Storm Water Management Plan and The Water Balance Report for Phaphama Project

Northern Cape, South Africa

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CLIENT

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Report Name	**Storm Water Management Plan and The Water Balance Report for Phaphama Project**	
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GLOSSARY OF TERMINOLOGY

Berm: A wall designed and constructed to change the direction of a natural surface water flow path.

Catchment: That area from which any surface runoff will naturally drain to a specified point.

Clean water: Natural runoff water from a catchment area that has not been contaminated through contact with known pollutants.

Dirty water: Water that has been, or could potentially become, contaminated through contact with known pollutants.

Dirty water system: Any systems designed to collect, convey, contain, store or dispose of dirty water.

Drainage channel: An artificial flow path designed to convey water.

Hydrology: The study of natural water cycles that include rainfall, evaporation and transpiration and resulting surface flows.

Mean Annual Runoff (MAR): The average amount of water running over the land surface during a given year.

Normal Dry Weather Flow (NDWF): The flow that is critical to the design and operation of wastewater treatment plants which occurs when groundwater is at or near normal with no surface runoff occurring.

WRSM: Water Resources Simulation Model

Pollution Control Dams (PCD): Specialised storage dams designed to prevent environmental pollution by containing and storing dirty water runoff for safe disposal through evaporation or by any other environmentally responsible process.

Process Water Dam (PWD): Specialised storage dams designed to store water for operational and process purposes.

Runoff: Water that falls as rainfall and is not lost through evaporation, transpiration or deep percolation into the ground. This water either does not penetrate soils but flows directly across the soil surface, or re-emerges from local soils to flow on the surface along natural flow paths or watercourses.

Watercourse: Watercourse refers to a river or spring; a natural channel in which water flows regularly or intermittently; a wetland, lake or dam into which, or from which water flows and 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)).

i) Introduction

Mhlaba Hydro and Geotechnical (PTY) LTD (hereafter Mhlaba) has been appointed by Kemu Holdings (Pty) Ltd (hereafter Kemu Holdings) to develop a storm water management plan and the water balance for the proposed Waterkloof iron ore project, "Phaphama" and in support of the environmental authorisations application processes that are being conducted in accordance with the National Water Act (NWA) and the Minerals and Petroleum Resources Development Act (MPRDA). The Waterkloof project area forms part of the Blackridge Project and is located on farm Waterkloof 95 within the Siyancuma Local Municipality in the Pixley ka Seme District Municipality, Northern Cape Province in South Africa (**Figure** Error! No text of specified style in document.**-1**).

a. Project Background

Motjoli Iron Ore Company (Pty) Ltd (Motjoli) acquired the Blackridge prospecting right, NC 30/5/1/2/11434 PR, from Aquila Steel South Africa Pty (Ltd) (Aquila) in 2017. The principal prospecting right (NC 30/5/1/1/2/1023 PR) was renewed and ceded on granting to Motjoli.

The Blackridge prospecting right is located between Griquatown and Groblershoop in South Africa's Northern Cape Province and covers an area of 88 330 hectares. Access is by the Griquatown-Groblershoop main bitumen road and secondary gravel roads south to Prieska and north to Postmasburg. The Blackridge prospecting right is situated approximately 65km south of Kumba Iron Ore's Kolomela Iron Ore Mine.

An iron ore resource was identified by Aquila on farm Waterkloof 95, a property and a component of the Blackridge prospecting right, hence the project has since been referred to as Waterkloof iron ore project, "Waterkloof". Exploration campaigns on Waterkloof saw a completion of 94 reverse circulations drilling which informed a 10.46Mt estimation of the mineral resource. Additional and infill diamond core drilling is envisaged to increase and upgrade the mineral resource status towards and during mine development.

