PIETERMARITZBURG QUARRY

STORMWATER MANAGEMENT PLAN

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1.0 INTRODUCTION

1.1 Purpose and Scope

MSBR Consulting (Pty) Ltd was appointed by Afrimat to produce a stormwater management plan (SWMP) for the Quarry in Pietermaritzburg, KwaZulu-Natal. Based on the site inspection and type of mining, the site is considered a small-scale mine in terms of the Department of Water and Sanitation (DWS) Best Practice Guidelines (BPGs) – A1 (2006). The site is close to a watercourse, namely the Mpushini River; therefore, flood lines must be determined for the site to ensure the quarry is outside the flood zone.

The Quarry is located on parent farm Maritzburg Quarries 15773 FT which covers an area of 80,4259.45 Ha.

The SWMP was developed in line with the requirements of the General Notice (GN) 704 of the National Water Act (Act 36 of 1998) as outlined in the Department of Water and Sanitation (DWS) Best Practice Guidelines (BPGs) – A1 (2006).

The flood line delineation has been undertaken in line with the requirements of the General Notice (GN 509) of the National Water Act (Act 36 of 1998).

1.2 Objectives

This work aims to upgrade and provide an improved environmentally sensitive stormwater management system for the site.

This stormwater management plan for the PMB Quarry has the following objectives:

i. To protect all life and property from damage by stormwater and floods.
ii. To prevent erosion of soil by wind and water.
iii. To conserve flora and fauna of the natural environment.
iv. To protect water resources in the downstream catchments from pollution and siltation by preventing runoff from entering and then leaving the site.
v. To prevent or eliminate contamination of groundwater.
vi. To protect and enhance the local and downstream watercourses and their eco-systems.

1.2.1 Key Water Impact Management Areas

The critical water impact management areas on the quarry are:

a) stormwater management,
b) erosion and sediment control
c) waste management.

1.3 Project Background

AFRIMAT has appointed MSBR to ensure the quarrying operations comply with all relevant legislative frameworks related to stormwater management. The SWMP must also comply with provisions and requirements of the National Environmental Management Act (107 of 1998) (NEMA) and all applicable environmental legislation.

In particular, MSBR must identify where the requirements are not executed and make recommendations. MSBR will ensure the Mine Manager is aware of the areas of improvement for environmental management and identify possible non-compliance with environmental aspects related to stormwater.

1.4 Location

The Pietermaritzburg Quarry is located about 10.5km to the southeast of Central Pietermaritzburg. The centre of the area is at approximately 29°38'16.62"S, and 30°28'43.54"E. Refer to **Error! Reference source not found.**s 1 to 4 below for the locality maps.

