GREATER SOUTPANSBERG
MOPANE PROJECT

SURFACE WATER ASSESSMENT FOR THE ENVIRONMENTAL IMPACT ASSESSMENT

FINAL REPORT

OCTOBER 2013

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PREPARED FOR:

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TO WHOM IT MAY CONCERN

DECLARATION

We the undersigned hereby declare that as employees of WSM Leshika Consulting (Pty) Ltd which is an independent consultancy firm, we have prepared the following report

Greater Soutpansberg Mopane Project
Surface Water Assessment for the Environmental Impact Assessment
October 2013

according to requirements of applicable Acts, *inter alia* the National Water Act, Act 36 of 1998 and concomitant Regulations, free from external influence.

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GREATER SOUTPANSBERG
MOPANE PROJECT

SURFACE WATER ASSESSMENT
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LIST OF ACRONYMS

A	Area
APP	Approved Professional Person for designing and inspecting Category II and III dams in terms of Chapter 12 of the NWA
CSIR	Council of Scientific and Industrial Research
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry (pre 2009)
ECSA	Engineering Council of South Africa
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity Rating
EMP	Environmental Management Plan
IFC	International Finance Corporation
GIS	Geographical Information System
GN704	Government Notice 704 of June 1999
HecRas	Hydraulic Engineering Centre's River Analysis System
LOM	Life of Mine
mamsl	metre above mean sea level
M2	1:2-year 24 hour rainfall event
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MIA	Mining infrastructure area
MPRDA	Mineral and Petroleum Resources Development Act (Act 28 of 2002)
MRA	Mining right application
NEMA	National Environmental Management Act (Act 107 of 1998)
NFEPA	National Freshwater Ecosystem Priority Areas
NWA	National Water Act (Act 36 of 1998)
PCD	Pollution Control Dam
PDF	Probability distribution function
PES	Present Ecological State
PIA	Plant Infrastructure Area
PrEng	Professional Engineer
RHP	River Health Program
RLT	Railway Load-out Terminal
RMF	Regional Maximum Flood
RoM	Run of Mine
SANBI	South African National Biodiversity Institute
SANRAL	South African National Roads Agency
SATS	South African Transport Services
SDF	Standard Design Flood

WR90	Surface Water Resources 1990 study
WR2005	Water Resources 2005 study
WQT	Water Quality Threshold

1. INTRODUCTION

1.1 Background

WSM Leshika Consulting (Pty) Ltd was appointed by Coal of Africa Limited to undertake the surface water assessment as part ofthe Environmental Impact Assessment for the Greater SoutpansbergMopane Project.

The Mopane Project is situated in the magisterial district of Vhembe, in the Limpopo Province, approximately 40 km (direct) and 63 km (via road) north of the town Makhado and 7 km west of Mopane in the Musina and Makhado Local Municipal areas. The nearest town is Musina, located approximately 30 km to the north – refer to **Figure** Error! Reference source not found.**1.1.**Musina and Makhado are connected by well-developed road infrastructure.

The Mopane Project, consisting of the Voorburg and Jutland Sections, is well situated with respect to major infrastructure, including rail, road and power. The Mopane Railway Station is located between the Voorburg and Jutland Sections to the east and is linked to the N1 with a surfaced road of 7 km length. The Jutland Section is traversed by the R525 road linkingMopane and Alldays. Private roads to connect mine infrastructure will need to be established.