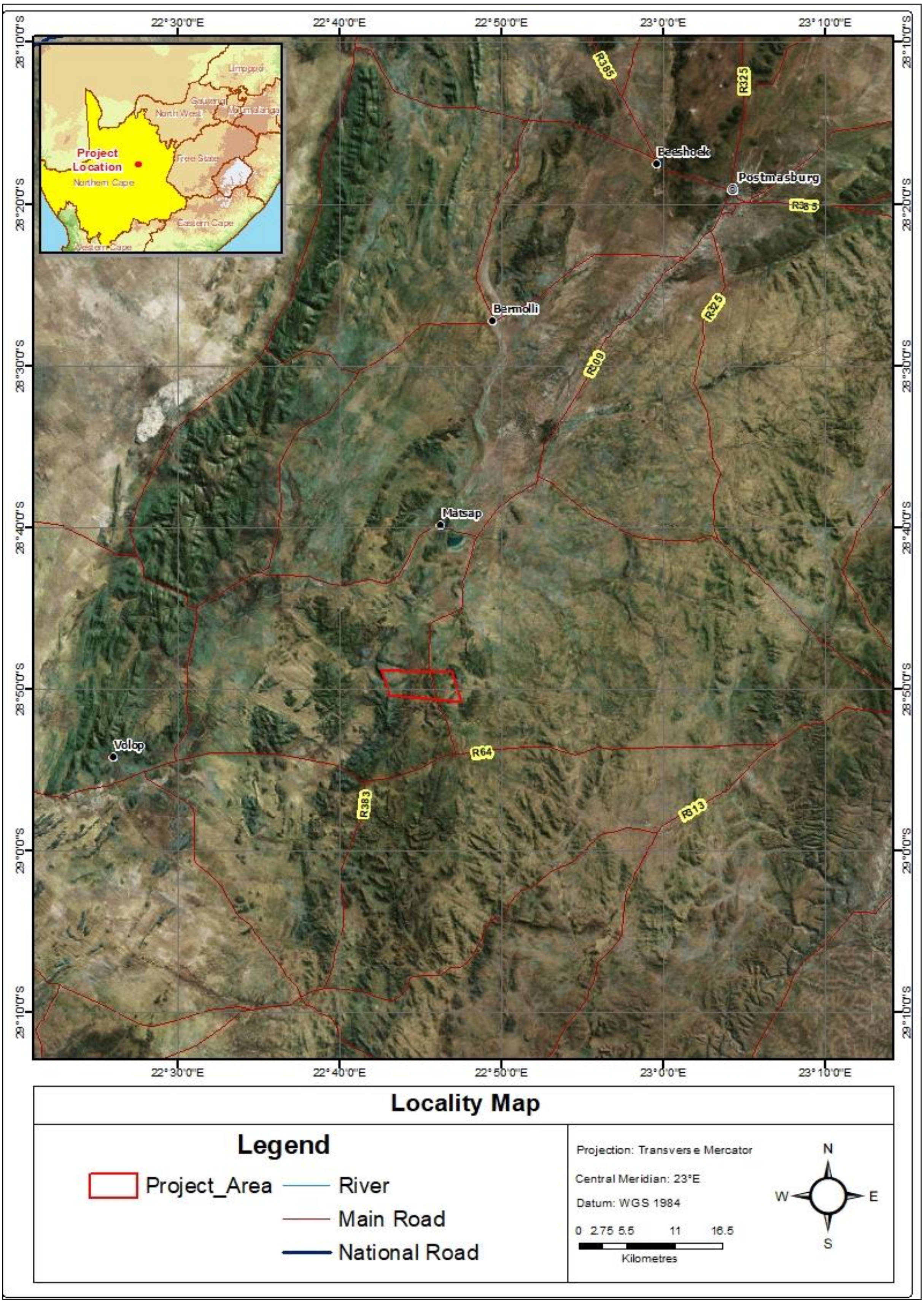

Figure Error! No text of specified style in document.**-1: Locality of the Project Area**

b. Terms of Reference and Objectives of the Study

The scope of work and objectives for the project includes the following:

- To ensure that the water balance and Storm Water management (SWM) measures on site are in line with Best Practice Guidelines (BPG's according to DWA, 2008) and comply with conditions in the National Water Act of 1998 (DWA);
- To provide proposed measures to ensure the separation of clean and dirty water on site;
- Conceptually placement of the proposed clean and dirty storm water management infrastructure; and
- To develop a water balance to enable quantify the amount of water which would potentially enter the mine system (through precipitation, groundwater flows and reticulated supply) as well as the amount which will potentially leave the system (through consumption, evaporation, surface outflows, loss in sewage effluent, product water loss and groundwater seepage).

c. Assumptions and Limitations

The following defines the assumptions and limitations applicable to this assessment:

Only the preliminary infrastructure layout has been developed for the Waterkloof project, therefore conceptual placement of the storm water management infrastructures will be finalised once the infrastructure layout has been finalised;

Storm water management plan was only developed for the provided infrastructure layout, any additional structures should apply the same storm water management principles as recommended in this report

The water balance was also developed based preliminary infrastructure layout and may need to be updated once the infrastructure layout has been finalised.

ii) Hydrological Baseline Environment

a. Site Location and Hydrological Setting

The project area is in the quaternary catchment D73B which is located at the Orange Water Management Area (WMA 06) as revised in the 2012 water management area boundary descriptions (government gazette No. 35517), this is shown in **Figure** Error! No text of specified style in document.**-2**. The surface water attributes of the affected quaternary catchment namely Mean Annual Precipitation (MAP), Mean Annual Runoff (MAR), and Mean Annual Evaporation (MAE) were obtained from the Water Resources of South Africa 2012 Study (WR2012) and are summarised in **Table** Error! No text of specified style in document.**-1**

Table Error! No text of specified style in document.**-1: Summary of the surface water attributes of the D73B quaternary catchment**

Catchment	Area (km^2)	MAP (mm)	MAR m^3* 10^6	MAE (mm)
D73B	1020	258	4.10	2450

Water Resources of South Africa 2012 Study

The D73B quaternary catchment has a net area of 1020 km^2 which receives an average of 258 mm of rainfall per annum whilst the potential evaporation is an average of 2450 mm per annum. The study also indicates that there is approximately 4.10 million m^3 runoff on average per year.

The only perennial river associated with this quaternary catchment is the Soutloop which is situated at approximately 17 km west of the proposed project area. Few unnamed non-perennial streams or drainage lines exist within the site and feeds into the Soutloop. Runoff emanating from this quaternary catchment drains in a south-westerly direction via the – non-perennial streams and Soutloop until it eventually drains into the Orange River.