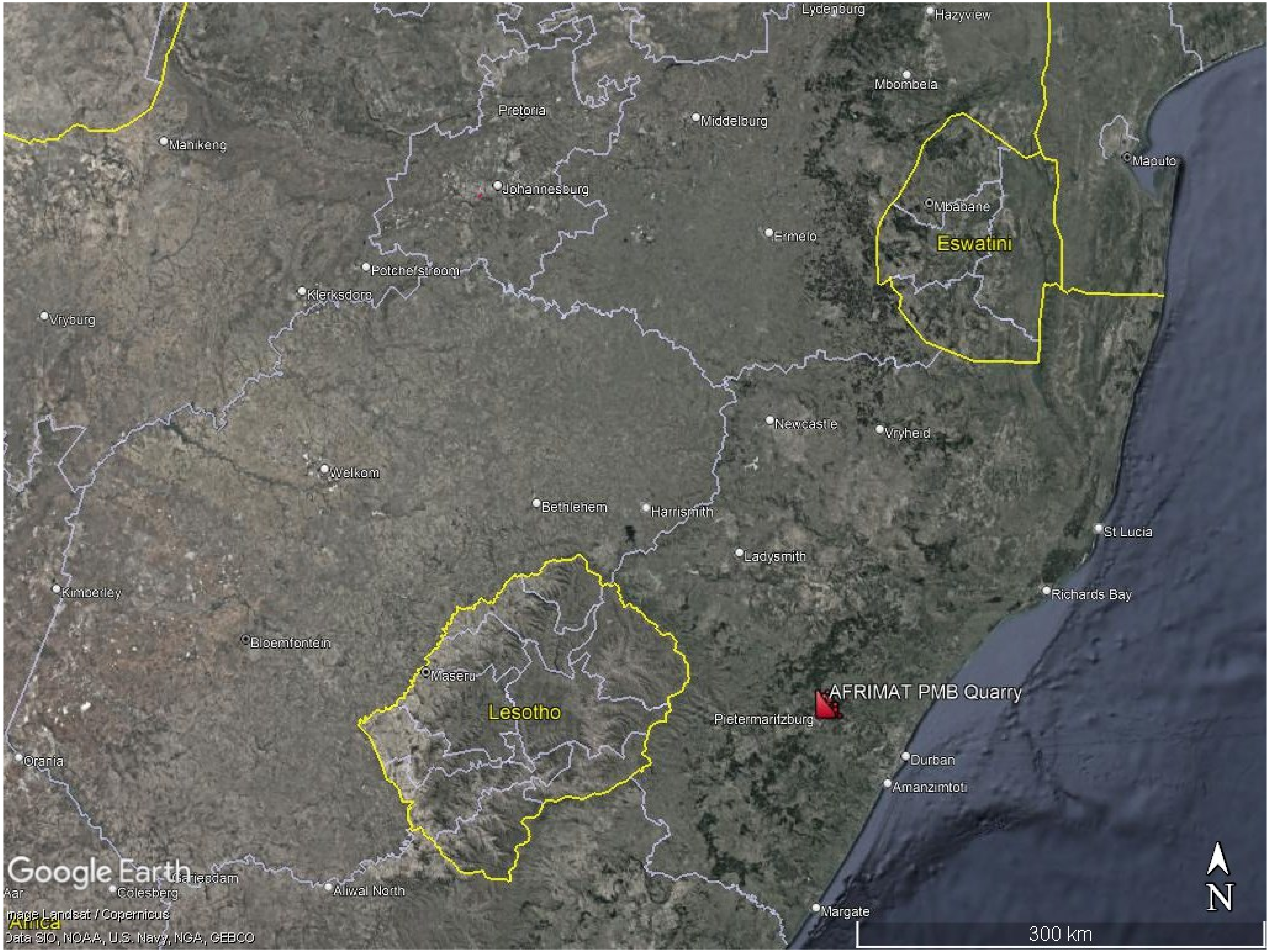

Figure 1: Locality in National Context

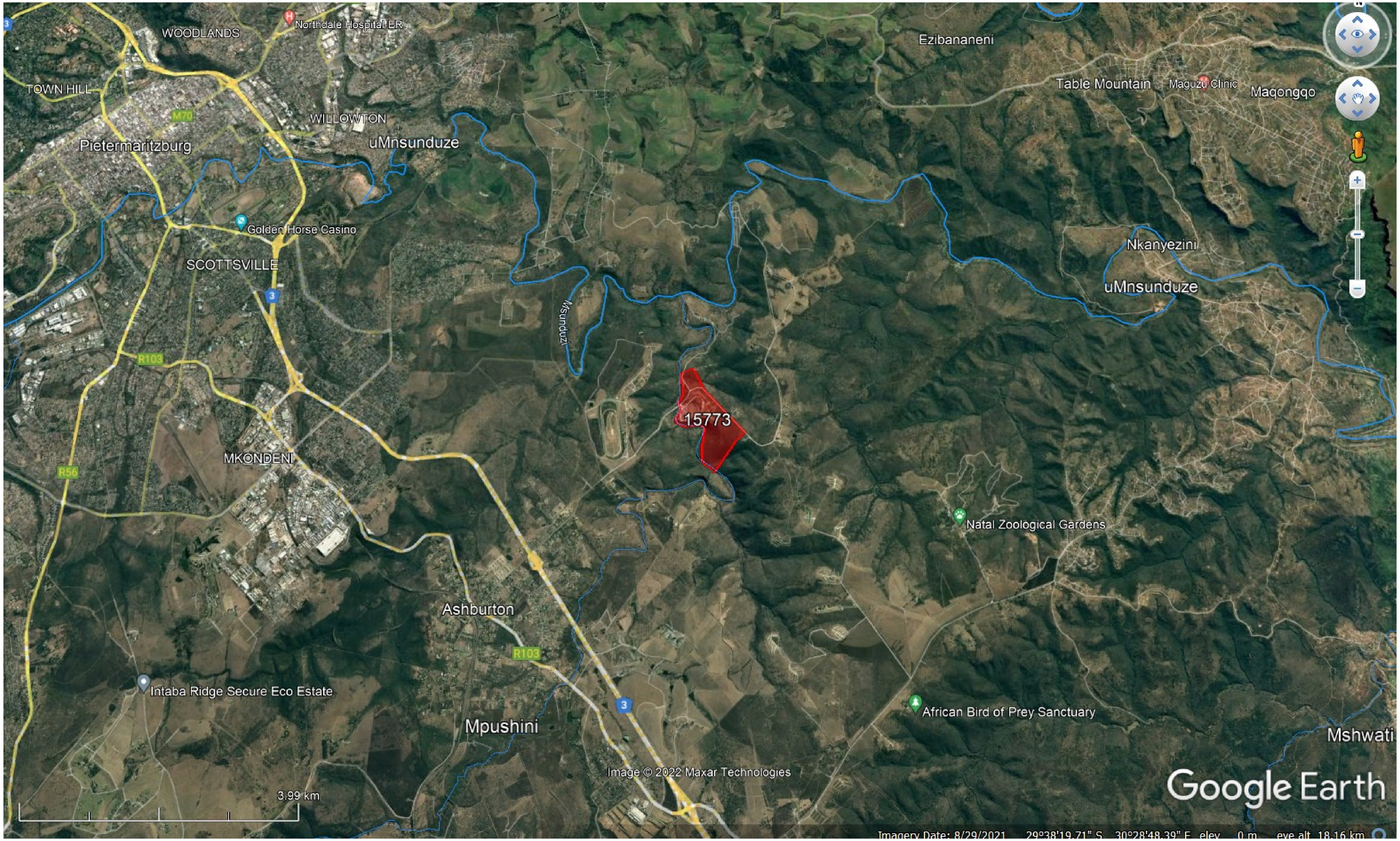

Figure 2: Locality in Pietermaritzburg Context

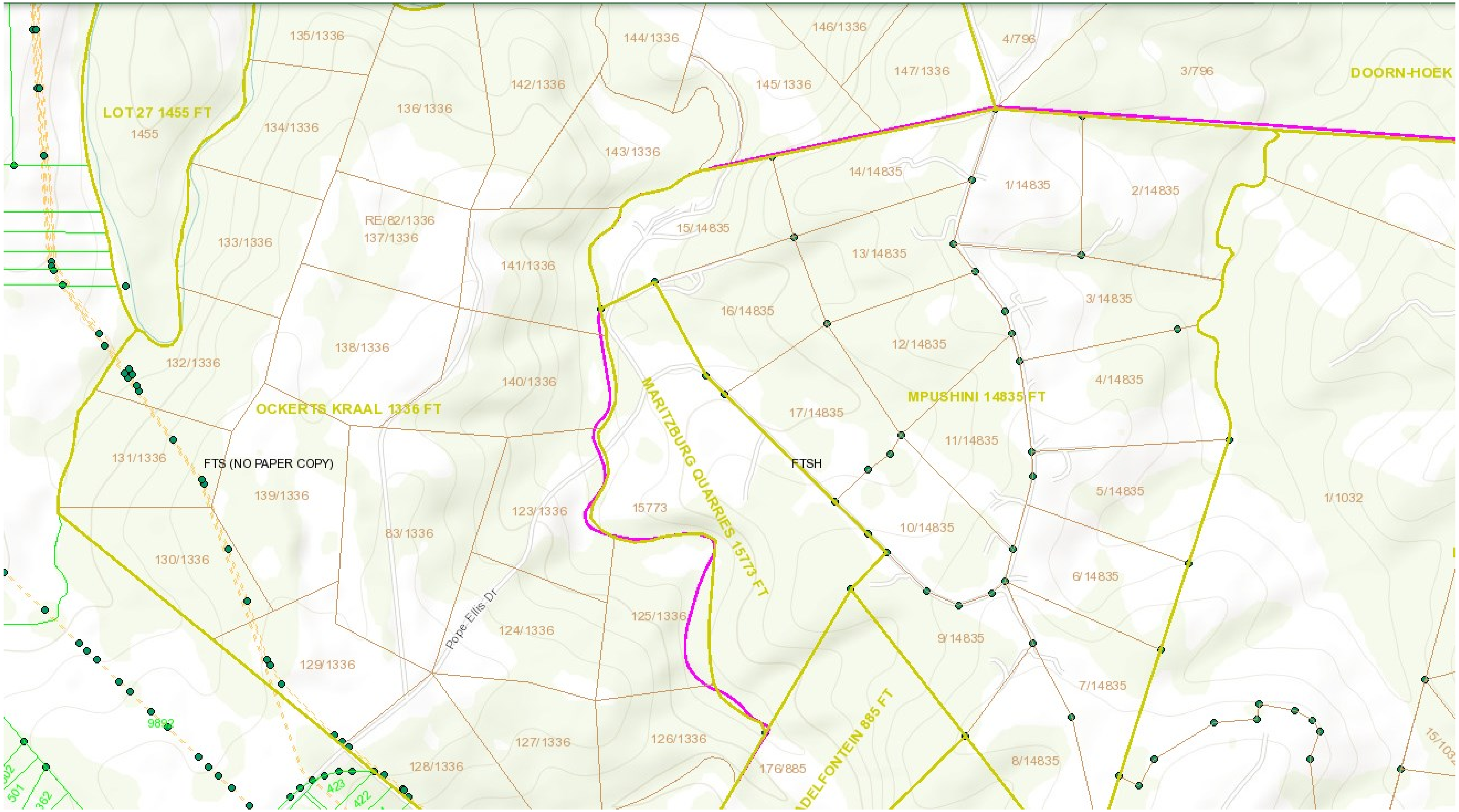

Figure 3: Cadastral Layout

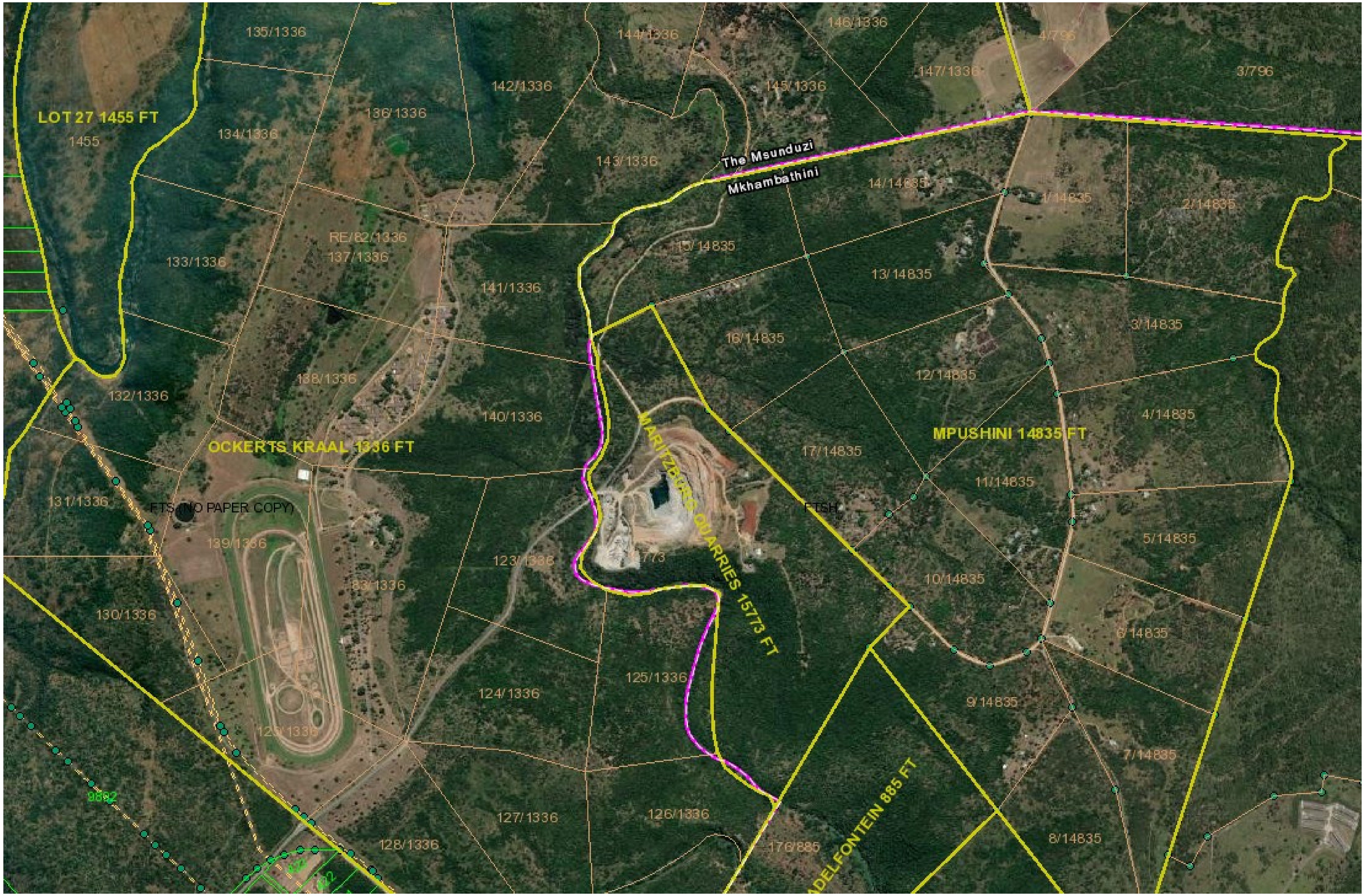

Figure 4: Cadastral on Satellite Imagery

1.5 Project Team

The following role players are involved in the planning and design of the SWMP report.