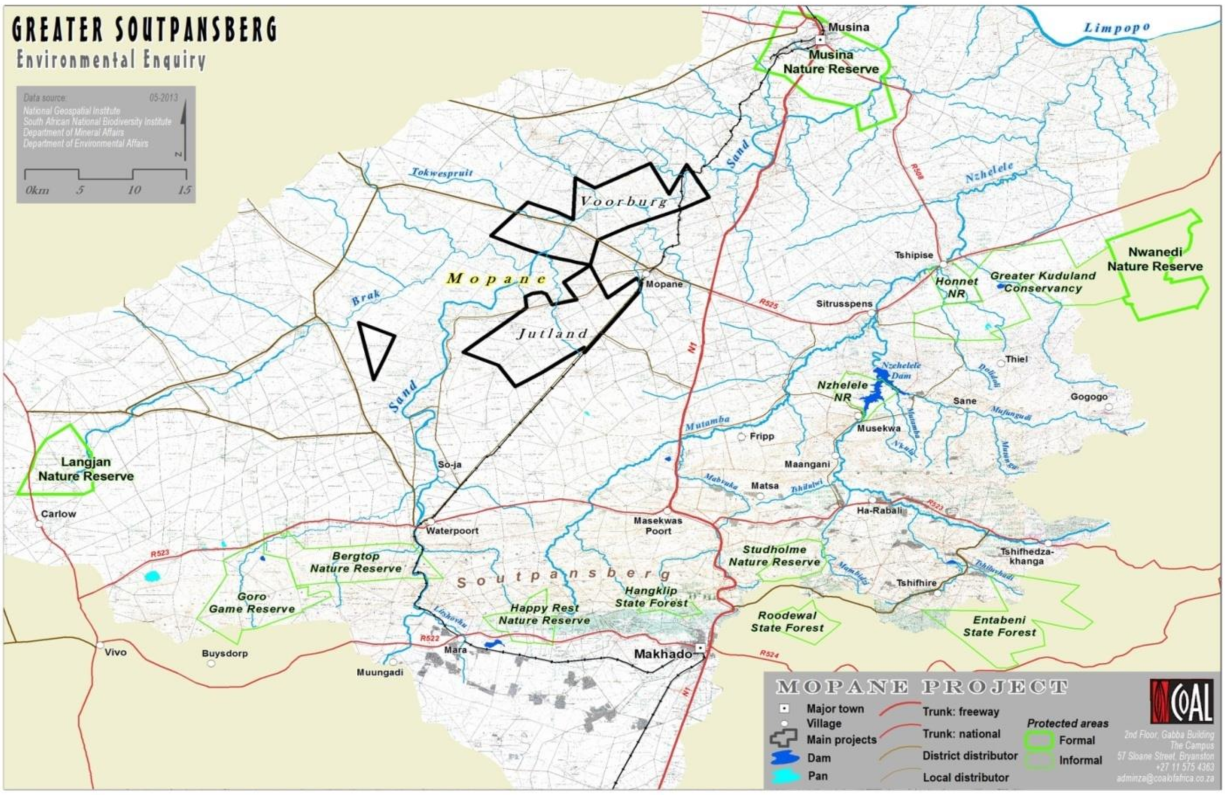

FIGURE 1.1: LOCALITY MAP

1.2 Scope of work

This report describes the results of the study done of surface water and related aspects as part of the Environmental Impact Assessment phase.

In the first step, climate data for the hot, semi-arid region has been collected asdescribed in **Section 3.1** in the report.A hydrological analysis of major stream crossingsthat may be impacted by theproposed infrastructure, as well as of the two major rivers, the Sand and Tokwe Rivers, has been done. The flood peaks thus determined were used to simulate the riverflow whereby the flood zones for various recurrence intervals were obtained. The model created in HecRasutilised the site survey to 0.5 m contour intervals. The contour map was provided by Patrick Matdibe and Associates.

River water samples were obtained and tested. The results were evaluated in respect ofaquatic, drinking water, irrigation and livestock water standards.The impact of the development on the quantity of surface water resources was determined, based on regional data described in the Water Resources 2005 study (*Middleton and Bailey 2009*). A conceptual layout of a stormwater management systems which would adhere to the requirements of Government Notice 704 (GN704) and follow the principles set out in the Best Practice Guidelines of the Department of Water Affairs (DWA), are indicated. The report concludes with an assessment of potential impacts and an identification of risks and description of proposed mitigation measures.

1.3 Project team

The team consisted of Anna M Jansen van VuurenPrEng, hydrology and hydraulics expert, assisted by Rian Coetzee, a technician experienced in surface water analyses. Their qualifications and relevant experience are summarised below. Junior staff was employed in draughting and routine analyses.

