28**	515
Clean Catchment 1	10	36 820	0.253	0.047431	0.074	0.4	198.125	**1.62**	652
Clean Catchment 1	20	36 820	0.253	0.047431	0.074	0.4	244.599	**2.00**	805
Clean Catchment 1	50	36 820	0.253	0.047431	0.074	0.4	317.979	**2.60**	1 047
Clean Catchment 1	100	36 820	0.253	0.047431	0.074	0.4	391.358	**3.20**	1 288

Drainage Area	Recurrence interval	Area (m^2)	Longest water course (km)	Ave slope (m/m)	Tc (hrs)	C - runoff coef.	Point intensity (mm/h)	Peak flow (m^3/s)	Flood vol (m^3)
Clean Catchment 2	2	4 887	0.155	0.00860	0.099	0.4	107.718	**0.12**	62
Clean Catchment 2	5	4 887	0.155	0.008602	0.099	0.4	146.680	**0.16**	85
Clean Catchment 2	10	4 887	0.155	0.008602	0.099	0.4	185.642	**0.20**	107
Clean Catchment 2	20	4 887	0.155	0.008602	0.099	0.4	229.187	**0.25**	132
Clean Catchment 2	50	4 887	0.155	0.008602	0.099	0.4	297.943	**0.32**	172
Clean Catchment 2	100	4 887	0.155	0.008602	0.099	0.4	366.699	**0.40**	212

Drainage Area	Recurrence interval	Area (m^2)	Longest water course (km)	Ave slope (m/m)	Tc (hrs)	C - runoff coef.	Point intensity (mm/h)	Peak flow (m^3/s)	Flood vol (m^3)
Overburden Stockpile	2	8 525	0.07	0.20952	0.016	0.2	138.022	**0.13**	11
Overburden Stockpile	5	8 525	0.07	0.209524	0.016	0.2	187.945	**0.18**	15
Overburden Stockpile	10	8 525	0.07	0.209524	0.016	0.2	237.868	**0.23**	19
Overburden Stockpile	20	8 525	0.07	0.209524	0.016	0.2	293.664	**0.28**	23
Overburden Stockpile	50	8 525	0.07	0.209524	0.016	0.2	381.763	**0.36**	31
Overburden Stockpile	100	8 525	0.07	0.209524	0.016	0.2	469.862	**0.45**	38

Drainage Area	Recurrence interval	Area (m^2)	Longest water course (km)	Ave slope (m/m)	Tc (hrs)	C - runoff coef.	Point intensity (mm/h)	Peak flow (m^3/s)	Flood vol (m^3)
Ancillary Area	2	10 960	0.085	0.03137	0.038	0.4	128.295	**0.31**	64
Ancillary Area	5	10 960	0.085	0.031373	0.038	0.4	174.700	**0.43**	87
Ancillary Area	10	10 960	0.085	0.031373	0.038	0.4	221.104	**0.54**	110
Ancillary Area	20	10 960	0.085	0.031373	0.038	0.4	272.968	**0.67**	135
Ancillary Area	50	10 960	0.085	0.031373	0.038	0.4	354.859	**0.86**	176
Ancillary Area	100	10 960	0.085	0.031373	0.038	0.4	436.749	**1.06**	217

Drainage Area	Recurrence interval	Area (m^2)	Longest water course (km)	Ave slope (m/m)	Tc (hrs)	C - runoff coef.	Point intensity (mm/h)	Peak flow (m^3/s)	Flood vol (m^3)

Incline Shaft	2	3 700	0.222	0.18619	0.040	0.6	127.455	**0.16**	34
Incline Shaft	5	3 700	0.222	0.186186	0.040	0.6	173.555	**0.21**	46
Incline Shaft	10	3 700	0.222	0.186186	0.040	0.6	219.656	**0.27**	58
Incline Shaft	20	3 700	0.222	0.186186	0.040	0.6	271.180	**0.33**	72
Incline Shaft	50	3 700	0.222	0.186186	0.040	0.6	352.534	**0.44**	93
Incline Shaft	100	3 700	0.222	0.186186	0.040	0.6	433.888	**0.54**	115

Drainage Area	Recurrence interval	Area (m^2)	Longest water course (km)	Ave slope (m/m)	Tc (hrs)	C - runoff coef.	Point intensity (mm/h)	Peak flow (m^3/s)	Flood vol (m^3)
Plant and ROM	2	8 700	0.1	0.04000	0.039	0.3	127.804	**0.19**	39
Plant and ROM	5	8 700	0.1	0.04	0.039	0.3	174.030	**0.25**	53
Plant and ROM	10	8 700	0.1	0.04	0.039	0.3	220.257	**0.32**	67
Plant and ROM	20	8 700	0.1	0.04	0.039	0.3	271.923	**0.39**	83
Plant and ROM	50	8 700	0.1	0.04	0.039	0.3	353.499	**0.51**	108
Plant and ROM	100	8 700	0.1	0.04	0.039	0.3	435.076	**0.63**	133

Table 5-3: Summary flood (peak flows and flood volume) calculations

Description	1:50 Volume	1:100 volume
Clean Catchment 1	1 047	1 288
Clean Catchment 2	172	212
Overburden Stockpile	31	38
Ancillary Area	176	217
Incline Shaft	93	115
Plant and ROM	108	133
	1 714	2 110

6. STORM WATER MANAGEMENT PHILOSOPHY

Storm water management involves the control of that surface runoff.

6.1. Clean Water Catchment Areas

The management of storm water is important as it limits erosion, therefore ensuring a sustainable solution to water management. Storm water from the external catchment will be diverted around the dirty footprint to allow uncontaminated water to flow back to the natural environment. The principles on which the water management plan is based, and which are implemented in the conceptual design can be summarised as follows:

6.1.1. No water retention from mined out areas

The proposed trenches discourage ponding of water. It is important to minimise water retention on mined out areas by allowing water to be removed from the surface as quickly as possible. This limits infiltration and potential for contamination of groundwater.

6.1.2. Diversion of Storm water runoff from the external catchment

There are existing berms that restrict water flow from the external catchment to enter the disturbed area. Some of the berms were assessed as part of this study.

Field observations are presented in Table 6-1 below:

Table 6-1: Field Observations

 Clean Water Trench Upstream of Security Check-In Point	 Clean Water Channel Upstream of Workshop Area
 Clean Water Channel 1 (See Design Recommendations)	 Clean Water Channel 2 (See design recommendations)

6.1.3.No discharge of contaminated surface water to the environment.