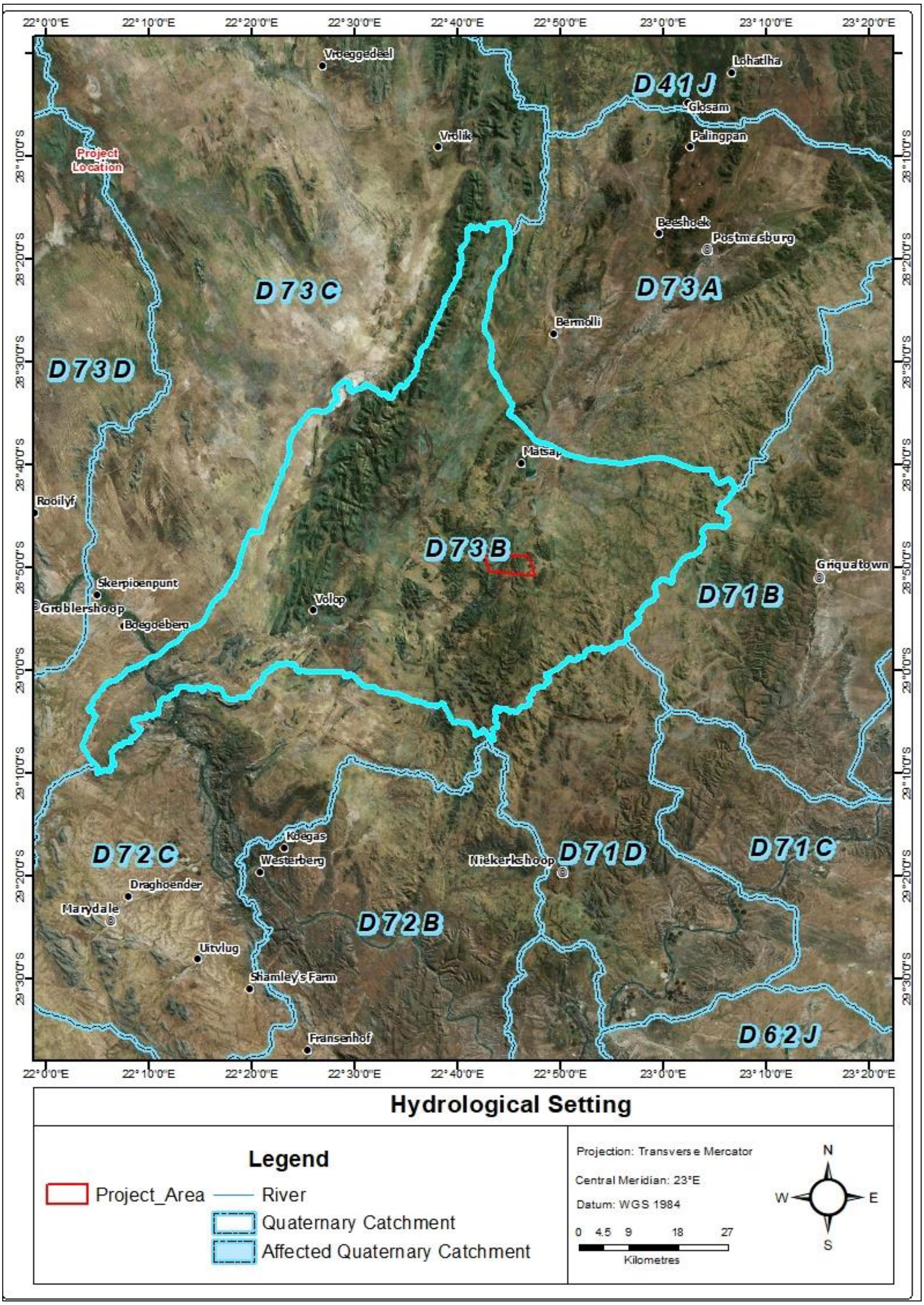

Figure Error! No text of specified style in document.**-2: Hydrological Setting**

b. Climate

The Northern Cape's weather is typical of desert and semi desert areas. This is a large dry region with fluctuating temperatures and varying topographies, high summer temperatures cause atmospheric instability and turbulence, which regularly lead to the development of thunderstorms. The temperature in the area varies between -9ºC and 42ºC, with an annual average of 19.2ºC. This section provides the climatic data conditions (rainfall and evaporation) of the rainfall and evaporation zones in which the project area is located.

- ***Rainfall and Evaporation***

The climate data used in this study was obtained from the Water Resources of South Africa, 2012 Study (WR2012), and Water Research Commission Report. Table Error! No text of specified style in document.**-2** present the average monthly rainfall and evaporation for the quaternary catchment D73B. The mean annual evaporation of 2450 is based on Symons Pan evaporation measurements and needs to be converted to lake evaporation. This is due to the Symons Pan being located below the ground surface and painted black which results in the temperature in the water being higher than that of a natural open water body. The Symons Pan figure is then multiplied by a lake evaporation factor to obtain the adopted lake evaporation figure which presents the monthly evaporation rates of a natural open water body, this was calculated to be a total average of 2060 mm/a. The monthly rainfall and evaporation rates are also shown in

Table Error! No text of specified style in document.**-2: Summary of rainfall data extracted from the WR2012**

Month	Rainfall (mm)	Evaporation (mm)
January	39	280
February	45	225
March	49	194
April	27	136
May	13	97
June	5	72
July	3	81
August	5	108
September	6	149
October	16	200
November	22	239
December	30	279
Mean Annual	**258**	**2060**