- AM Jansen Van Vuuren. Civil Professional Engineer (ECSA Reg No 770359)

  Years of experience: 34
  Academic qualifications: M Eng (Hydraulics), University of Pretoria, 1983
  B Eng (Hons)(Civils) University of Pretoria, 1977
  B Eng (Civils) University of Pretoria, 1972
  Professional societies: Fellow of SAInstitute of Civil Engineering
  Key experience:
  Anna van Vuuren is a water engineer working in the field of water supply, stormwater management, hydrology and specialised hydraulic designs. Expert in the analysis of flood lines, hydraulic characteristics related to bridge and large drainage structures, as well as urban flood studies and stormwater management. Experience is widespread and includes planning, analysis, design and construction supervision of water supply schemes and in the

field of hydrology, the calculation of main catchment area runoffs and routing of flows as well as assessment of spillway capacity for dam safety inspections. She has attended post-graduate courses on flood hydrology jointly presented by Pretoria University and the Department of Water Affairs and Forestry, RSA. She is external examiner (Hydraulics, final year) at the University of Pretoria and has contributed to the SANRAL Drainage Manual (Chapter 8).

Recent involvement in the field of mining development includes the following projects:

Stormwater study: Sishen South Iron Ore Mine, Postmasburg, Northern Cape, RSA. (2003 – 2007).*Complete assessment of surface water aspects for EIA, including floodlines and conceptual design of stormwater to divert clean water around pits and waste dumps, followed later by amendments for the changed mine layout and finally designing the structures for the surface water diversions, sizing the equipment required to dewater the pits and to pump rainwater from the pits. Client: Kumba Resources*.

Project Phoenix: Thabazimbi (2006). Project manager for the pre-feasibility study for bulk water supply and pit de-watering, including also cost estimates, a groundwater model and flood mitigation measures for the re-vitalised pit and new plant developments. Client: Kumba Resources.

Surface water assessment input to EIA/EMP of Vele Mine. (2008-2010). *Complete assessment of surface water aspects for EIA and EMP, including floodlines (for site streams and the Limpopo River) and conceptual design of stormwater systems to divert clean water around pits and plant area. Client: Jacana Environmentals cc.*

- **Rian Coetzee.** Senior Civil Engineering Technician

  Years of experience: ***16***

  Academic qualifications: National Diploma (Civil Engineering)

  Diploma (Project Management)

  Professional societies: ***None***

  Key experience:

  Rian Coetzee is a specialist in the water and sanitation fields and hydrology. He is particularly experienced in the planning of civil engineering infrastructure and in stormwater studies. He was responsible for the design and site supervision of the Glen Alpine Dam flood damage repair work and rehabilitation work of the flood damaged Capes Thorn Dam in the Limpopo Province (Spies Dam), which included the hydraulic design of the spillway, earth embankment rehabilitation and down stream protection measures. He was also responsible for the hydrological and hydraulic calculations for the Tshituni, Dutuni, Rabali and Matangari dams.

  He has undertaken numerous flood studies for development projects and his tasks included site inspections, calculations and drafting of reports. Recent involvement in related fields includes the following:

Resource assessment for the Groot Marico Eco Estate: Included project management for the geotechnical investigation, geohydrological investigation, hydrological investigation and bulk services for water and sanitation.

Water Resource Assessment in the Phalala River: Investigated water resources to augment and or supply water to the Phalala villages, population projections, water demands, report writing and compilation of GIS maps.

Strategic Planning to augment water to the Lower Steelpoort mines Identify possible sources, sizing of infrastructure, report writing and GIS.

Project Phoenix: Thabazimbi (2006).*Involved in floodline studies and water balances for the pre-feasibility study for the re-vitalised pit and new plant developments. Client: Kumba Resources.*

Surface water assessment input to EIA/EMP of Vele Mine. (2008-2010).*Involved in floodline studies (for site streams and the Limpopo River) and conceptual design of stormwater systems to divert clean water around pits and plant area. Client: Jacana Environmentals cc.*

1.4 Project description

The Mopane Project footprint covers an area of 1 572 ha for mining and a further 1964 ha for infrastructure development. The Voorburg mining pits cover approximately 905 ha and theelongated Jutland mining pitof about 12 km long, a further 667 ha. The mine footprint of the Voorburg mining pit is restricted by the Sand River running along the northern side of the mining pit.

The mining and infrastructure layouts are shown in **Figure 1.2**. This drawing demonstrates the total extent of mining and is not a moment in time. The pits will be backfilled concurrent to mining and it is anticipated that no more than 600 ha will be open at any one time.

The Mopane Project has the potential to produce good quality semi soft coking coal and a domestic thermal coal product. Measured and indicated resources are approximately 633.48 million tons mineable in situ.