Table 1: Project Team

Client	Afrimat Aggregates (Pty) Ltd	Project Manager – Mr. Sduduzo Manda *15 Bloekom Street* *Vryheid* *3100* Tel: +27 34 980 9233 Email: sduduzo.mdanda@afrimat.co.za
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2.0 LEGAL REQUIREMENTS

Water is the main resource affected by mining in South Africa. Mining has had a negative impact on water resources, a significant risk to our water scare country. The National Water Act (NWA), 1998 (Act 36 of 1998) has legislated water management to ensure ecological integrity, economic growth, and social equity when managing and using water. The use of water for mining-related activities is regulated by Government Notice No. GN 704 dated 4 June 1999.

Other relevant legislation includes:

- Minerals Act (Act No 50 of 1991)
- Environment Conservation Act, 1989 (Act No 73. Of 1989)
- National Water Act
- National Environmental Management Act

3.0 KEY DESIGN GUIDELINES & STANDARDS

The following documents will guide the philosophy and design of the stormwater management system for the Quarry. These will be in conjunction with the requirements of the National Water Act and the National Environmental Management Act

- Best Practice Guideline - A1: Small-Scale Mining (Standard Format) -- August 2006
- Best Practice Guideline - A5: Water Management for Surface Mines -- July 2008
- Best Practice Guideline - G1: Storm Water Management -- August 2006
- Best Practice Guideline - H3: Water Reuse and Reclamation -- June 2006
- The South African Guidelines for Sustainable Drainage Systems (Armitage et al., 2013)
- South African National Roads Agency Limited- Drainage manual- 6th Edition (SANRAL, 2013)
- The application of the National Building Regulations SANS 10400.
- Water Quality Guidelines Volume 7 – Aquatic Systems

4.0 ANALYSIS OF THE STORMWATER SITUATION

4.1 Available Information

The following information was made available for the preparation of this report:

- Lidar surveys of existing Quarry
- Previous environmental management plans
- Water use data

- Existing mining rights and permit
- Site visit conducted on the 28th February 2022 with the assistance of the quarry manager.

4.2 SITE DESCRIPTION

4.2.1 Hydrology

The study area is in drainage region U - Mvoti to Umzimkulu Water Management Area no 11. The site falls within the Mzimkhulu Water Resource Region. The quaternary catchment is U20J which is drained primarily by the uMnsunduze River, with the main tributaries within the drainage area being the Slang Spruit, Mpushini, and the Mshwati rivers. The uMnsunduze River drains eastwards to confluence within the uMngeni River just outside the quaternary catchment of U20J. The uMngeni River drains southeasterly and discharges into the Indian Ocean in Durban.

The average precipitation is approximately 840 mm/annum in this quaternary catchment.

4.2.2 Geology

The site geology falls under two main subgroups:

a) Dwyka- Diamictite (polymictic clasts, set in a poorly sorted, fine-grained matrix) with varved shale, mudstone with dropstones and fluvioglacial gravel common in the north.
b) NAMIBIAN-Megacrystic biotite granite

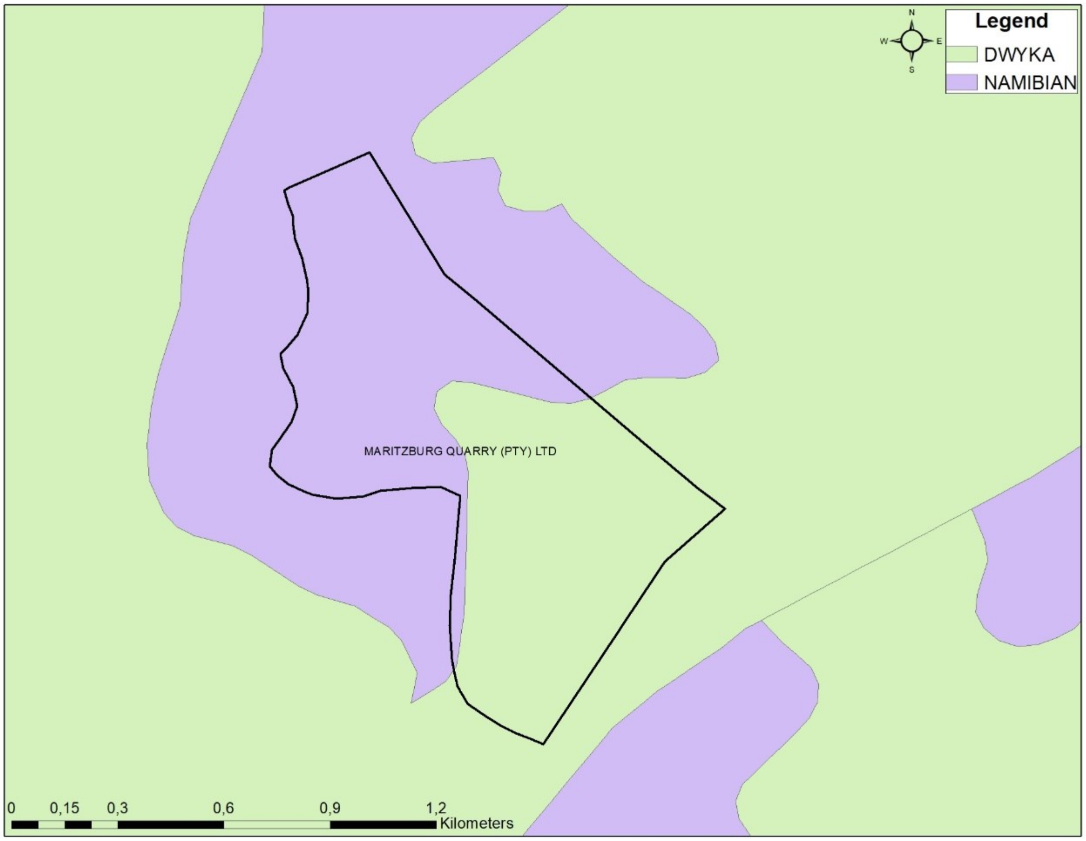

Figure 5: Site Geology

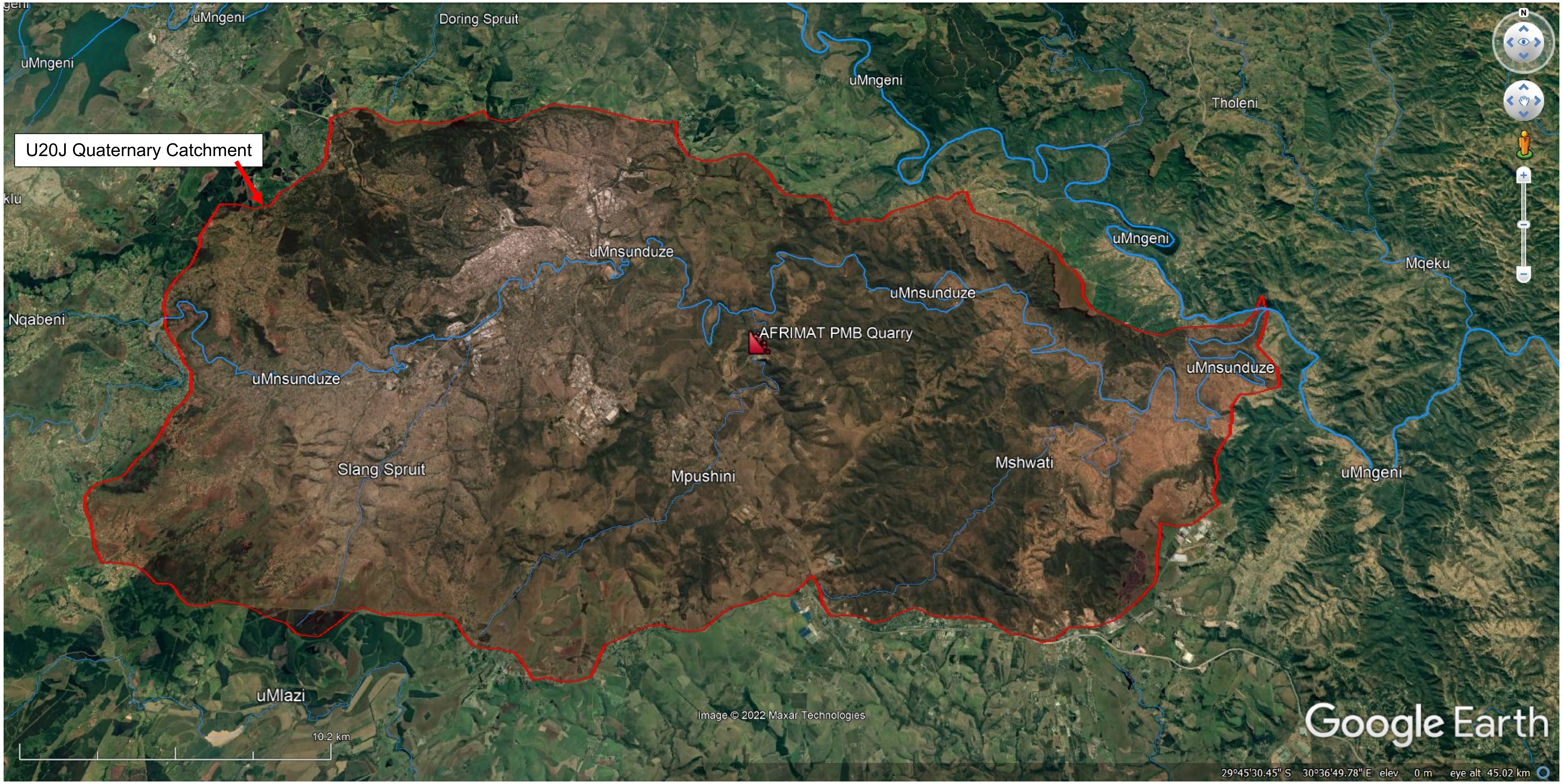

Figure 6: Study Area and Quaternary Catchment (In Red)

4.3 The Impact of Development on Rainfall-Runoff

4.3.1 Pre-Development Site

Prior to development, the site consisted of thicket and bushland based on the landcover in the adjacent areas. The course and catchment of the Mpushini river has not been majorly modified, and the natural vegetation along the river is largely one of the secondary grasslands and bushed grasslands, bushland, and bushland thicket.