Data from 1920 - 2009

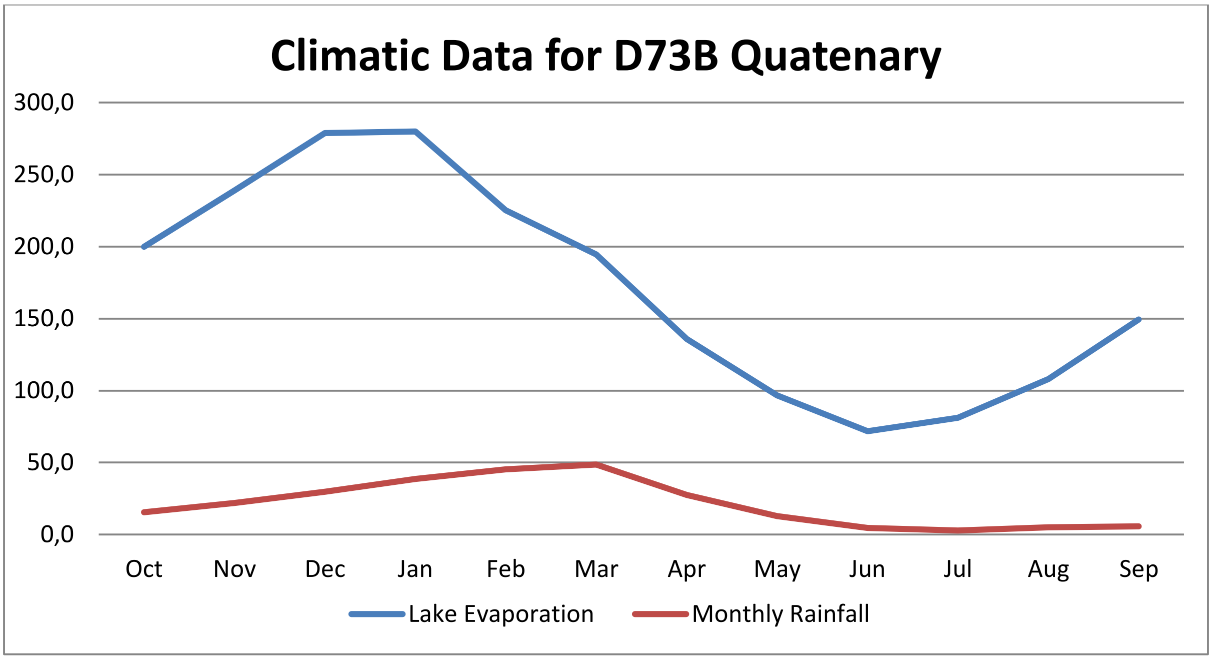

Figure Error! No text of specified style in document.**-3: Average monthly rainfall and evaporation rates**

From the rainfall and evaporation data above, higher rainfall values (39 mm, 45 mm and 49 mm) were recorded for the months of January, February and March respectively whilst the minimum rainfall was recorded in August (1.6 mm). In general, this area receives minimal rainfall over a year which amounts to an average of 258 mm/annum. Higher evaporation rates are experienced during the months of November, December, and January whilst the lowest evaporation occurs in June. The potential average annual evaporation rate of 2060 mm is higher than the average annual precipitation rate of 258 mm, which classify this area as a semi-arid area.

c. Storm Rainfall Depths

The closest weather stations to the Project area are presented in **Table** Error! No text of specified style in document.**-3**. The data was used to estimate the 24 hour design rainfall depth (**Table** Error! No text of specified style in document.**-4**) using the Design Rainfall Estimation (DRE) method in South Africa (Smithers and Schulze, 2003).

Table Error! No text of specified style in document.**-3: Summary of the Closest Rainfall Stations**

Station Name	SAWS Number	Distance from Project Centre (km)	Record Length (years)	Lat (°) (')	Long (°) (')	MAP (mm)	Altitude (m)
RANGE	0286497_W	7.6	37	28° 46'	22° 48'	292	1143
BRECKENRIDGE	0286170_W	16.3	27	28° 50'	22° 36'	258	1097

WESTFIELD	0286300_W	21.7	28	29° 0'	22° 40'	285	1219
GOUP	0254572_W	23.4	55	29° 1'	22° 50'	294	1278
NIETENA	0287138_W	34.4	48	28° 47'	23° 4'	337	1331
WITWATER	0254871_W	34.6	37	29° 1'	23° 0'	274	1387

Table Error! No text of specified style in document.**-4** presents the estimated rainfall depth for a 24 hour rainfall event for various return periods using the Design Rainfall Estimation (DRE) in South Africa (Smithers and Schulze, 2003) for the stations mentioned in **Table** Error! No text of specified style in document.**-3** above.

Table Error! No text of specified style in document.**-4: Estimated 24 Hour Design Rainfall Depth**

Design rainfall return period (yrs)	1:2	1:5	1:10	1:20	1:50	1:100	1:200
24 Hr design peak rainfall (mm)	50.5	71.5	86.3	101.2	121.5	137.6	154.4

iii) Storm Water Management

a. Principles of Storm Water Management & Legislative Background

A conceptual Storm Water Management Plan (SWMP) provides guidelines for ensuring that flood and rainfall events in general do not result in adverse effects on neighbouring water courses and catchments, do not affect surrounding land, or result in loss of life. A conceptual SWMP must address the issues arising from the interaction between mining activities and the hydrological cycle and the impacts that these natural processes and human activities have on each other.