The resource outcrops and dips predominantly to the north. It is estimated that in most instances it is mineable to a depth of 200 m through open cast methods. Due to the flat dipping nature of the coal resource a normal strip open cast mining method is likely to prove the most cost effective.

The current planning is that construction and mining will commence at the Voorburg Section first, followed by the Jutland Section as capacity in infrastructure is developed. The Voorburg Section will be mined at 2.5 million tonnes per annum (Mtpa) product for a period of 33 years followed by the Jutland Section mined at 2.5 Mtpaof product for a period of 28 years.

From the date of granting of the mining right (anticipated to be in 2015) further exploration, feasibility studies and final design studies will be undertaken. Construction is anticipated only to commence in 2018. Production at the Voorburg Section will commence in late 2019 and build up to 4 Mtpa Run-of-Mine (RoM) (2.5 Mtpa product) by 2020.RoM will be crushed and screened andthe product will be transported by conveyor to the beneficiation plant next to the railway loop on Jutland. Due to rail logistics constraints, mining at the Voorburg Section continues for about 33 years to exhaustion of the resource.The total life of the Mopane Project is in excess of 50 years.

It is expected that additional rail capacity will become available after 2030, allowing for an increase in coal production. Mine development at the Jutland Section will therefore commence in 2030 with first production in 2032. To cater for the additional production from 2033 onward, a further coalbeneficiation plant will be required at the Jutland Section and a new Rapid Load-out Terminal (RLT) will be built at the rail loop.

Infrastructure to support the mining activities has been laid out and engineered to best suit the topography and mining pit layouts, but can be influenced by the environmental impact assessments and stakeholder engagement process.

Although the mining operation will start at the Voorburg Section, the centre of gravity for the infrastructure layouts will be on the farm Pretorius 531 MS next to Mopane Railway Station. The Voorburg Section will however be provided with a workshop and other necessary infrastructure required for the mining operation.

The centrally located Infrastructure Hub (at the Mopane Railway Station) will comprise the coal beneficiation plant, personnel support structures, vehicle support structures, water management structures and management and monitoring systems.