4.3.2 Post-Development Life Cycle

Once quarrying began, the previously vegetated site was excavated, creating a deep depression that increased over several years. This reduced the stormwater runoff from the site considerably. However, there would be a risk of surface water contamination due to the unprotected surfaces with no vegetal covering giving rise to sediment transport. The resulting discharge from the site will be less than the predevelopment runoff, which is the opposite effect of typical development.

The course and catchment of the Mpushini river has not been majorly modified, and the natural vegetation along the river is largely one of the secondary grasslands and bushed grasslands, bushland, and bushland thicket.

4.3.3 Quarry Life Cycle

The Pietermaritzburg Quarry is in the Operational Phase. The mining activities over the life of a typical quarry are carried out in five phases as indicated below:

1. Planning and authorization phase – includes the consideration of alternatives and exploration activities
2. Construction Phase – which will include demarcating the permitted mining area, vegetation removal, topsoil stripping and stockpiling, and the introduction of mining machinery and equipment onto site.
3. Operational Phase – which will involve the mining dolerite from the permitted area using open cast mining methods. This will include blasting to loosen the hard rock. Thereafter, loosened material will be transported to the crushing and

screening processing plant, where it will be screened to various sized stockpiles before it is sold and transported from site to clients.

4. Decommissioning Phase – which includes the rehabilitation of the affected environment before submitting a closure application to the Department of Mineral Resources and Energy (DMRE).
5. Post closure phase - management of post-closure residual and latent impacts

Figure 7: Post Development Site

5.0 STORMWATER MANAGEMENT STRATEGY

5.1 Water Management Hierarchy

In terms of the principles of integrated water management, the strategy must be applied in the following steps:

Step 1: Prevent and minimise pollution at the source

Step 2: Reuse the dirty stormwater

Step 3: Treat the contaminated stormwater

A stormwater management plan for small-scale mining aims to protect water resources and ecosystems.. This is achieved by ensuring pollution is minimized or eliminated. The primary sources of pollution are the dust from aggregate located on stockpiles and the crushers.

5.2 Stormwater Management Philosophy

The basic principles as outlined by the DWS state the following:

a) Clean stormwater runoff from uncontaminated sites must be diverted away from potential contamination.
b) Contaminated stormwater must be contained and conveyed separately from the clean stormwater.
c) The SWMP must incorporate the life cycle of the quarry over different hydrological cycles and must consider risk management.

a) All statutory requirements of various regulatory agencies and stakeholders' interests must be considered and incorporated.

Therefore, the site is divided into two systems the first being clean stormwater system and the second, dirty stormwater system.

5.2.4 Clean Stormwater Management

The most commonly used approach is to construct berms and/or cut off drains on the upstream sections of the quarry. This prevents surface runoff from flowing onto the site. The contours of this site naturally prevent stormwater runoff from flowing onto the site.

5.2.5 Dirty Water Management

The dirty stormwater should be kept separate from the clean stormwater. The dirty stormwater should be collected for use in dust control. Sediment in the dirty stormwater must be managed as indicated in the Erosion & Sediment Control section below.

5.2.6 Minimise Land Disturbance and Protect Exposed Surfaces

a) Dust control on roads. Dust can contaminate the atmosphere, which can be controlled by spraying dirty stormwater from the stormwater runoff or impoundment located in the centre of the quarry.
b) Regular maintenance of roads. Roads to be free of erosion damage and have adequate drainage in the form of open channels to prevent water ponding.
c) Grassing of slopes

5.2.7 Erosion & Sediment Control

- Manage runoff by minimising steep slopes are far as possible
- Vegetate exposed surfaces

A concrete-lined silt trap must be constructed as per design. The silt trap will be placed adjacent to the weighbridge. This silt trap will be easily cleaned with a front-end loader or using shovels.

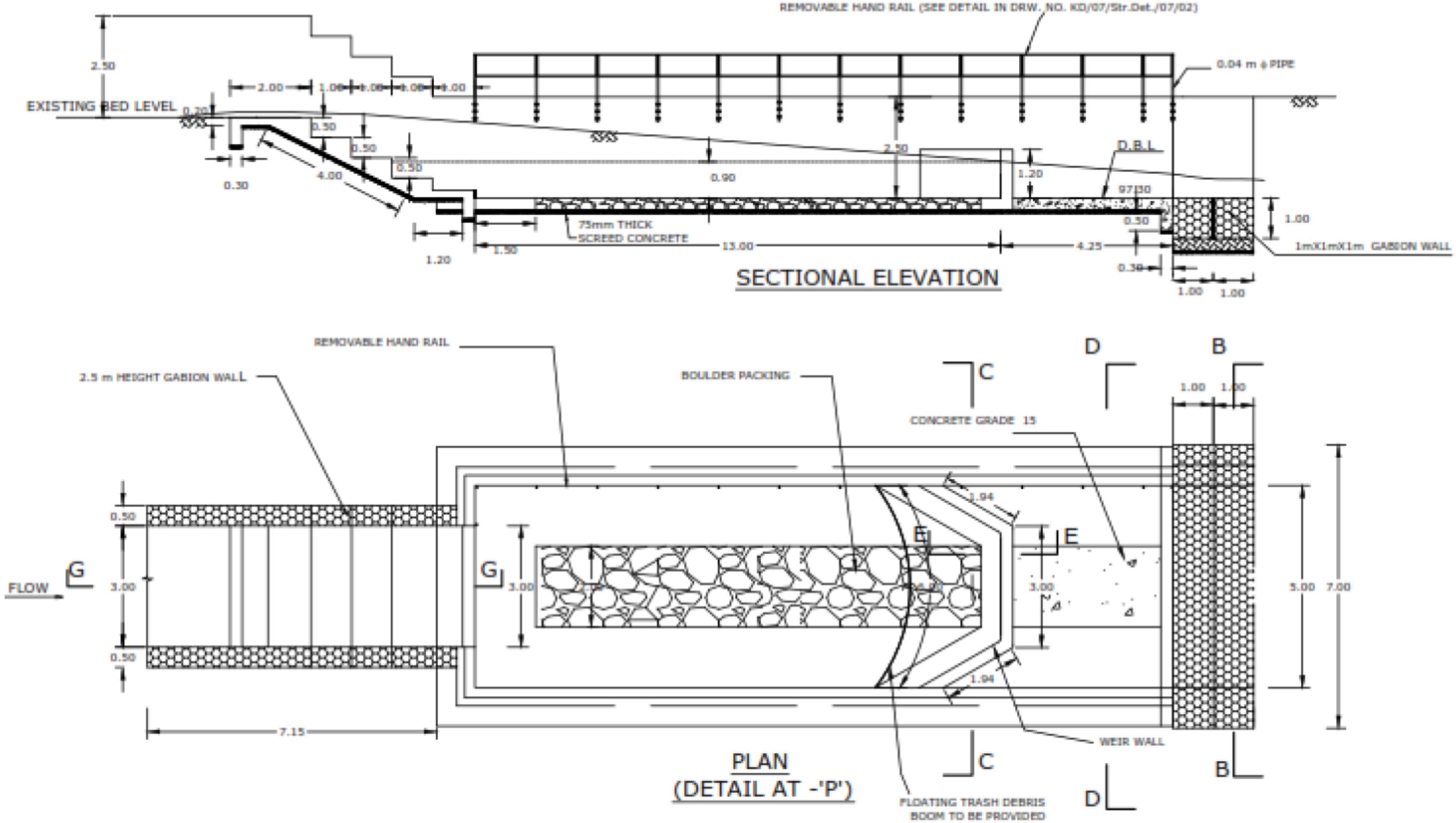

Figure 8: Silt Trap Quarry wastewater purification is achieved by settling and filtering

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III[rd] International Innovative Mining Symposium