As indicated in Figure 6-1, no discharge activities are anticipated. Water from the clean water catchment is kept away from the dirty water catchment areas.

Figure 6-1: Clean Water Catchments

6.2. Dirty Water Catchment Areas

6.2.1.The containment of contaminated water

Due to the volumes associated with the direct rainfall and runoff from the mine, water that emanates from dirty catchment areas must be managed in such a way that soil erosion is discouraged. Stormwater from the dirty catchments (Figure 6-2) is considered as contaminated and is stored for other potential uses in the pollution control facilities located at the most downstream point of the dirty catchments. Pollution control facilities are lined in order to prohibit potential infiltration of contaminants into the soil profile as well as groundwater sources.

6.2.2 The re-use of contained dirty water

After ensuring efficient collection of water, proper containment is required. This is achieved by the existing PCD to collect dirty runoff from the overburden stockpiles. Water within the PCD is reused for dust suppression and underground mining processes. Water is pumped from the containment facilities through goosenecks into water bowsers for dust suppression; and to the Ericson Dam for use underground.

Figure 6-2: Dirty Water Catchment

7. STORM WATER MANAGEMENT MEASURES

Storm water management and drainage planning are critical components of integrated water and waste management at a mining site. Management thereof should take the catchment into account and place the mine into the context of the catchment.

7.1. Underground Mining Areas

Underground mining methods allows for extraction of deeper deposits of coal. The approved environmental authorisations for Tumelo Colliery addressed the underground mining (bord-and-pillar) of the reserves associated with the No. 2 Seam. Upon further assessment of the resource, Tumelo now intends to amend the mine plan to include the partial pillar extraction of the No. 2 Seam. During this phase of mining, coal will be extracted from the existing underground mine, leaving behind an open space known as a stope. This method is used the rock is sufficiently strong not to collapse into the stope, although in most cases artificial support is also provided.

Underground mining areas are indicated in Figure 7-1 below.

7.1.1.Ponding due to surface subsidence

Subsidence is a time-dependent process, in which there is a lowering of the ground surface in response to the removal of coal. Deformation of the rock mass may be by either elastic, plastic, or brittle processes or by any combination of these processes. Subsurface deformation leading to surface subsidence includes the local lateral and up- ward displacements of rock above unmined areas (near mine boundaries or barrier pillars) caused by the downward movement of overburden into mine cavities. Strains induced by mining and transmitted through intervening strata to the sur- face may be compressive or tensile and may have both horizontal and vertical components.

7.1.2.Impacts of subsidence on surface runoff

Damage from subsidence over underground mines has been a serious problem for many years and will become more widespread as the demand for resources, particularly coal, increases. Water wells may become dry when aquifers are disturbed by rock movements. Surface subsidence may result in reduction of stormwater runoff yield. Affected areas must be regraded to eliminate ponding of water.

Figure 7-1: Underground Mining Areas

7.2. Overburden Stockpile, RoM Stockpile and Plant

The main hydrological impact associated with stockpiles is erosion and the generation of erosion gullies. The stockpiles must be at slope not steeper than 1:3 in order to reduce the velocity of storm water and to prevent the development of erosion gullies. The mine will manage erosion within the mine footprint as follows:

- provide erosion control infrastructure (including drains and energy dissipaters) in all areas of concentrated water discharge, along all linear infrastructure, and in any area within the footprint where erosion has resulted/been accelerated due to mining or related activities;
- construct/modify all erosion control infrastructure/measures to ensure maximum prevention of erosion and sediment runoff;
- inspect all stormwater and erosion control structure on a monthly basis and directly following storm events, and:
- repair any siltation or erosion;
- clean-out the dirty water storage infrastructure to ensure optimum functioning;
- determine the cause/s of clogging, obstruction, siltation or erosion, and address these;
- repair/replace any damaged/ineffective infrastructure.

Coal stockpiles must be placed on impermeable liners (pad). Berms and concrete channels must be located below all polluting activities/components.

Table 7-1: Objectives of the SWMP for stockpile

Project Phase	Objectives and related stormwater management measures
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water quality impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil.
Operational Phase - Stormwater management measures	1. Operation of any infrastructure near surface water bodies must be undertaken in a manner that compliments good engineering/environmental practice. This can be achieved by the construction of vegetated berms. 2. After storm events, the areas must be inspected for damages. Should there be any damage, the mine must

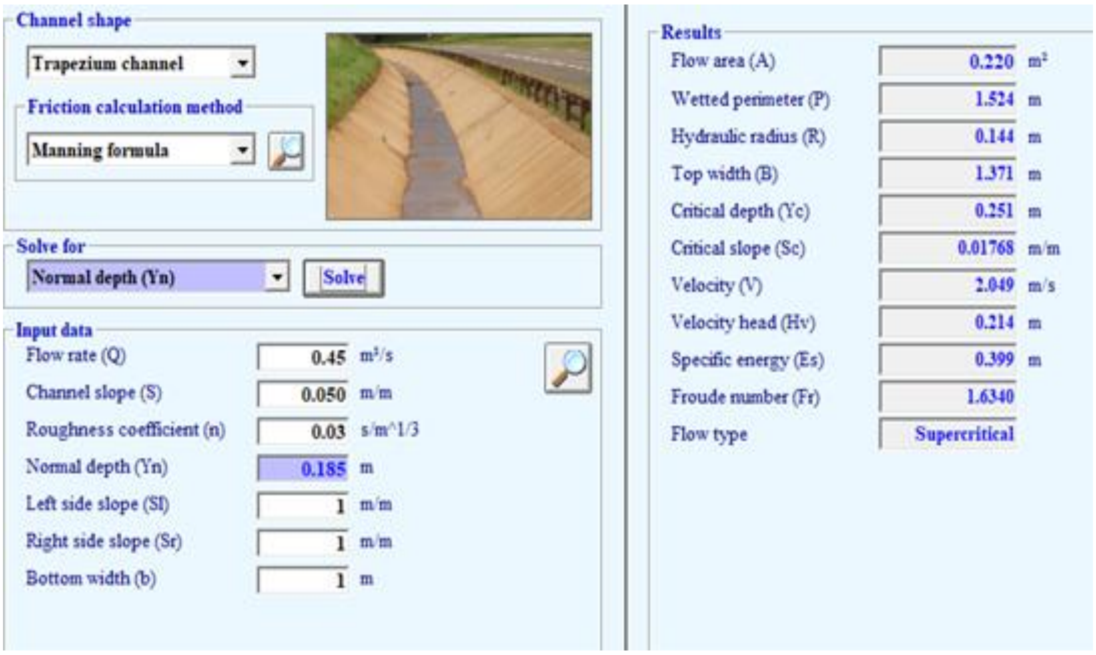
Project Phase	Objectives and related stormwater management measures
	a. Repair damaged areas, b. Clean-out silted up areas, c. Replace perimeter controls, d. Implement area inlet protection, and stabilization methods. e. Repair rills and gullies as needed.
Decommissioning and Closure Phase - Objectives	1. To ensure protection of surface water resources; 2. To maintain as far as possible, the MAR of the Woestalleenspruit; 3. To avoid/minimise adverse surface water quality impacts; 4. To avoid/minimise adverse surface water impacts due to flow interruption; 5. To minimise sediment transport.
Decommissioning and Closure Phase - Stormwater management measures	1. Stockpiles and all infrastructure associated with the project must be removed. 2. Surface water monitoring will continue until a positive environmental trend is established 3. On gentle slopes, water will be encouraged to flow off the rehabilitated surface, as surface flow, as quickly as possible without causing erosion. 4. Periodic checks must be carried out during the wet season and associated flood events to identify areas where erosion is occurring. 5. Appropriate remedial action, including the rehabilitation of the eroded areas, and where necessary, the relocation of the paths causing the erosion, are to be undertaken.