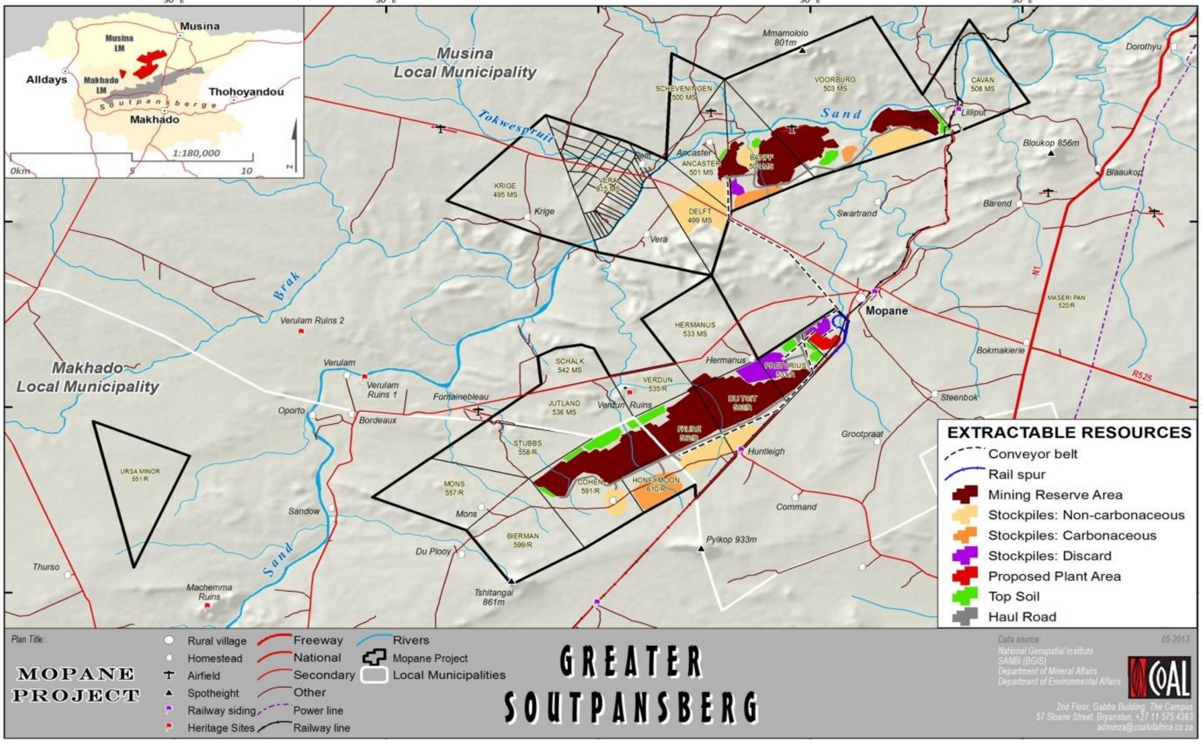

FIGURE1.2: LOCATION OF PROPOSED MINING PITS IN RELATION TO MAJOR DRAINAGE LINES

Other mine infrastructure includes:

- Access and on-site haul roads
- Topsoil stockpiles and berms
- Overburden (carbonaceous and non-carbonaceous) stockpiles for initial placement, thereafter to be disposed in-pit
- RoM coal storage area
- RoM coal processing plant (primary, secondary and tertiary crusher)
- Associated conveyors from the processing plant to the product storage areas
- Product stockpile areas
- Carbonaceous discards stockpile
- Storm water management infrastructure (i.e. clean & dirty water run-off canals and dams)
- On-site water management and reticulation systems
- Change houses and offices
- Wastewater (sewage) treatment plant
- Bulk electricity supply infrastructure
- Bulk water supply infrastructure
- Railway Siding and rail loop
- Rapid Load-out Terminal (RLT)

2. APPLICABLE LEGISLATION

2.1 South African legislative and standards frameworks

The methodology followed in the surface water assessment is largely prescribed by the legal requirements, as elaborated on in the best practice guidelines. In this regard the following Acts and guideline documents are of relevance:

Mineral and Petroleum Resources Development Act (MPRDA) (Act 28 of 2002) and relevant regulations
National Environmental Management Act (NEMA) (Act 107 of 1998) and relevant regulations
National Water Act (NWA) (Act 36 of 1998)
Government Notice No. 704 (GN 704) (June 1999) on the use of water for mining and related activities aimed at the protection of water resources
DWAF’s Best Practice Guidelines:

G1 for Stormwater Management (2006)

G2 for Water and Salt balances (2006)

G3 for Water Monitoring Systems (2006)

A5 for Water Management for Surface Mines (2006)

(Note that not all of the BPG's are deemed relevant for the EIA/EMP phase, since some focus on detail design issues)

Mining and associated infrastructure development is guided by the provisos in the GN 704, particularly regulations 4, 6 and 7.

Locality is addressed in regulation 4, where estimated flood zone widths are set as buffer zones for development, or zone widths are prescribed, as summarised hereunder:

a. No facility, including residue deposits, dam, reservoir within the 1:100-year floodline or within 100 m from any watercourse, borehole or well
b. No underground or opencast mining or any other operation or activity under or within the 1:50-year floodline or within a horizontal distance of 100 m, whichever is the greatest
c. No disposal of any residue or substance likely to cause pollution of a water resource in the workings of any underground or opencast mine
d. No placement of any sanitary convenience, fuel depots reservoir for any substance likely to cause pollution within the 1:50-year floodline

The *capacity requirements* of clean and dirty water systems are given in regulation 6 and the relevant issues are listed below:

(i) Clean water systems should not spill into any dirty water system more than once in 50 years
(ii) Likewise, any dirty water system should not spill into clean water systems more than once in 50 years
(iii) Any dam that forms part of a dirty water system to have a minimum freeboard of 0.8 m above the full supply level
(iv) In summary, the water systems should be designed, constructed and maintained to guarantee the serviceability for flows up to and including the 1:50-year flows

Measures to *protect water resources* are listed in regulation 7 and include for the collection and re-use, evaporation or purification of water containing waste; measures to be taken to minimise the flow of any surface water into any mine or opencast workings; prevention of erosion or leaching of materials from any stockpile; ensuring that process water is recycled as far as practicable.