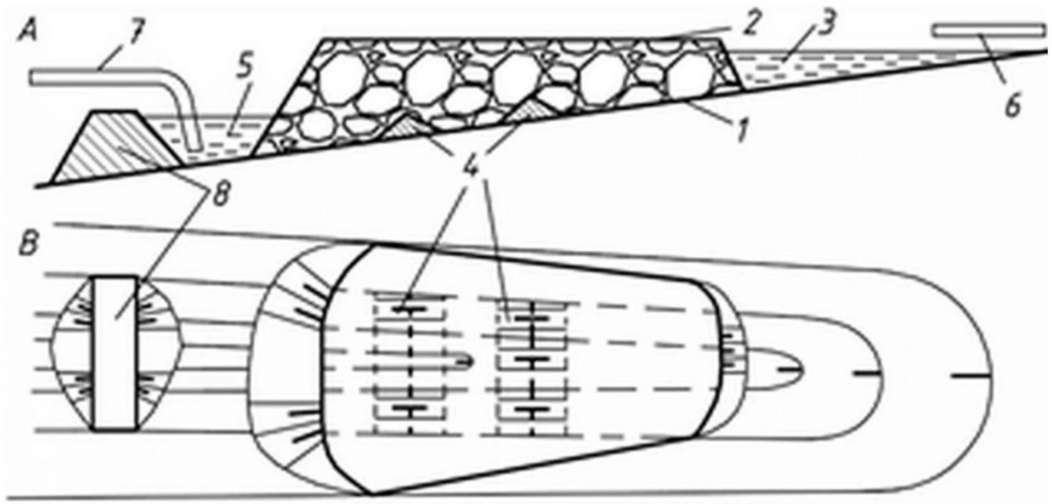

Fig. 4. Construction of the filtering array with waterproof stopping.

A) longitudinal section; B) plan view; 1) the bottom of the filter; 2) filtering array; 3) receiver for contaminated water; 4) waterproof stopping; 5) lodgement of purified water; 6) conduit for feeding of contaminated water; 7) conduit for purified water removing; 8) water retention levee.

The filter body is a water-holding dam, piled of rocks with low hydraulic permeability.

5.3 Waste Management

Other waste generated by the mine includes sewage, garbage, wash water, used oils and grease, petrochemical spills, etc.

All effluent water from the quarry buildings shall be disposed of in a properly constructed French drain, situated as far as possible but not less than 100 metres, from a stream, river pan, dam, or borehole. Only domestic type water shall be allowed to enter this. Any effluents containing oil, grease, or other industrial substances shall be collected in a grease trap and removed from the site, either for resale or for appropriate disposal at a recognised facility.

Spills should be cleaned up immediately by removing the spills together with the polluted soil and disposing thereof at a recognised facility to the satisfaction of the regulators.

Non-biodegradable refuse (such as glass bottles, plastic bags, metal, scrap, etc.) shall be stored in a container at a collecting point, collected regularly, and disposed of at an authorised disposal facility. Precautions shall be taken to prevent any refuse from spreading on and from the campsite.

Biodegradable refuse generated from the quarry, vehicle yard, storage area or any other area shall either be handled as above or be buried in a pit excavated for that purpose and by covering it with layers of soil, incorporating a final 0,5 metre thick layer of topsoil (if practical) or as specified by the local authority, if applicable.

Suitable covered receptacles shall be provided and conveniently placed for waste disposal. All used oils, grease or hydraulic fluid shall be placed therein and these receptacles will be removed from the quarry on a regular basis for disposal at a

6.0 HYDRAULIC DESIGN

6.1 Catchment area delineation

Three delineations were done for the catchment, as shown in Figure 9.

i) To determine flow to the stream for the 1:100 year flood line calculations

ii) To determine the 1:50 year flood volumes within the dirty stormwater system

iii) To determine the 1:50 year flood volumes within the clean water system

6.1.8 Clean Stormwater System

Figure 9 There are two clean water systems on the site. The first is stormwater that is completely prevented from entering the quarry space. The second is the area with topsoil stockpiles that are by-products of the mining activities. These sites must be grassed to ensure they remain clean stormwater areas. The stormwater from these sites has the potential of flowing onto the dirty area, which must be prevented by installing cut-off berms and drains as per design. The clean stormwater system with the potential to overtop into the dirty stormwater system is denoted by C4.

6.1.9 Dirty Stormwater System

The precipitation on the quarry area, includingthe pit, roads and stockpile, and loading areas, is considered dirty. There is a high potential for sediment transport which must be prevented. The centre of the pit has an impoundment that can double up as a stormwater dam. This dam can be used to recycle water for dust control and other suitable quarry activities. The Maritzburg Quarry uses approximately 6,481m^3 of water per annum. This could all come from the impoundment.

Some stormwater does not flow to the impoundment but rather directly to the outlet. A new cut-off drain has been proposed between the boundaries of C2 and C3. This drain will return the dirty stormwater to the impoundment. Following the flood line analysis, done in a later section, there is a risk of flooding in the area next to the main offices; therefore, it is necessary to ensure the dirty system does not drain across this area as much as possible.

Figure 9: Catchment Delineation

6.2 Design Calculations

The method adopted for this report is the Rational Method as described in the guidelines proposed by the Road Drainage Manual published by the National Transport Commission. Table 2 below is an extract from the South African Roads Agency Road Drainage Manual with recommended values of run-off factor C for use in the rational method.

The Rational Method was used for predicting the peak flows from the Maritzburg Quarry Site. The rational method is recommended for a catchment less than 15km^2 or 1500Ha.

The formula used is: $$Q = \frac{CIA}{3.6}$$

Where Q = peak discharge in m^3/s

C = Coefficient of run-off

I = rainfall intensity in mm/hr

A = catchment area in km^2

The mean annual precipitation (MAP) for the areas is assumed to be 840mm.

6.3 Methodology

Storm water drainage

The site was split up into four sub-catchments to size the hydraulic elements. The runoffs were calculated for these catchments, and a size for the drain was computed for the 50-year flood. The areas were calculated using AutoCAD.

i) Clean Stormwater

Catchment 4 are cut-off areas which divert uncontaminated water around the site.

The rest of the site has berms that prevent stormwater from entering or flowing out of the site unchecked.

ii) Contaminated stormwater

Catchments 1, 2, and 3 are dirty stormwater areas. Catchment 1 drains into the impoundment in the center of the quarry. Catchment 2 currently drains towards the weighbridge and exists the site. A new drain has been proposed between catchments 1 and 2 to divert dirty stormwater into the impoundment. This will eliminate the risk of dirty stormwater spilling into the river during a 1:50 year storm.

6.4 Assumptions

The following procedure for calculating the runoff coefficients was carried out for all the sub catchments. The detailed procedure as shown was done for the entire site. Table 2 below shows the runoff coefficients as detailed in the procedure below.

1. The catchment area was treated as a rural catchment as there is no significant development on-site in terms of paved surfaces and buildings.
2. Catchment area is the area of the site since surface runoff from outside the site is diverted away by earth berms and the natural topography.

3. Catchment factor is based on the runoff coefficients for rural watersheds i.e. $C = C_r + C_i + C_v + C_s$

Dirty Areas – C1

4. Catchment factor is based on the runoff coefficients for rural watersheds i.e. $C = C_r + C_i + C_v + C_s$

   Relief - 0.28 high because the site is generally steep.

   Soil infiltration - 0.16 extreme due to the presence of impermeable rock.

   Vegetal cover - 0.12 less than 20% of the area has good cover

   Surface storage - 0.06 due to the surface impoundment

   Making the total 0.62

Dirty Areas – C2

Relief - 0.28 high because the site is generally steep.

Soil infiltration - 0.08 high as there is some soil cover although there is rock beneath it

Vegetal cover - 0.12 less than 20% of the area has good cover

Surface storage - 0.10 few drainage ways no depressions

Making the total 0.58

Dirty Areas – C3

Relief - 0.2 high because the site is generally steep.

Soil infiltration - 0.08 high as there is some soil cover although there is rock beneath it

Vegetal cover - 0.12 less than 20% of the area has good cover

Surface storage - 0.10 few drainage ways no depressions

Making the total 0.50

Clean Areas – C4

Relief - 0.28 high because the site is generally steep.