The following channel upgrades are recommended:

7.2.1. Dirty Water Channel 1

Dirty water Channel 1 is recommended downstream of the Overburden Stockpile. The existing channel must be upgraded to a concrete lined channel with the design specifications indicated in Table 7-2. A channel with a bottom width of 1m and a depth of 0.6m will be enough to collect runoff from this area. Based on the flood calculations for the Overburden Stockpile, the channel must be designed to contain a peak flow of 0.45m³/s.

Table 7-2: Proposed Dirty Water Channel 1



Channel shape: Trapezium channel
Friction calculation method: Manning formula
Solve for: Normal depth (Yn) — Solve

Input data

Flow rate (Q)	0.45	m³/s
Channel slope (S)	0.050	m/m
Roughness coefficient (n)	0.03	s/m^1/3
Normal depth (Yn)	0.185	m
Left side slope (Sl)	1	m/m
Right side slope (Sr)	1	m/m
Bottom width (b)	1	m

Results

Flow area (A)	0.220	m²
Wetted perimeter (P)	1.524	m
Hydraulic radius (R)	0.144	m
Top width (B)	1.371	m
Critical depth (Yc)	0.251	m
Critical slope (Sc)	0.01768	m/m
Velocity (V)	2.049	m/s
Velocity head (Hv)	0.214	m
Specific energy (Es)	0.399	m
Froude number (Fr)	1.6340	
Flow type	Supercritical	

7.2.2. Dirty Water Channel Downstream of the ROM Stockpile area

In order to collect runoff from the Plant and ROM Stockpile area, the existing channel must be upgraded to a concrete lined channel with the design specifications indicated in Table 7-3. A channel with a bottom width of 1m and a depth of 0.6m will be enough to collect runoff from this area.

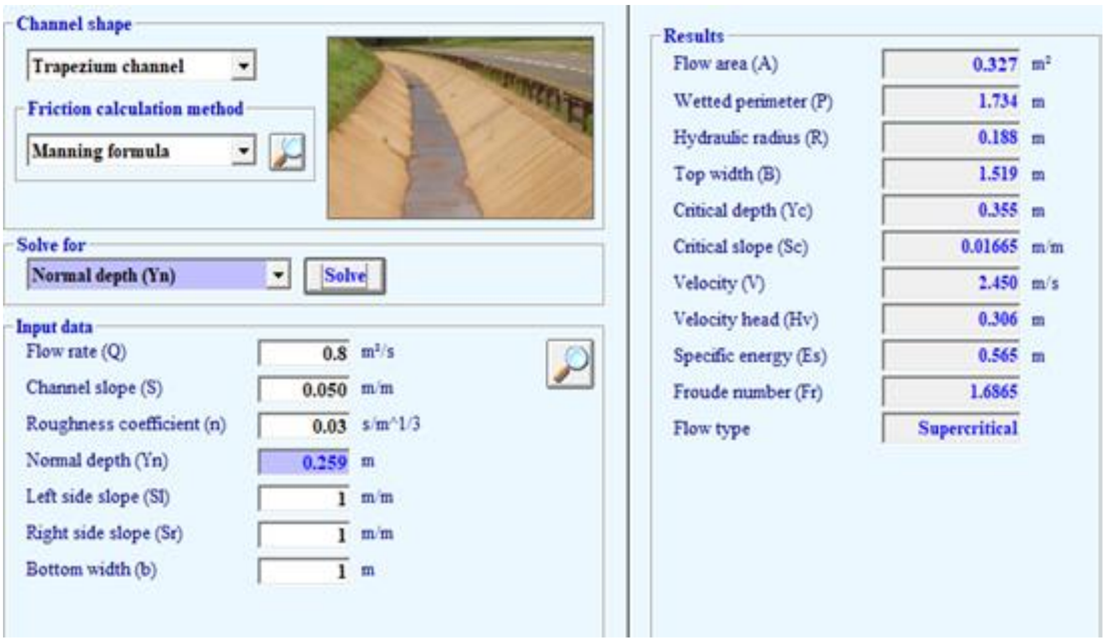
Based on the flood calculations for the Plant and ROM stockpile area, the channel must be designed to contain a peak flow of 0.63m³/s.

Table 7-3: Proposed Dirty Water Channel Downstream of ROM Stockpile

7.2.3.Dirty Water Channel 3

Catchment 3 must be managed as a dirty water catchment. The existing channel is a vegetated berm. This berm must be upgraded to a concrete lined channel with the specifications indicated in table 7-4. A channel with a bottom width of 1m and a depth of 0.6m will be enough to collect runoff from this area. Based on the flood calculations for the stockpile area, the channel must be designed to contain a peak flow of 0.8m^3/s.