Of note is the fact that exemption from requirements of regulations 4 to 8 and 10 to 11 may be obtained from the Minister.

In the conceptual designs proposed here, the regulations are adhered to with the major exception of item (b) above, where it is proposed that the north western portion of the East pit is extended to areas within the 1:50-year floodline, but outside of the 100 m limit. This aspect is discussed in more detail in **Section 4.3** below.

The *major stormwater management principle* prescribed in GN 704 is the one indicating that clean and contaminated stormwater should be kept separate by draining contaminated water to lined dams or ponds for re-use or evaporating and diverting clean stormwater around dirty areas.

Based on the above requirements, the first step in the surface water study is to estimate the flood peaks along affected drainage lines and determine the associated flood zone widths. For this exercise proper site survey data is required to apply standard, accepted methods such as the Rational Method or to do statistical analyses of available data to determine the flood peaks. By using the survey data to model the river flow in the HecRas software, the flood widths are determined. The results of this exercise are described in **Section 3**.

By overlaying the proposed development on the site map, the layout of an adequate stormwater management system is determined and conceptually designed, as described in **Section 6** of this report.

2.2 International standards and guidelines

The IFC performance standards and guidelines and Equator principles were studied and the present conclusion is that most of the aspect listed in these documents had been covered by the local legislation and standards.

2.3 Licencing requirements

The following applications and licences for surface water will probably be required by the Department of Water Affairs and Forestry, in terms of the National Water Act (Act 36 of 1998):

Art 21: Licencesmay be required for the following water uses:

Taking water from a water resource
Storing water
Impeding or diverting the flow of water in a watercourse
Disposing waste
Altering the bed, banks, course or characteristics of a watercourse

Art 27: Considerations for issue of general authorisations and licences

Art 25(2):Transfer of water use authorisations

Art 120: Registration of a dam with a safety risk

If any of the storage dams has a wall higher than 5 m and a capacity larger than 50 000 m^3, the dam must be registered at DWAF. If classified as a category 2 dam, it must be designed and the construction monitored by an Approved Professional Person (APP).

The procedure for applying for a licence is set out in Article 41 of the NWA.

3. DESCRIPTION OF THE BASELINE ENVIRONMENT

3.1 Regional Climate

The Mopane Project area is situated in a semi-arid zone to the north of the Soutpansberg. The regional climate is strongly influenced by the east-west orientated mountain range which represents an effective barrier between the south-easterly maritime climate influences from the Indian Ocean and the continental climate influences (predominantly the Inter-Tropical Convergence Zone and the Congo Air Mass) coming from the north.

The rainfall in this area usually varies between 300 to 400 mm in summer, while experiencing very dry winters. The area is characterized by cool, dry winters (May to August) and warm, wet summers (October to March), with April and September being transition months.

The mountains give rise to wind patterns that play an important role in determining local climates. These wind effects include wind erosion, aridification and air warming.

3.2 Temperature

Average monthly minimum and maximum temperatures for the Tshipise weather station (No. 0766277 1) some 32 km south-east of the Mopane Project area is shown in **Table 1** below. Note that this station is the closest station with long term available climate data. Average daily maximum and minimum summer temperatures (November to February) at the weather station range between ~33°C and ~20°C, while winter temperatures (May to August) range between ~28°C and ~7°C respectively. The high average temperatures are reflected by the fact that the minimum average daily summer temperature is a high 20°C and the minimum average daily winter temperature does not dip below 7°C.

Table 1: Temperature data for Tshipise for the period from 1994 to 2006

Month		Temperature (° C)		
	Highest Recorded	Average Daily Maximum	Average Daily Minimum	Lowest Recorded
January	42.2	32.8	21.5	12.6
February	41.4	32.3	21.5	14.9
March	42.9	31.5	20.1	13.0
April	40.9	30.1	16.3	5.7
May	42.3	27.9	11.2	1.7
June	34.3	25.6	8.2	-0.4
July	34.1	25.0	7.3	-1.2
August	37.4	27.8	10.3	1.7
September	41.2	27.7	12.9	3.6
October	41.4	29.1	16.5	8.0

November	42.5	32.2	20.1	11.1
December	43.4	33.1	21.0	13.8
Year	43.4	29.6	15.6	-1.2

Source: Weather SA (Station No 0766277 1)

The Department of Agriculture's Agricultural Geo-referenced Information System (AGIS) hosts a wide spectrum of spatial information maps for public use. The two figures below, **Error! Reference source not found.3.1** and **Error! Reference source not found.3.2,** indicate the maximum and minimum annual temperature for the region that was obtained from their natural resources atlas on climate.