Therefore, a conceptual SWMP must:

- Take into account aspects such as water quality and quantity within a hydrological cycle;
- The associated upstream and downstream environmental impacts;
- The impacts on mining operations due to both floods and droughts; and
- Should follow a precautionary approach being proactive rather than reactive.

Good storm water management is based on separating clean and dirty water and therefore incorporates the fundamental principle of pollution prevention. The following four primary principles have been applied in developing the conceptual SWMP at the site:

To keep clean water clean and to keep clean and dirty water systems separated (ensure that clean water is returned to the catchment);

To contain any dirty water within a separate system and minimize the risk of spilling into any clean water system;

Sustainability - to maintain the prevention of contamination of clean water throughout the life cycle of the mine and over hydrological cycles (even after mine closure until such time that the risk of pollution of the environment has been minimized; and

Respect and incorporate the interest of all stakeholders in the catchment into the updated conceptual SWMP.

The environmental rights of the people of South Africa are specified in Section 24 of the Constitution. This guarantees everyone the right to an environment that is not harmful to her/his health or well-being, and for the environment to be protected for the benefit of present and future generations. This is to be achieved through reasonable legislation and other measures.

The National Water Act (NWA) emphasizes the effective management of South Africa's water resources through the basic principles of Integrated Water Resources Management (IWRM). Both the NWA and IWRM seek to achieve social equity, economic efficiency and ecosystem sustainability, which are undertaken within a framework that includes institutional roles, an enabling environment (legislative, regulation and policy) and management instruments. Efficiency in water distribution and use is a fundamental premise of water conservation and water demand management. The NWA stipulates that water use authorizations must be obtained for all water uses contemplated as part of mining.

i. Proposed Storm Water Infrastructure and Conceptual sizing of dirty water channels

The proposed conceptual layout of dirty water diversion drains and containment dams can be seen in Figure Error! No text of specified style in document.**-5**. All diversion drains and containment dams have been sized to prevent flooding from the 1:50-year design rainfall event. A conservative approach was used to size all channels to accommodate a maximum flow rate of 0.060 m^3/s. This flow rate was determined for a drain on the largest stormwater catchment at the project site. The general dimensions of a proposed typical stormwater drain are presented in **Error! Reference source not found.**. The schematic of stormwater drains is presented in Figure Error! No text of specified style in document.**-4** which shows an adjoining drain and berm structure required to channel stormflow as well as separate clean water from entering contaminated catchments.

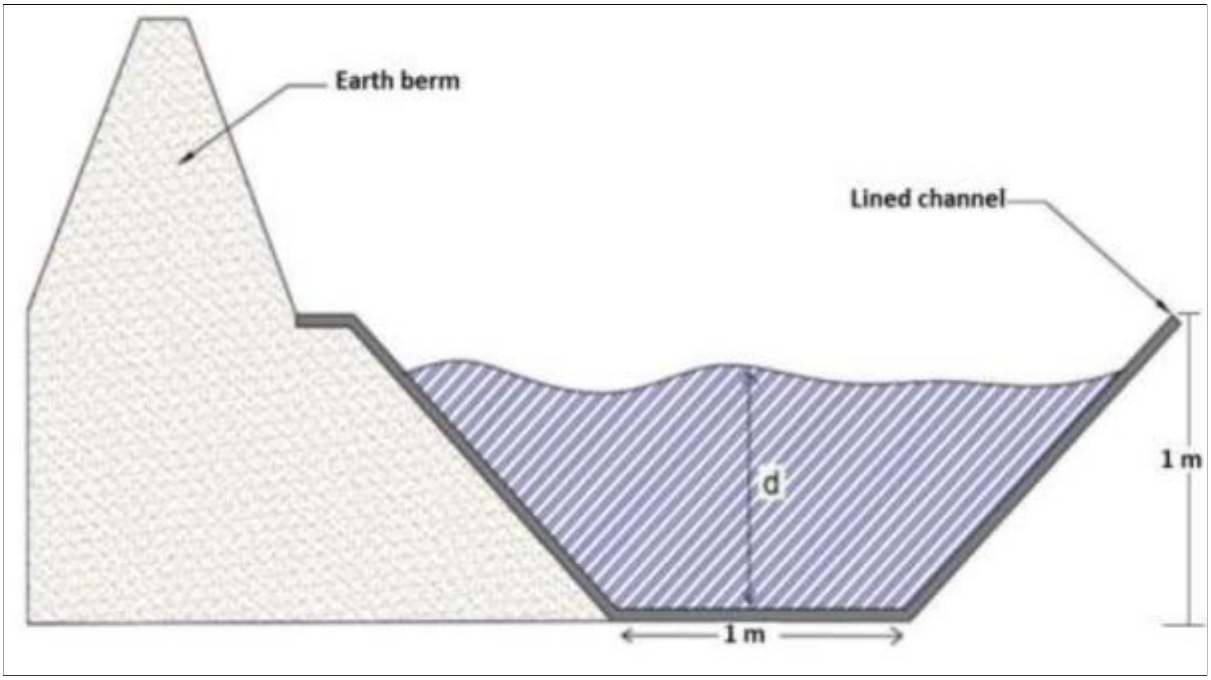

Figure Error! No text of specified style in document.**-4: Typical drain adjoined to a berm for stormwater channelisation**

Dirty water channel placements were identified to ensure dirty water runoff is contained within the project area. The proposed PCD is responsible for containing the dirty water from the plant area and waste dump areas. Runoff from all other dirt areas should also report to this PCD. Dirty water channels are to be based on a lined trapezoidal channel designs.