Table 7-4: Proposed Dirty Water Channel 3



7.3. Ancillary Infrastructure

Ancillary infrastructure on site includes the administrative complex, change houses, parking area, workshop, stores, weighbridge, wash bay and water reticulation for potable water supply (JoJo tanks). These will continue to be utilised for the life of mine. The main concern from the workshop area is hydrocarbon spillages. The mine will manage the workshop by ensuring that:

- storing and handling all 'dirty' substances on concrete/impermeable liners and/or within bunded areas (110% of storage capacity of tanks), including fuels, lubricants, chemicals and other hazardous substances;
- fencing and security control at areas with chemicals/hazardous substances;
- adopting a zero-runoff policy from all 'dirty' areas; and
- ensuring workshops, stores and material handling facilities are inspected regularly for spillage and waste, and spills are cleaned up immediately and waste materials removed.

Table 7-5: Objectives of the SWMP for Storage facilities

Project Phase	Objectives and related stormwater management measures
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse surface water quality impacts; 2. To avoid/minimise silt transportation due to loosened soil. 3. To review EMS and amend if necessary, to identify any water impacts due to mining activities.
Operational Phase - Stormwater management measures	1. Hydrocarbons to be stored within bunding. A concrete base and a sealed wall of masonry, brickwork, concrete or even prefabricated steel provides the holding capacity. 2. The EMS must be reviewed regularly to ensure rapid and efficient response to and management of hazardous material spills during the operational phase. 3. The EMS must define the procedures for handling hazardous materials / chemicals during the operational phase. The EMS must address the following: a. There must be procedures in place for spill prevention and clean-up; b. Storage of fuels and chemicals; c. Vehicle and plant washing; d. Vehicle and plant repairs.

Project Phase	Objectives and related stormwater management measures
	4. Spill prevention, control and containment measures included into the EMS must be reviewed regularly. 5. All oil/water separators will be maintained in good working order. 6. No washing of project vehicles in any surface water bodies in and around the Project Area. 7. All project vehicles will be washed at designated wash bays on site. Wash bays will include oil/grease and sediment traps. 8. Suitable clean-up of areas where spillage of soil contaminants occurs and appropriate disposal thereof. 9. No *ad hoc* maintenance of vehicles in and around the surface water bodies. 10. All vehicles will be maintained at the designated workshop, which will include an oil/grease trap. 11. Chemicals and fuels will be stored in bunded areas with emergency spill response equipment. 12. The sewage treatment system will be managed in a manner that results in zero discharge of raw sewage to the environment.
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 1. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards.; 2. To ensure protection of surface water resources; 3. To avoid/minimise adverse surface water quality impacts;

Project Phase	Objectives and related stormwater management measures
Decommissioning and Closure Phase - Stormwater management measures	1. Spill prevention, control and containment measures included into the EMS during operational phase will be reviewed to amend decommissioning and closure procedures for rapid and efficient response to and management of hazardous material spills during the decommissioning and closure phase of the project. 2. Surface water monitoring will continue until a positive environmental trend is established.

7.3.1. Dirty Water Channel 2

This channel collects water from Dirty water Channel 1 as well as runoff from the Ancillary area.

This channel must be able to contain runoff from the Workshop area as well as channel 1. The required peak flow for this channel is 1.51m³/s (1.06+0.45).

As seen in Table 7-4 below, a channel with a bottom width of 1.5m and a depth of 0.8m will be enough to collect runoff from this area.

Table 7-6: Proposed Dirty Water Channel 2

Name of project: Tumelo Coal Mine (Pty) Ltd
River/channel name: Proposed Dirty Water Channel 2
Date: 19 July 2009
Description of site: Coal Mine
Designer: IL Phalane

Channel shape: Trapezium channel
Friction calculation method: Manning formula
Solve for: Normal depth (Yn) — Solve

Input data

Flow rate (Q)	1.51	m³/s
Channel slope (S)	0.050	m/m
Roughness coefficient (n)	0.03	s/m^1/3
Normal depth (Yn)	0.300	m
Left side slope (Sl)	1	m/m
Right side slope (Sr)	1	m/m
Bottom width (b)	1.5	m

Results

Flow area (A)	0.540	m²
Wetted perimeter (P)	2.348	m
Hydraulic radius (R)	0.230	m
Top width (B)	2.100	m
Critical depth (Yc)	0.425	m
Critical slope (Sc)	0.01512	m/m
Velocity (V)	2.797	m/s
Velocity head (Hv)	0.399	m
Specific energy (Es)	0.699	m
Froude number (Fr)	1.7613	
Flow type	Supercritical	

7.4. Access road

Tumelo Colliery is accessed via the D2539 just south of the Hendrina Power Station. The access road is approximately 3km in length, tarred and in fair condition. Internal vehicle movement at Tumelo Colliery is via a series of paved and unpaved roads. No additional haul or access roads are associated with the project.

Table 7-7: Objectives of the SWMP for access road

Project Phase	Objectives and related stormwater management measures
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water impacts due to flow interruption; 4. To avoid/minimise silt transportation due to loosened soil.
Operational Phase - Stormwater management measures	1. It is essential to take care of and prevent erosion and sediment transport. To achieve this objective the culvert outlets must be treated with rock gabion mattresses supported by stone pitching or rock riprap, where necessary. 2. Clean run-off will be diverted around the Project Site into the nearest natural drainage path. 3. The diversion channels must be operated to accommodate the 1:50 years flood. 4. The mine's EMS must include spill prevention, control and containment measures. This must be reviewed regularly.
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 1. To ensure decommissioning, demolition and decontamination of building structures, infrastructure and waste storage areas is undertaken in a way that conforms to Best Practice Standards.; 2. To ensure protection of surface water resources; 3. To minimise sediment transport.
Decommissioning and Closure Phase - Stormwater	1. Surface water monitoring will continue until a positive environmental trend is established.

Project Phase	Objectives and related stormwater management measures
management measures	2. Periodic checks must be carried out during the wet season and associated flood events to identify areas where erosion is occurring. Appropriate remedial action, including the rehabilitation of the eroded areas, and where necessary, the relocation of the paths causing the erosion, are to be undertaken.

7.5. Pollution Control Dam

The purpose of the Pollution control dam is to:

- collect the water arising within any dirty area, including water seeping from mining operations, outcrops or any other activity, into a dirty water system.