Soil infiltration - 0.14 high as there is a lot of top soil on the stockpiles

Vegetal cover - 0.06 good vegetal cover

Surface storage - 0.10 few drainage ways no depressions

Making the total 0.58

Table 2: Recommended values of run-off factor C for use in the rational method:

	Extreme	**High**	**Normal**	**Low**
Relief - C_f	0.28-0.35	0.20-0.28	0.14-0.20	0.08-0.14
	steep, rugged terrain with average slopes above 30%	hilly, with average slopes of 10-30%	rolling, with average slopes of 5-10%	relatively flat land, with average slopes of 0-5%
Soil Infiltration - C_i	0.12-0.16	0.08-0.12	0.06-0.08	0.04-0.06
	no effective soil cover either rock or thin soil mantle of negligible infiltration capacity	slow to take up water, clay or shallow loam soils of low infiltration capacity or poorly drained	normal; well drained light or medium textured soils, sandy loams	deep sand or other soil that takes up water readily, very light well drained soils
Vegetal Cover - C_v	0.12-0.16	0.08-0.12	0.06-0.08	0.04-0.06

	Extreme	High	Normal	Low
	no effective plan cover, bare or very sparse cover	poor to fair; clean cultivation, crops or poor natural cover, less than 20% of drainage area over good cover	fair to good; about 50% of area in good grassland or woodland, not more than 50% of area in culitvated crops	good to excellent; about 90% of drainage area in good grassland, woodland, or equivalent cover
Surface - C_s	0.10-0.12	0.08-0.10	0.06-0.08	0.04-0.06
	negligible; surface depression few and shallow, drainageways steep and small, no marshes	well defined system of small drainageways, no ponds or marshes	normal; considerable surface depression storage lakes and ponds and marshes	much surface storage, drainage system not sharply defined; large floodplain storage of large number of ponds or marshes

6.1 Time of Concentration

The time of concentration T_c, is calculated from the formula:

$$T_c=60\ ((8.71L^2)/\ (10^{10}S))^{0.385}$$

Where tc =time of concentration in (min)

S=Ground slope to inlet

L=Length of channel in (m)

6.2 Stormwater Calculations

The runoff discharge was calculated to be for the whole site. The design storm was taken as the 1 in 50 year storm as per GN 704. This is to ensure that the clean and dirty stormwater systems do not overtop during this flood return period.

6.5 Design Parameters

The following tables provide the typical design parameters relevant for the SWMP.

Table 3: Manning's Roughness for Overland Flow

Land Surface Type	Manning n
Urban:	
Concrete, Asphalt, or Gravel	0.005 - 0.015
Average Grass Cover	0.40
Rural Residential (1 - 10 acre lots, maintenance or grazing assumed)	0.40
Urban Residential (maintained lawns assumed, with effects of landscaping, driveways, roofs included in combined value):	
1 - 3 building units/acre	0.30
3 - 10 building units/acre	0.20
> 10 building units/acre	0.15
Commercial/Industrial (effects of landscaping, driveways, roofs included in combined value)	0.11
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 - 0.40
Light Turf	0.20
Dense Turf	0.17 - 0.80
Dense Grass	0.17 - 0.30
Bermuda Grass	0.30 - 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 - 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 - 0.40
Sparse Vegetation	0.05 - 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 - 0.34
20% Debris Cover	0.05 - 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 - 10 acre lots, maintenance or grazing assumed)	0.40
Cultivated Areas:	
Bare Packed Soil (free of stone)	0.10
Fallow (no residue)	0.05
Conventional Tillage:	

Land Surface Type	Manning n
No Residue	0.06 - 0.12
With Residue	0.16 - 0.22
Chisel Plow:	
No Residue	0.06 - 0.12
With Residue	0.10 - 0.16
Fall Disking (with residue)	0.30 - 0.50
No Till:	
No Residue Cover	0.04 - 0.10
20 - 40% Residue Cover	0.07 - 0.17
60 - 100% Residue Cover	0.17 - 0.47
Rural Residential (1 - 10 acre lots, maintenance or grazing assumed)	0.40
Sources: *-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA* *-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S.* *Department of Agriculture, Washington, DC*	

6.6 Stormwater Discharge Calculation

The following section shows the parameters used in the estimation of peak discharges for the rational method. As per GN 704 the requirement is that the clean water system does not overflow into the dirty system for the 1:50 year flood. The dirty water system must also not spill into the clean water system for the 1:50 year flood.

Table 4: Runoff Calculations

Description	Symbol	Formula	Units	DISCHARGE AREAS INDIVIDUAL CATCHMENTS			
				C1	C2	C3	C4
Catchment area measured	A_m	State	ha	9.7151	1.9863	0.8251	1.4548
Catchment factor	C_f	State	Coeff.	0.62	0.58	0.50	0.58
Length of flow	L	State	km	0.21	0.39	0.17	0.52
Fall	H	State	m	74.62	32	14	12
Return period	n	State	Years	50	50	50	50
Mean Annual Rainfall	r	State	mm	840	840	840	840
Time of concentration	t_c	(0.87*L^2/1000*S)^0.385	mins	1.74	5.09	2.66	10.20
Constant	C	State	m/s	0.62	0.58	0.50	0.58
Rainfall Intensity	I	(2050Log (nr)-3000)/(t_c+20)	mm/hr	297.9	258.1	285.9	214.5

Description	Symbol	Formula	Units	DISCHARGE AREAS INDIVIDUAL CATCHMENTS			
				C1	C2	C3	C4
Effective Area	A	$A_m \times S$	ha	6.02	1.15	0.41	0.84
Runoff discharge	Q	C x I x A	m³/sec	3.1	0.5	0.2	0.3

6.7 Minimum Velocity and Grades in Channels

The minimum velocities in the pipes and channels must be in the range 0.9m/s-2.5m/s. The slopes of the drains were taken as the average slopes of the natural ground level.

Table 5: Sizing of Drains

Description	Symbol	Formula	Units	DISCHARGE AREAS		
				C2 (Dirty) Drain	C4 (Clean) Drain	Drain Drift
Drain depth	D	*State*	m	0.3	0.2	0.15
Top width	Wt	*State*	m	0.90	0.60	1.80
Bottom Width	Wb	*State*	m	0.30	0.20	0.60
Slope	S	*State*	Ratio	0.059	0.095	0.059
Manning's n value	n	*State*	$s/m^{1/3}$	0.012	0.012	0.012
Sectional Area	A	*Calc*	m²	0.18	0.08	0.18
Wetted Perimeter	P	*Calc*	m	1.15	0.77	1.84
Drain full Capacity	Q	*Calc*	m³/s	1.06	0.46	0.77
Drain full Capacity	Q_{full}	VxA	m³/sec	**1.1**	**0.5**	**0.8**
Runoff discharge	Q	CxIxA	m³/sec	**0.48**	**0.29**	**0.48**
% Drain full	$Q_{full\%}$	Q/Q_{full}	%	45	64	62

6.8 Lining of the Storm Water Drains

We have considered concrete lining, gabion mattresses, stone pitching and Multi cells for the stormwater drains at the Maritzburg Quarry. The lining would then be placed to a depth that is expected to carry water. The rest of the drain would be grassed with a freeboard of 500mm. i.e., 400mm as per depth on table above to be lined then the 500mm freeboard to be grassed.

The options we have looked at are:

- Concrete lining
- Gabion/river mattresses
- Stone pitching
- Multi cells (similar to hyson cells)

Stone itching was the pragmatic choice given the abundance of stone as the site is a stone quarry.

It must be reiterated that the stockpiles must be grassed to ensure they remain clean stormwater areas. The grassing must be indigenous species of grass which requires little or no maintenance.

The detailed stormwater designs can be found in Appendix A.

7.0 Floodline Determination

The floodline analysis is based on the 1:50 and 1:100-year flood events and is based on the Mpushini River adjacent to the property's western boundary. The flood line delineation has been undertaken in line with the requirements of General Notice (GN 509) of the National Water Act (Act 36 of 1998). The flood line study is based on present day conditions. The process of flood line delineations includes initially calculating the 1:50 and 1:100-year return period peak discharge values, and thereafter hydraulically simulating the peak discharge value along the watercourses of interest. A typical flood line investigation requires detailed spatial information in the form of cross-sectional survey data and/or detailed contour information to produce accurate flood line delineations. Unfortunately, no detailed spatial information was available for this study. Therefore, freely available contour data at a resolution of five metres (5 m) was sourced from the Chief Surveyor General, Department of Land Affairs. This data was used to undertake the hydraulic modelling using HEC-RAS to simulate the 1:50 and 1:100-year design floods. The floodlines produced in this study are, thus, as accurate as the available spatial data applied in this study. The resultant floodlines delineated in this study are sufficient for planning and/or WULA purposes, but not for detailed design purposes.

7.1 Design Philosophy

The entire catchment contributing to flow along the stream at the quarry was required for flood line determination. The rational equation is therefore unsuitable as it normally is used on areas not exceeding 1500Ha. The Standard Design Flood (SDF) Method was therefore used. The SDF is based on the rational equation. The difference is that instead of determining C from catchment characteristics the C is determined from statistical analysis of recorded data within the region which is then calibrated. The only inputs to this method is the area, length and slope of the main stream. The standard design flood method was developed for South Africa by Alexander to provide a uniform approach to flood calculations. The method is based on calibrated discharge coefficients for recurrence periods of 2 to 100 years. The discharge parameters are based on historical data for 29 basins in South Africa

7.1.10 Methodology

The procedure for the SDF is as follows:

Step 1: Identify the drainage basin from the the standard design flood drainage basins

The Maritzburg Quarry is in **region 24**.

Step 2: Delineate the catchment ad determine the area in km^2

The catchment was delineated and found to be 8413ha or **A = 84km²**.