Table Error! No text of specified style in document.**-5 Summary of catchment hydrology – dirty water**

Name	Area (km^2)	Length of longest watercourse (m)	Height Difference (m)	Rainfall Intensity (Q_{50})	Tc (hours)	C-Factor
Waste Dump Catchment	0.004	76	2.3	3.5	20.52	0.48
Plant Area Catchment	0.2	148	3	2.8	26.11	0.408

Table Error! No text of specified style in document.**-6 Summary of peak flows – dirty water**

Name	Peak flows for various recurrence intervals (years)					
	2 year	5 year	10 year	20 year	50 year	100 year
Waste Dump Catchment	0.000	0.001	0.001	0.001	0.002	0.002
Plant Area Catchment	0.017	0.025	0.034	0.044	0.060	0.078

Table Error! No text of specified style in document.**-7 Summary of channel sizing – dirty water**

Channel Section	**Q (m^3/s)**	**Bottom width (m)**	**Calculated Top width (m)**	**Calculated depth (m)**	**Velocity (m/s)**	**Design depth (m)**	**Type**
Waste Dump Catchment	0.002	0.5	1	0.55	0.032	1.0	Trapezoidal lined
Plant Area Catchment	0.060	0.5	1	0.68	0.061	1.0	Trapezoidal lined

All dirty water channels are to be sized having side slopes of 1:3, bottom width of 0.5 m and design depth of 1

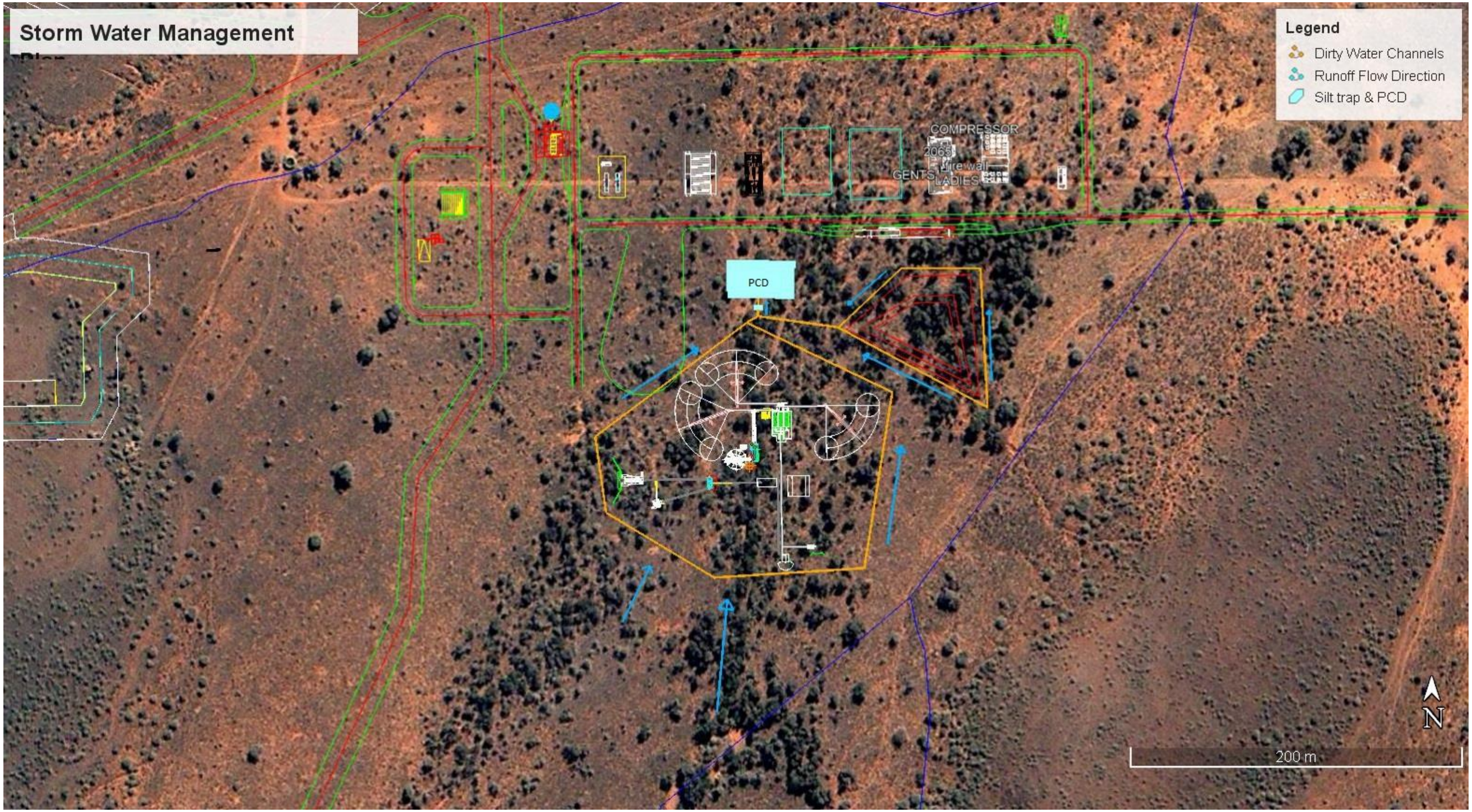

Figure Error! No text of specified style in document.**-5: Proposed Stormwater Management Plan**

iv) Water Balance

Sustainable water resource management forms part of the mine's integrated water management principles and involves the development of an integrated water accounting approach to accurately reflects the reality of water use on the mine. Water accounting uses a water balance approach to quantify the amount of water entering a system, used and water leaving the system.