In order to meet the requirements of Government Notice Number 704, the PCD must comply to the following:

- design, construct, maintain and operate any dirty water system at the mine or activity so that it is not likely to spill into any clean water system more than once in 50 years;
- design, construct, maintain and operate any dam or tailings dam that forms part of a dirty water system to have a minimum freeboard of 0.8 metres above full supply level;
- design, construct and maintain all water systems in such a manner as to guarantee the serviceability of such conveyances for flows up to and including those arising as a result of the maximum flood with an average period of recurrence of once in 50 years;
- construct the stormwater and erosion management infrastructure prior to land clearing to control erosion/runoff during construction, where applicable;
- construct/modify all dirty water containment and management facilities to be separate from clean water systems, and to be adequately sized to contain storm events and not overflow

Table 7-8: Objectives of the SWMP for PCD

Project Phase	Objectives and related stormwater management measures
Operational phase - Objectives	To ensure protection of water resources; 1. To avoid/minimise adverse Mean Annual Runoff impacts; 2. To avoid/minimise adverse surface water quality impacts;
Operational Phase - Stormwater management measures	1. No discharge is anticipated directly from the PCD. 2. The regular maintenance of silt traps must be undertaken to ensure these remain clear of debris, especially after each runoff event. 1. Clean water must be diverted around the mine footprint area. 3. Stormwater control infrastructure is designed to account for the 1:50 year storm event. 4. All vehicles will be maintained at the designated workshop, which will include an oil/grease trap.
Decommissioning and Closure Phase - Objectives	***Objectives and Targets for the Decommissioning and Closure Phase*** 1. To ensure protection of surface water resources; 2. To avoid/minimise adverse surface water quality impacts; 3. To avoid/minimise adverse surface water quantity impacts due to flow interruption;
Decommissioning and Closure Phase - Stormwater management measures	1. All rehabilitation activities must be limited to the already disturbed area. 2. No further removal of vegetation should be allowed. 3. Demolish all concrete structures i.e. dirty water channels and silt traps; 4. Remove any silt that accumulated in the dam in line with the Hazardous waste management strategy for the operation; 5. Remove liners and following waste classification testing dispose appropriately; 6. Profile footprint to be free draining with no low points to accumulate water.

8. WATER BALANCE CALCULATIONS

GCS Water and Environment (Pty) Ltd (GCS) was appointed in January 2018 to undertake a Water and Salt Balance Update study for Tumelo Coal Mine. This data was reviewed and verified. No significant changes were noted as the mine was on care and maintenance. The report may be amended after updating flow meter data.

Water for domestic purposes is currently trucked from Forzando North Colliery. However, it is understood that in future this will be sourced from the onsite borehole and/or the Boschmanskop Dam as per the approved IWUL, License No.: 24090831. Water will be treated on site for consumption purposes.

Process water requirements are limited to that of dust suppression and for use underground by the continuous miners. Water for dust suppression purposes is abstracted directly from the PCD. Water found in the underground workings is pumped to the existing PCD on surface which has a design capacity of 3,200 m^3, excluding freeboard. Once settled the water within the PCD is pumped to the Erikson Dam with a storage capacity of 140 m^3 for use underground.

Sewage from the administrative complex and change houses are managed via a system of septic tanks. From here the water is pumped to a self-contained sewage treatment plant, with a capacity of 10m^3/day. Treated effluent from the plant is disposed into the PCD for re-use.

Technically, the water balance provides information on the type and amount of water entering and leaving the system, along with the estimation of possible consumptive losses. In the case where there are other systems to be involved during the operational phase, the report should be updated to incorporate such developments. As the activities' proceeds there may be a need to involve other circuits to account for all water used.

Figure 8-1 summarises the findings from the GCS report.

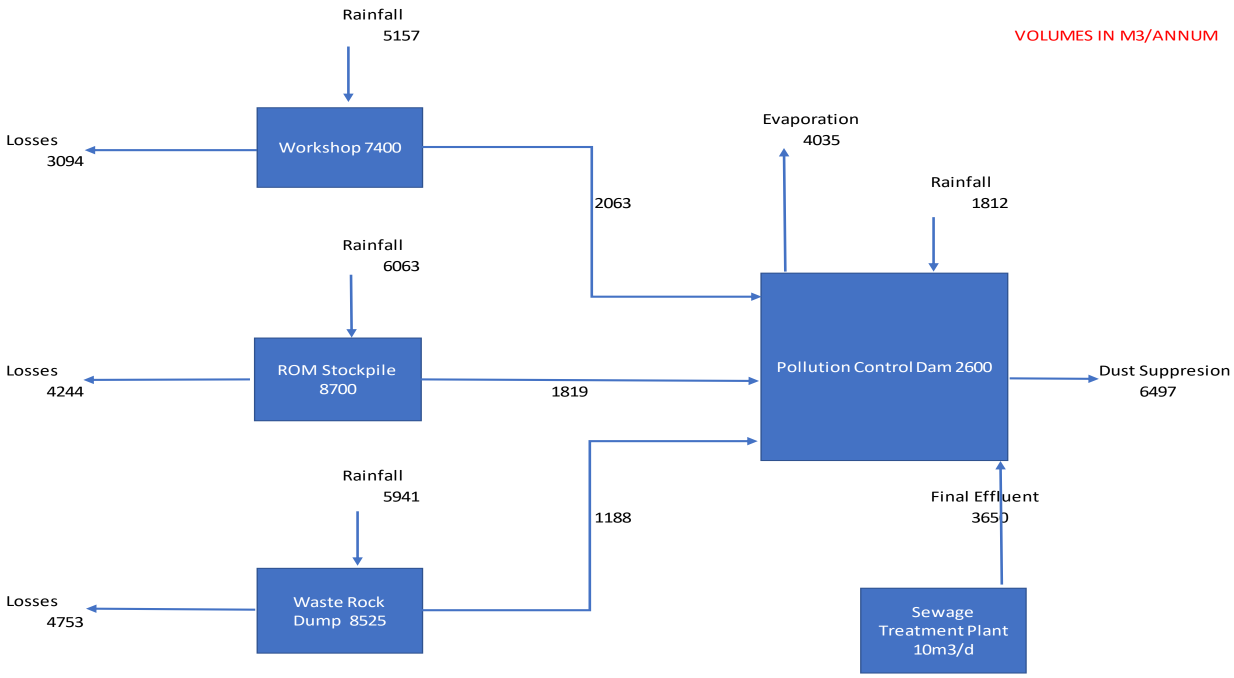


Figure 8-1: Water Balance Sketch

9. POTENTIAL IMPACTS

The following sub-sections contain a description of the activities which resulted or can result in impacts on the hydrological regime specifically related to the activities which have already commenced. This is followed by an assessment of the impacts related to these activities

The identified potential impacts are as follows:

- Deterioration of water quality:
    - Waste streams (e.g. process water, effluent etc.) will be generated during the operational and decommissioning phases. If waste is not properly managed, stormwater which gets in contact with waste will be contaminated.
    - Hazardous waste like grease and oil may impact on surface runoff and quality.