Step 3: Determine the length of the main stream to the edge of the catchment

The length of the mainstream is **L = 22.4km**

Step 4: Determine the 10_85 slope (difference in elevation at 10% and 85% of the stream divided by 75% of the main stream length)

10% - 564m; 85% - 822 therefore elevation difference = 258m. 75% of the main stream length = 16.8km giving the 10_85 slope **S = 15.35m/km**

Step 5: Determine the time of concentration

$$Tc = \left[\frac{0,87L^2}{1000S_{av}} \right]^{0,385}$$

where:

T_C = time of concentration (hours)
L = watercourse length (km)
S_{av} = average slope (m/m)

Tc = 0.22hours

Step 6: Calculate Point Precipitation using the modified Hershfield equation where:

$$P_{t,T} = 1,13(0,41 + 0,64\ln T)(-0,11 + 0,27\ln t)(0,79M^{0,69}R^{0,20})$$

where:

M = mean of the annual daily maxima from **Table 3B.1**.
R = average number of days per year on which thunder was heard from **Table 3B.1**.

Table 6: Extract from table 3B.1 (SANRAL)

Basin	SAWS station number	SAWS site	M (mm)	R (days)	C_2 (%)	C_{100} (%)	MAP (mm)	MAE (mm)
24	240 269	Newlands	76	15	15	80	910	1200

M = 76mm

R = 15 days

t = 60 x Tc = 13.5mins

therefore the point precipitation is:

Table 7: Point Precipitation

Return Period	1:50	1:100
Point Precipitation (mm)	52.54	60.54

Step 7: Calculate Point Intensity

The intensity is found by multiplying the point precipitation depth by the area reduction factor ARF(%) to determine the average rainfall over the catchment for the required

return period. The intensity is then found by dividing this value by the time of concentration.

$$ARF = (90000 - 12800\ln A + 9830\ln t)^{0,4}$$

Table 8: Point Intensity

Return period	1:50	1:100
ARF (%)	81	81
P (mm)	42.50	48.97
I (mm/hour)	189.36	218.19

Step 8: Calculate the return period factors

$$C_T = \frac{C_2}{100} + \left(\frac{Y_T}{2,33}\right)\left(\frac{C_{100}}{100} - \frac{C_2}{100}\right)$$

Table 9: Return period Factors

T	2	5	10	20	50	100	200
Y_T	0	0,84	1,28	1,64	2,05	2,33	2,58

Therefore the factors are:

C_{50} - 0.3639

C_{100} – 0.40

Step 9: The flood peak Q(m^3/s) is calculated for each return period as follows:

$$Q_T = \frac{C_T I_T A}{3,6}.$$

Table 10: Flood Peaks

Return Period	1:50	1:100
C	0.3639	0.4000
I	189.36	218.19
Q (m3/s)	1608.1	2036.4

Step 10: SDF Hydrograph

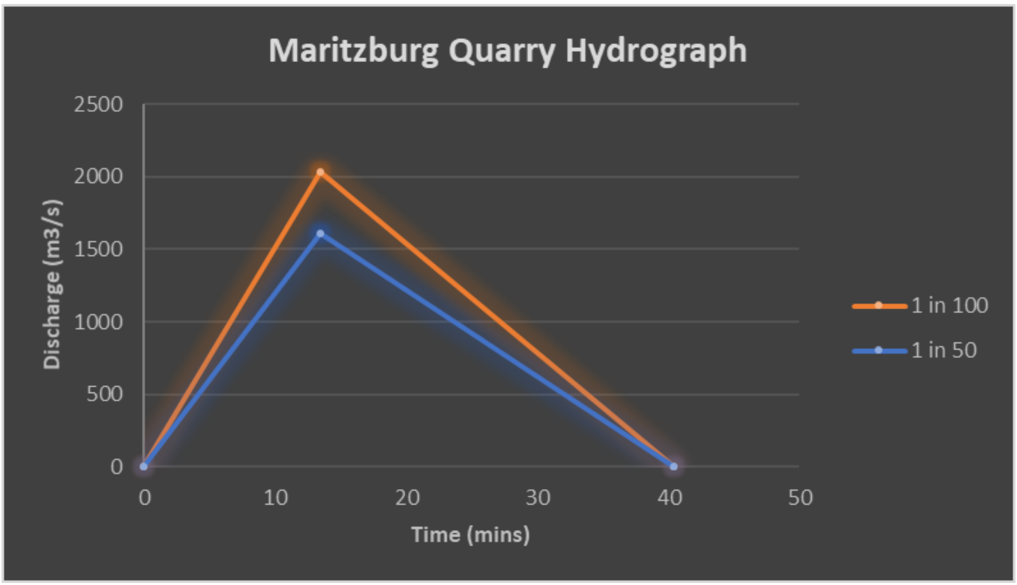

Figure 10: Maritzburg Quarry Hydrograph

7.1.11 1:100 Year Floodlines

The catchment area draining to the Pietermaritzburg quarry is largely undeveloped. The course and catchment of the Mpushini river has not been majorly modified and the natural vegetation along the river is largely one of secondary grasslands and bushed grasslands, bushland, and bushland thicket. Considering the proximity to Pietermaritzburg town there is a high risk that the flood lines will rise as Pietermaritzburg develops.

Table 11: Peak Discharges for the PMB Quarry Catchment

	TOTAL
Peak Runoff (1:50)	1608.1m^3/s
Peak Runoff (1:100)	2036.4m^3/s

The discharges were then routed using HEC-RAS through the cross sections in the study area as shown in the Figure below. The analysis was done using steady state flow as the peak discharge had already been determined.