The water balance is developed in accordance with the Best Practice Guideline G2 – Water and Salt Balances (DWAF, 2006), and this should be used by the mine as a water management tool to achieve the following key principles of water management:

- Reduced raw water intake;
- Water re-use and recycling;
- Pollution prevention; and
- Impact reduction and prevention.

The static excel based water balance was developed utilising results of the hydrological assessment to provide hydrological inputs as rainfall, runoff and evaporation into modelling calculations.

a. Water Balance Boundary

In line with DWA's best practice, a clear definition and understanding of the boundaries of the water system and layout of the water circuits are required to develop a water balance for the mine. The boundaries are defined according to the mine processes and natural phenomena. They are subdivided into the water demands, water sources and water storage as discussed below.

- ***Water demand/usage***

Waterkloof project requires water for the following uses:

- Mineral processing;
- Dust suppression; and
- Potable water for drinking and other domestic uses.

- ***Water sources***

The envisaged water sources in the Waterkloof project include:

- Rainfall and runoff collected at the mine site;
- Groundwater/Borehole water.

- ***Water storage/containment facilities***

Water storage infrastructure includes:

- Pollution Control Dam (PCD)

Raw Water Dam; and

JoJo tanks.

b. Calculations, Design Basis, Coefficient and Assumptions

The following data and assumptions were made in order to develop this water balance model (**Table** Error! No text of specified style in document.**-8**):

Table Error! No text of specified style in document.**-8: Summary of Data and Assumptions**

Component	Value	Unit	Source
Tonnes per annum	1250	Mt/annum	Scoping Report, 2018
Plant/processing water Requirement	691200	m^3/annum	Assumption (0.08 m^3/ton)
Raw water storage dam	8500	Area (m2)	Assumption
Pollution control dam	5500	Area (m2)	Assumption
Waste Dump	35000	Area (m2)	Assumption
Product Stockpile	6000	Area (m2)	Assumption
Plant Area	20000	Area (m2)	Assumption
Waste dump runoff Coefficient	0.35	%	Assumption
Product stockpile runoff Coefficient	0.15	%	Assumption
Plant area runoff Coefficient	0.45	%	Assumption
Plant leakages & product losses	0.2	%	Assumption
Water Treatment Plant Losses	0.1	%	Assumption
Dust suppression demand	15000	m^3/annum	Assumption
Number of Employees per shift	50	people	Assumption
Water per person per day	50	litres	(WHO)
Fireline/Fire Tank	80000	litres	Assumption

c. Water Balance Results

The average annual water balance calculations showed the following;

The total potential runoff that may be captured from the dirty mine catchments amounts to 5715 m^3/annum;

The total potential direct rainfall that may be captured in the open water storage facilities (PCD & Water storage dam) amounts to 3612 m^3/annum;

Potential evaporation in this area is higher than the potential rainfall, stored water is likely to be significantly reduced through evaporation;

A schematic representation of the average annual water balance as well as the process flow is presented in **Figure** Error! No text of specified style in document.**-6** and **Figure** Error! No text of specified style in document.**-7**.