- Change in flow regime:
    - Clean water diversion channels are constructed upstream of the surface infrastructure area in order to separate clean and dirty water. This resulted in the change in flow direction as water will be collected with artificial infrastructure.
    - Increase in Hydrological Yield: Vegetation cover reduces hydrological yield. Vegetation were removed on establishment of surface infrastructure. Due to an increased percentage of bare surfaces, there is a higher potential for hydrological yield.

- Erosion/sediment transport: Vegetation protects the surface by restricting the movement of sediments. Although no erosion gullies were identified during the site visit, should there be upgrade activities which include vegetation removed, soil will be loosened and this will result in a higher potential for sediment transport during storm events.
- Potential failure of dirty water infrastructure and flooding of artificial infrastructure: During the operational phase, the PCD and the dirty water channels must be maintained in line with the requirements of GN 704. Spillages from the dirty water systems may impact negatively on the chemical and microbiological characteristics of the receiving water resources.

These impacts are rated in tables below:

Table 9-1: Deterioration of water quality

Impact Component	**Impact 1**	**Significance prior to Mitigation**	**Significance with Mitigation**
Activity	Operation and maintenance of dirty water infrastructure. Spillages of chemicals and hydrocarbons.		
Risk/ Impact	Deterioration of water quality.		
Project Phase (during which impact will be applicable) CO = construction, OP = operational, CL = Closure and post-closure Nature of Impact	OP, CP Negative		
Type of Impact	Direct: due to the close proximity of the Boschmanskop Dam, pollution incidents may directly result in the deterioration of water quality.		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Likelihood/ probability	Likely	3	2
Duration	Long-term The management of dirty water infrastructure is required from the construction the post closure phase.	3	2
Extent	Area of influence The Woestallenspruit is a significant stream in the catchment. In the event of	3	1

	pollution, pollutants will be easily washed further downstream.		
Receptor Sensitivity	Moderate	3	2
Magnitude	Moderate	3	2
Impact Significance	Moderate	Moderate 12 3	Minor 9 2
Mitigating and Monitoring Requirements			
Required Management Measures	The clean and dirty water flow areas on a mine site were identified and flood volumes quantified. Dirty water channels should be designed and upgraded to collect contaminated water and to dispose it into the PCD. Spills should be cleaned up immediately. Maintenance of all dirty water systems. Regular cleaning of clean water diversion systems. Emergency response measures must be put in place. Dirty water should be prioritised for re-use.		
Required Monitoring (if any)	Monthly surface water quality monitoring.		
Responsibility for implementation	Environmental Officer and Mine Manager		
Impact Finding			
Impact Finding	Impact can be managed through proper design and maintenance of hydraulic structures and through management measures		

Table 9-2: Change in flow regime

Impact Component	**Impact 1**	**Significance prior to Mitigation**	**Significance with Mitigation**

Activity	There is no anticipated change on the existing infrastructure. The current infrastructure was assessed as part of status quo.		
Risk/ Impact	1. Change in flow regime 2. Increase in hydrological yield 3. Change in catchment characteristics		
Project Phase (during which impact will be applicable) CO = construction, OP = operational, CL = Closure and post-closure Nature of Impact	OP Negative		
Type of Impact	Direct: artificial infrastructure like channels and berms, may have a significant impact on the flow regime due to the change in flow direction and velocity.		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Likelihood/ probability	Likely	2	1
Duration	Long-term As part of clean and dirty water separation, Water management infrastructure will be required for the life of mine.	3	2
Extent	Area of influence	2	1
Receptor Sensitivity	Moderate	3	2
Magnitude	Moderate	3	2
Impact Significance	Moderate significance	Moderate 10 3	Minor 8 2

Mitigating and Monitoring Requirements	
Required Management Measures	Dirty water channel should be maintained to optimally collect contaminated water and to dispose it into the PCD.
Required Monitoring (if any)	Water balance must be conducted and amended annually. The outcomes of the study must be used as a management tool as well as a means of investigating the latest technologies for water management.
Responsibility for implementation	Environmental Officer and Mine Manager
Impact Finding	
Impact Finding	Impact can be managed through management programmes.

Table 9-3: Spillages from dirty water infrastructure

Impact Component	**Impact 1**	**Significance prior to Mitigation**	**Significance with Mitigation**
Activity	Maintenance and operation of dirty water infrastructure during and after flood events.		
Risk/ Impact	Spillages from dirty water infrastructure.		
Project Phase (during which impact will be applicable) CO = construction, OP = operational, CL = Closure and post-closure	OP		
Nature of Impact	Negative		
Type of Impact	Direct: Dirty water management measures as discussed in this report must be implemented.		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Likelihood/ probability	Likely	3	2
Duration	Long-term The management of dirty water infrastructure is during all phases of the mine, including the post closure phase.	3	2
Extent	Area of influence: The Boschmanskop Dam is a significant stream in the catchment. In the event of pollution, pollutants will be easily washed further downstream.	3	1

Receptor Sensitivity	Moderate	3	2
Magnitude	Moderate The magnitude will depend on the location of infrastructure components.	3	2
Impact Significance	Moderate significance	Moderate 12 3	Minor 9 2
Mitigating and Monitoring Requirements			
Required Management Measures	The PCD must be operated to have a minimum freeboard of 0.8m above full supply level. All dirty water infrastructure must be regularly maintained. Oil separators and dirty water trenches must be cleaned regularly. SWMP must be adhered to throughout the project.		
Required Monitoring (if any)	Monthly surface water quality monitoring.		
Responsibility for implementation	Environmental Officer and Mine Manager		
Impact Finding			
Impact Finding	Impact can be managed through proper Storm Water Management Measures.		