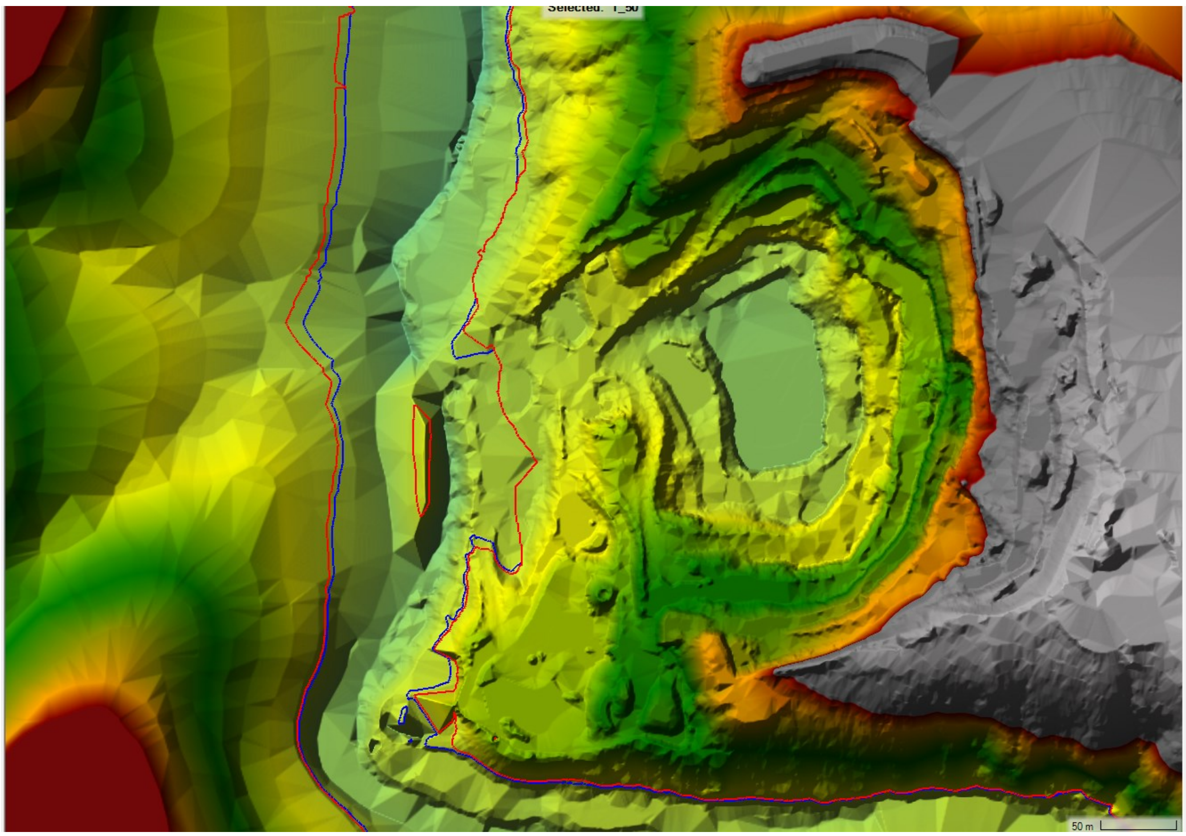

Figure 11: HEC RAS Floodline Visualisation

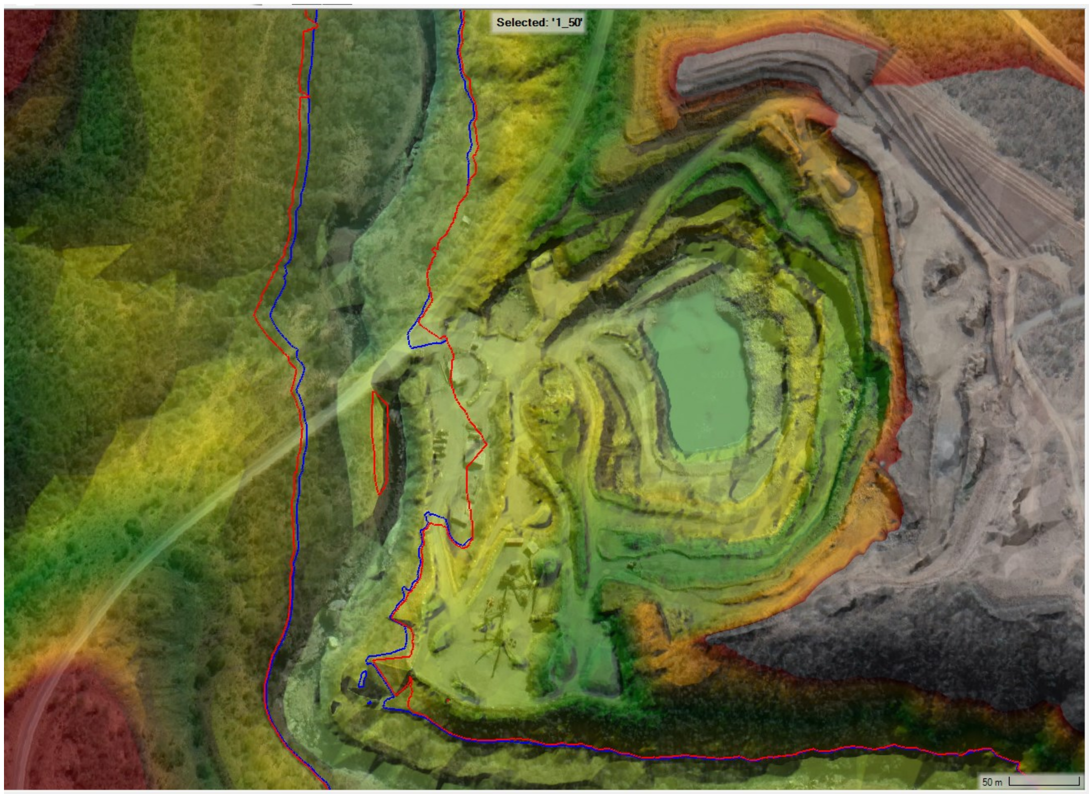

Figure 12: Hybrid Map of Imagery Over Topography Showing Floodlines

Figure 13: Satellite Imagery showing Floodlines

7.2 Stormwater Balance

Stormwater balance or climatic stormwater balance is a model that calculates the total stormwater in a system after a rainfall event.

The total rainfall = Surface runoff + infiltration + evapotranspiration + change in storage

A stormwater balance model was created using data from the nearest meteorological station, U2E001, which is located in Pietermaritzburg. The station had 17 years of historical rainfall and evaporation data. The data was averaged out in terms of the hydrological year which starts in October and ends in September. The detailed analysis is in Appendix B .

The total available storage is about 35,721m^3 calculated in the surface impoundment which can reach a level of 556m before it risks spilling out into the river. The infiltration is extremely difficult to estimate as the infiltration rate can vary between seasons and is depends on the soil's moisture levels. The site is underlain with rock .There are other pathways for water to infiltrate which could be through rock fractures and other pathways.

The quarry manager provided information that enables an average infiltration rate to be calculated using the stormwater balance model. According to the report from the manager, the impoundment has not flooded or gone empty in 5 years. This works out to an average infiltration rate of $0.037m^3/m^2$/day. This was calculated by iterating the infiltration rate until the movement of water in the surface impoundment was in line with the reports from the quarry manager.

8.0 KEY FINDINGS & RECOMMENDATIONS

Currently the site is not fully compliant with stormwater management principles in terms of GN704. Compliance can be attained by applying the recommendations in this report. An exemption will be required as the site is in contravention of regulation 4 of GN704 due to its proximity to a river and potential flooding. Water tests must be conducted on the surface impoundment before discharging into the Mpushini River.

Treatment options for the dirty water have been proposed. These can only be detailed and finalised after a detailed study of the chemical composition of the water in the surface impoundment and geohydrology has been done and approved by the Department of Water & Sanitation.

This report will ensure compliance with stormwater management but does not provide for treatment and discharge of the dirty stormwater into the river. A water use license application (WUL) will be required if Afrimat intends on emptying the impoundment into the stream.

It is recommended that the water in the surface impoundment be used to maintain and encourage the vegetal cover on the stockpiles by irrigating frequently as well as dust suppression on the internal roads. These uses will not trigger an additional water use license application.

i. In terms of Regulation 3 The Maritzburg Quarry needs to have an exemption to regulation 4 (a) & (b) due to the quarry and its facilities being within 100m from a river or within the 1:00 year floodline.

ii. It is recommended that all other regulations in GN 704 be adhered to by applying the designs in this report.

iii. Water tests must be conducted on the dirty water system to establish if there are any adverse effects on the water that prevents it from being safely discharged. *The South African Water Quality Guidelines: Volume 7 Appendix 4 provides a list of target water quality ranges for discharging water from the quarry into the environment. These would need to be met by the treatment process.*

iv. Should there be any findings, then the following additional measures will be necessary in terms of Regulation 7(a) & (b) The Maritzburg Quarry must carry out underground water monitoring upstream and downstream of the quarry in terms of geohydrological flows of groundwater to ensure the quarrying activities do not have an adverse impact on the ground water. Should the water contained in the pit be polluted measures must then be taken to purify and discharge the water. Additionally, in terms of Regulation (c) geophysics must be conducted to determine if there is potential contamination through cracked or fissured formations beneath the quarry.

Table 12: Summary of Compliance to Regulations

No	Regulation	Compliance Status
1	***Regulation 3. Exemption from requirements of regulations*** *The Minister may in writing authorise an exemption from the requirements of regulations 4, 5, 6, 7, 8, 10 or 11 on his or her own initiative or on application, subject to such conditions as the Minister may determine.*	Exemption from Minister required for Regulation 4
2	***Regulation 4: Restrictions on locality*** *No person in control of a mine or activity may*	NO - Exemption required for

No	Regulation	Compliance Status
	locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on water-logged ground, or on ground likely to become water-logged, undermined, unstable or cracked; *(a) 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 the 1:50 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, whichever is the greatest;* *(b) 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* *(c) use any area or locate any sanitary convenience, fuel depots, reservoir or depots for any substance which causes or is likely to cause pollution of a water resource within the 1:50 year flood-line of any watercourse or estuary.*	Regulation 4 (a) & (c)
3	***Regulation 6 (c): Capacity requirements of clean and dirty water systems*** *Every person in control of a mine or activity must-* *(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;*	YES – IF SWMP IS IMPLEMENTED
4	***Regulation 6 (b), (d) and (f): Capacity requirements of clean and dirty water systems*** *Every person in control of a mine or activity must-*	YES – IF SWMP IS IMPLEMENTED

No	Regulation	Compliance Status
	(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; *(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;* *(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*	
5	***Regulation 7 (a): Protection of water resources*** *Every person in control of a mine or activity must take reasonable measures to-* *(a) prevent water containing waste or any substance which causes or is likely to cause pollution of a water resource from entering any water resource, either by natural flow or by seepage, and must retain or collect such substance or water containing waste for use, re-use, evaporation or for purification and disposal in terms of the Act;*	YES – IF SWMP IS IMPLEMENTED
6	***Regulation 7 (h): Protection of water resources*** *Every person in control of a mine or activity must take reasonable measures to-* *(h) cause all domestic waste, including wash-water, which cannot be disposed of in a municipal sewage system, to be disposed of in terms of an authorisation under the Act. Regulation 10 (1)*	YES – IF SWMP IS IMPLEMENTED
7	***Regulation 7 (b), (f) and (h): Protection of water resources*** *Every person in control of a mine or activity must take reasonable measures to-* *(a) prevent water containing waste or any substance which causes or is likely to cause pollution of a water resource from entering any water resource, either by natural flow or by seepage, and must retain*	YES – IF SWMP IS IMPLEMENTED

No	Regulation	Compliance Status
	or collect such substance or water containing waste for use, re-use, evaporation or for purification and disposal in terms of the Act; *(b) design, modify, locate, construct and maintain all water systems, including residue deposits, in any area so as to prevent the pollution of any water resource through the operation or use thereof and to restrict the possibility of damage to the riparian or in-stream habitat through erosion or sedimentation, or the disturbance of vegetation, or the alteration of flow characteristics;* *(c) cause effective measures to be taken to minimise the flow of any surface water or floodwater into mine workings, opencast workings, other workings or subterranean caverns, through cracked or fissured formations, subsided ground, sinkholes, outcrop excavations, adits, entrances or any other openings;* *(f) ensure that water used in any process at a mine or activity is recycled as far as practicable, and any facility, sump, pumping installation, catchment dam or other impoundment used for recycling water, is of adequate design and capacity to prevent the spillage, seepage or release of water containing waste at any time;* *(h) cause all domestic waste, including wash-water, which cannot be disposed of in a municipal sewage system, to be disposed of in terms of an authorisation under the Act.*	

9.0 References

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APPENDIX A: Design Drawings

APPENDIX B: DESIGN CALCULATIONS