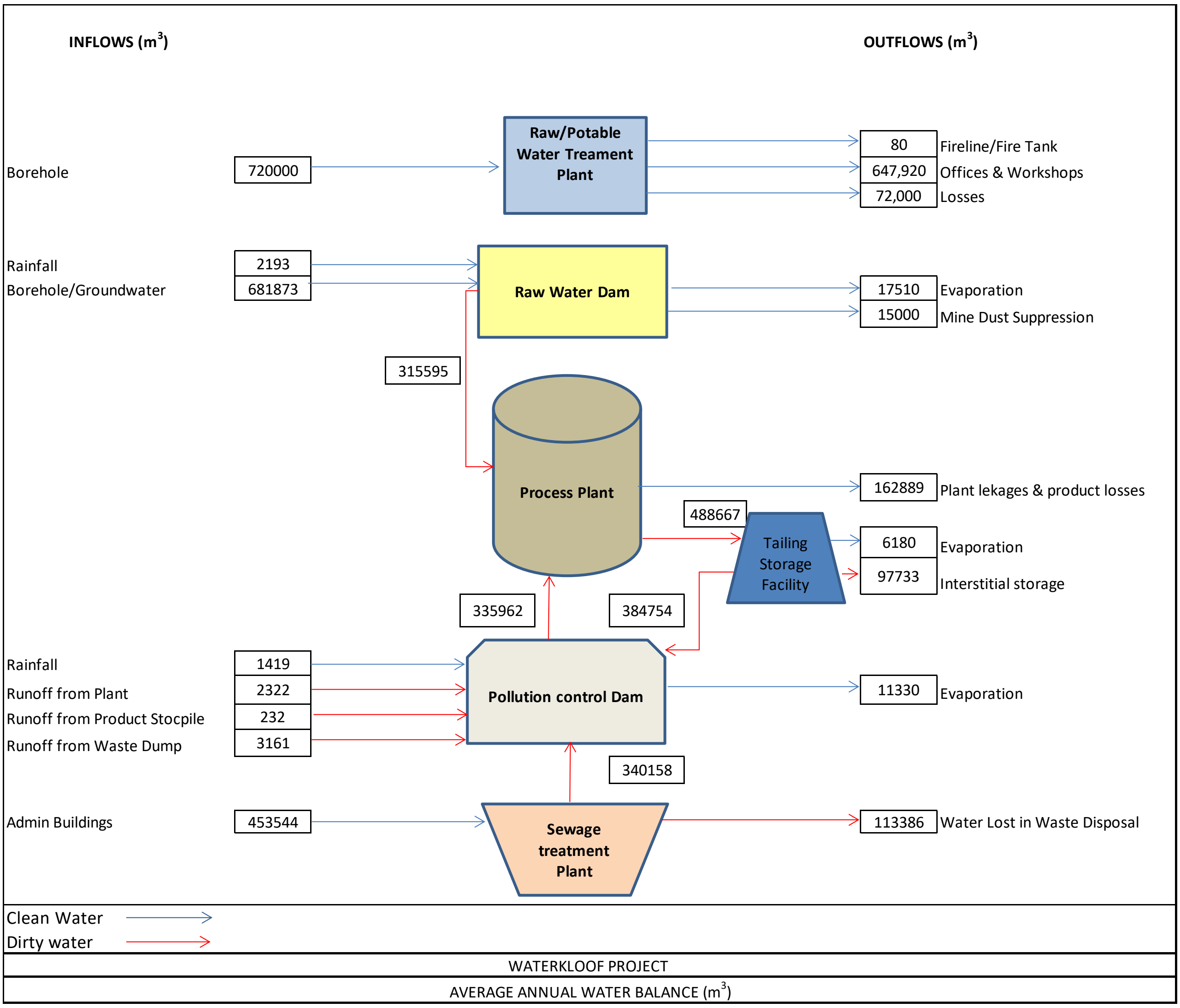

Figure Error! No text of specified style in document.**-6: Waterkloof Water Balance and Process Flow**

WATERKLOOF AVERAGE ANNUAL WATER BALANCE (m3)					
Facility Name	**Water In**		**Water Out**		**Balance**
	Water Circuit/stream	**Quantity (m3/a)**	**Water Circuit/stream**	**Quantity (m3/a)**	
Raw/Potable Water Treament Plant	Borehole	720000	Fireline/Fire Tank	80	
			Offices & Workshops	647,920	
			Losses	72,000	
	Total	**720,000**		**720,000**	**0.00**
Raw Water Dam	Rainfall	2,193	Evaporation	17,510	
	Borehole/Groundwater	681,873	Mine Dust Suppression	15,000	
			Process Plant	315,595	
			Water in storage	335,962	
	Total	**684,066**		**684,066**	**0.00**
Process Plant	Raw Water Dam	315,595	Plant lekages & product losses	162,889	
	Pollution control Dam	335,962	Tailings storage facility	488,667	
	Total	**651,556**		**651,556**	**0.00**
Pollution control Dam	Rainfall	1,419	Process Plant	335,962	
	Tailings storage facility	384,754	Evaporation	11330	
	Sewage treatment Plant	340,158	Water in storage	384,754	
	Total Runoff	5,715			
	Total	**732,045**		**732,045**	**0.00**
Sewage treatment Plant	Admin Buildings	453,544	PCD	340,158	
			Water Lost in Waste Disposal	113,386	
	Total	**453,544**		**453,544**	**0.00**
Tailing Storage Facility	Process Plant	488,667	Evaporation	6,180	
			Interstitial storage	97,733	
			Water in storage	384,754	
	Total	**488,667**		**488,667**	**0.00**

Figure Error! No text of specified style in document.**-7: Waterkloof Water Balance (Simplified DWS Format)**

v) Conclusion and Recommendations

The project area is in the quaternary catchment D73B which is located at the Orange Water Management Area (WMA 06). The weather in region is typical of desert and semi desert areas with large dry region having high summer temperatures and varying topographies. The area does not receive significant amount of rainfall and the potential evaporation is high due to increased temperatures that are experienced in the area. Potential runoff generation in this area is very low and poses low risks on impacting the natural surface water resources

The following recommendations on the developed storm water management plan and water balance can be made:

The stormwater management plan should be implemented to ensure clean and dirty water separation, thereby mitigating the impact of pollution to the downstream watercourses, Sizing, and the engineering designs of the recommended storm water infrastructures should also be updated once the final site layout has been issued;

Principles of storm water management plan presented in this report should be applied to any additional dirty water infrastructure that may be proposed on the final layout;

Water balance should also be updated on an annual basis to calibrate with the actual data recorded on site;

vi) References

DWA. (2006). Water and Salt Balances: Best Practice Guidelines for Water Resource Protection in the South African Mining Industry. Pretoria: Department of Water Affairs.

WRC. (2015). Water resources of South Africa 2012 study. Pretoria: Water Research Commission