Table 9-4: Erosion

Impact Component	**Impact 1**	**Significance prior to Mitigation**	**Significance with Mitigation**
Activity	Site is already established. However, the clean water diversion channels and culverts still pose a risk for erosion.		
Risk/ Impact	Culvert outlets can directly impact on sediment transport. Loose particles are erodible. Stockpile areas can contribute to erosion		
Project Phase (during which impact will be applicable) CO = construction, OP = operational, CL = Closure and post-closure Nature of Impact	OP Negative		
Type of Impact	Direct: clearance of vegetation will directly lead to impact		
	Define Significance Categories	Significance Prior to Mitigation	Significance With Mitigation
Likelihood/ probability	Possible	2	1
Duration	Short Term	2	1
Extent	Site	2	1
Receptor Sensitivity	Moderate	3	2
Magnitude	Moderate	3	2
Impact Significance	Moderate	Moderate 9 3	Minor 7 2
Mitigating and Monitoring Requirements			

Required Management Measures	The topography of all disturbed areas must be rehabilitated, in such a manner that it blends with the surrounding natural area. This will reduce soil erosion and improve natural re-vegetation. The necessary flood attenuation and erosion control structures to be put in place at each outlet.
Required Monitoring (if any)	A maintenance schedule for the removal of silt on water management infrastructure must be established.
Responsibility for implementation	Environmental Officer and Mine Manager
Impact Finding	
Impact Finding	Impact can be managed through Erosion Control Measures .

10. FLOODLINES

In order to accurately model the flow in the river the roughness parameters along each cross section had to be defined.

10.1. Roughness parameters

The river was divided into three sections i.e. the left bank, main channel and right bank. The positioning of the main channel was based on the anticipated flow in the river (low flows). The Manning *n* roughness values used WAS 0,035 m/s$^{1/3}$.

Manning equation:

$$Q = \frac{1}{n}\frac{A^{\frac{5}{3}}}{P^{\frac{2}{3}}}S_0^{\frac{1}{2}}$$

Where:

Q	=	flow rate (m^3/s)
n	=	Manning value (s/m$^{1/3}$)
A	=	flow area (m^2)
P	=	wetted perimeter (m)
S_0	=	slope (m/m)

10.2. Froude Number

The Froude number provides information on the flow regime in the river. A Froude number less than 1,0 indicates sub-critical flow which is controlled downstream and a Froude number greater than 1,0 indicates supercritical flow which is controlled upstream. For all return period flood peaks the flow regime was sub-critical (Fr < 1,0))

$$\mathrm{Fr}^2 = \frac{\mathrm{Q}^2\mathrm{B}}{\mathrm{g}\mathrm{A}^3}$$

Where:

Fr	=	Froude number
Q	=	flow rate (m^3/s)
A	=	flow area (m^2)
B	=	width open to atmosphere (m)
g	=	gravitational acceleration (m/s^2)

The public domain and internationally accepted software package HEC-RAS developed by the US Army Corps of Engineers was used to hydraulically model the river system. The system consists of three components i.e. flow data, geometric data and simulation options. These components are described in more detail below.

The following catchments were used for delineating floodlines:

• Area of catchment	= 44.391 km²
• Length of longest watercourse	= 8.619 km
• 1085 height difference	= 65 m
• Average slope	= 0.0101 m/m
• Mean annual daily max rain	= 58 mm
• Days on which thunder was heard	= 20 days
• Basin evaporation index MAE/MAP	= 2.54
• 1:50 years, 24-hour storm event peak flow	= 240.89m³/s
• 1:100 years, 24-hour storm event peak flow	= 307.69 m³/s

10.3. Flood line Output data

The output variables can be defined as follows:

- Crit W.S.: Critical Water Surface Elevation.
- E.G. Slope: Slope for the energy grade line
- Flow Area: Total Area of cross section active flow.
- Froude # Chnl: Froude Number for the main channel.
- Q total: Total flow in cross section
- Top W Chnl: Top Width of the main channel.
- Vel Chnl: Average Velocity of flow in main channel.

Results from the HEC-RAS flood line model are presented in the table below. Each cross section (from 20 (upstream) to 1 (downstream)) is provided with its specific variables. The variables are obtained by calculating the energy loss over each cross section as water moves downstream up to the discharge point.

Please refer to Table 10-1 and Figure 10-1 for more details

Table 10-1: Floodline output table used to plot

River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
		(m3/s)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)
9	1 in 50	240	1611.62	1612.33	0.009506	2.05	100.49	163.39
9	1 in 100	307	1611.62	1612.45	0.00919	2.25	119.68	169.33
8	1 in 50	240	1605.98	1607.07	0.016391	2.91	82.53	146.64
8	1 in 100	307	1605.98	1607.17	0.017038	3.15	97.57	158.6
7	1 in 50	240	1602.18	1604.48	0.008565	3.41	70.38	60.38
7	1 in 100	307	1602.18	1604.93	0.009576	2.69	114.01	151.77
6	1 in 50	240	1606.04	1607.44	0.009398	2.96	81.06	92.12
6	1 in 100	307	1606.04	1607.62	0.009026	3.14	97.84	98.87
5	1 in 50	240	1599.04	1601.13	0.012535	4.07	58.93	51.42
5	1 in 100	307	1599.04	1601.33	0.012517	4.42	69.42	53.46
4	1 in 50	240	1603.4	1605.61	0.008408	3.53	67.93	54.42
4	1 in 100	307	1603.4	1605.86	0.008092	3.74	82.11	58.71
3	1 in 50	240	1591.64	1592.73	0.079054	7.35	32.66	46.94
3	1 in 100	307	1591.64	1592.85	0.080821	7.88	38.95	51.25
2	1 in 50	240	1607.49	1608.84	0.009329	2.91	82.48	95.92
2	1 in 100	307	1607.49	1609	0.009004	3.12	98.42	100.4
1	1 in 50	240	1591.84	1592.59	0.189958	9.46	25.37	48.22
1	1 in 100	307	1591.84	1592.7	0.176053	10.03	30.62	50.36

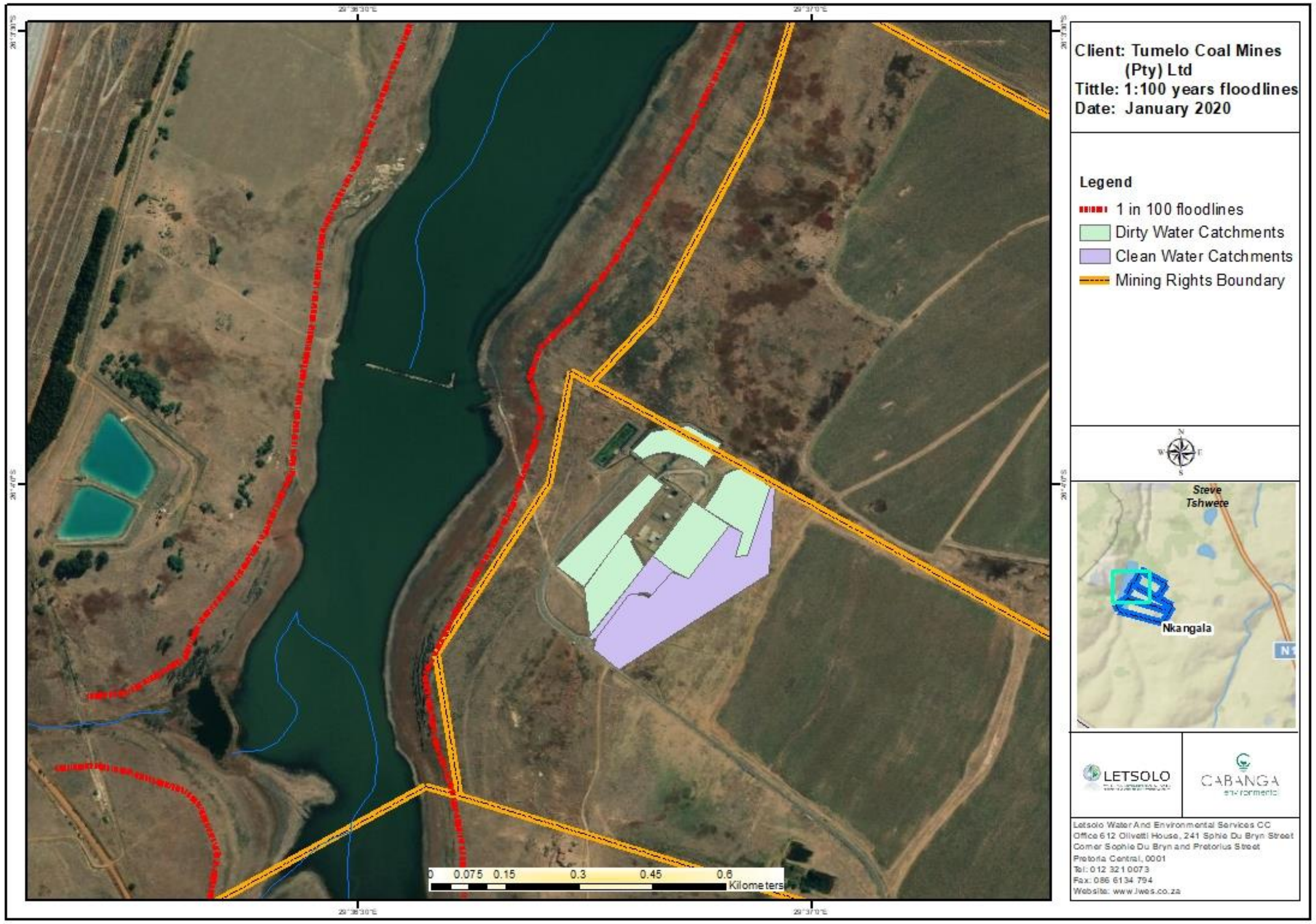


Figure 10-1: 1 in 100 years floodlines

11. CONCLUSION AND RECOMMENDATIONS

The objectives of this study are to address the impact of mining operations on the water flow and water quality processes of the hydrological cycle, and the associated upstream and downstream environmental impacts. The receiving sensitive water resource for this study is the Boschmanskop Dam which is located downstream of the mine.

The intended change in the mine plan, will not result in any changes to the surface infrastructure. It is however recommended that the dirty water channels be upgraded.

The implementation of proposed management measures will have significant effect in decrease of calculated impact on the hydrological environment. On assessment of such major issues as water quality, flow, erosion and dirty water infrastructure, hydrological impact would be reduced on mitigation.

11.1. Conclusion

The conclusions are summarised as follows.

11.1.1. Storm water management principles

The management of storm water is important as it limits erosion and pollution, therefore ensuring a sustainable solution. Some dirty water collection systems are not concrete lined. The peak flows were recommended for the upgrade of these channels to acceptable standards.

11.1.2. The containment of contaminated water

The existing dirty water management system in a form of channels and berms collects contaminated water from dirty water catchments and discharges into a PCD. The existing PCD is designed to hold a 1:100 years, 24-hour storm event. The 1:100 flood volume is 2 925m^3. The dam is designed to contain 3 200m^3 (excluding freeboard).

No dirty water is discharged to the clean environment through any seepage or intended channels directing contaminated water to the clean environment.

11.1.3. The re-use of contained dirty water

Water found in the underground workings is pumped to the existing PCD. Water re-use is limited to that of dust suppression and for use underground by the continuous miners. Water for dust suppression purposes is abstracted directly from the PCD.

11.2. Recommendations

The recommendations are summarised as follows:

11.2.1. Maintenance

All water management facilities must be regularly inspected and monitored to ensure that the facilities can meet the design requirements. The water management facilities must be cleaned and maintained, to ensure that all conveyances can accommodate the 1:50 year flood without overtopping.

11.2.2. General Recommendations

Reasonable measures as recommended in this report must be implemented in order to reduce the impact on surface water resources. In view of the above conclusions, the following recommendations are made:

- Only environmentally friendly materials must be used;
- Vegetation stripping must be limited to the minimum width required;
- The topography of all disturbed areas must be rehabilitated, in such a manner that it blends with the surrounding natural area. This will reduce soil erosion and improve natural re-vegetation;
- The disturbed areas and footprint of the mine's operations must be kept as small as possible.
- During the operational phase, uncontaminated surface water from the site must be allowed to freely flow to the environment.
- The monitoring of both surface and underground resources is vital to indicate potential impacts on natural systems.

12. REFERENCE LIST

Department of Water Affairs and Forestry, 2008. Best Practice Guideline G1: Storm Water Management.

Department of Water Affairs and Forestry, 1999. Government Gazette, Government Notice R704. National Water Act, 1998 (Act No. 36 of 1998): Regulations on use of water for mining and related activities aimed at the protection of water resources

Department of Environmental Affairs, 2013. Government Gazette, Government Notice R634. National Environmental Management: Waste Act (59 of 2008): Waste Classification and Management Regulations. The Government Printing Works: Pretoria.

GCS Water and Environment (Pty) Ltd (GCS), 2018.