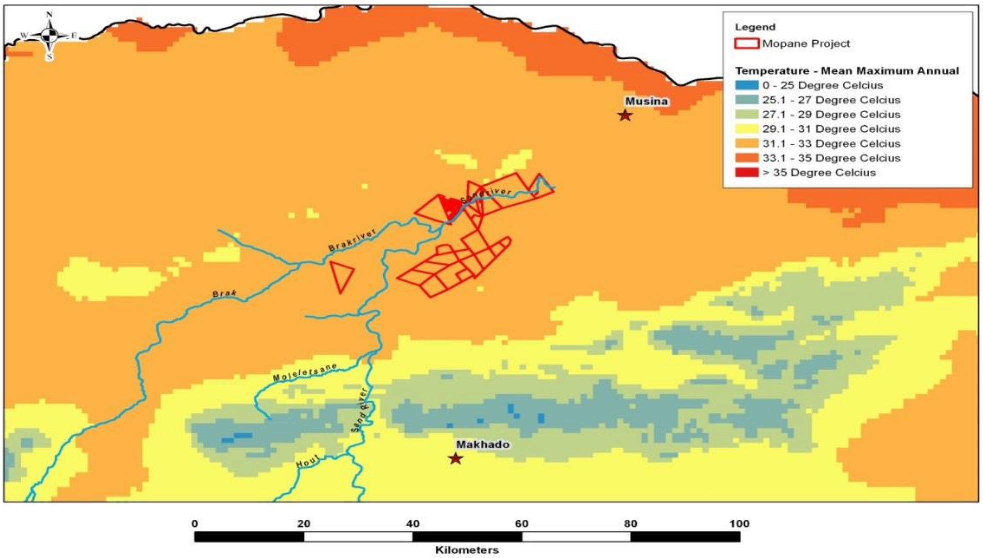

FIGURE 3.1: MEAN ANNUAL MAXIMUM TEMPERATURE

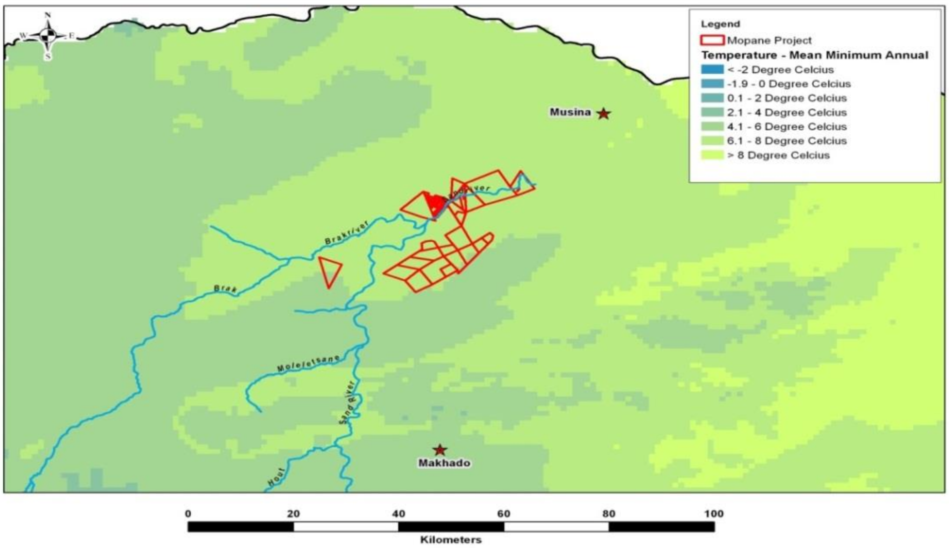

FIGURE 3.2: MEAN ANNUAL MINIMUM TEMPERATURE

3.3 Mean Annual Precipitation and Mean Monthly Rainfall

The Mopane Project is situated within the Sand River Basin, which is a tributary of the Limpopo River. The Sand River originates south of Polokwane in a cold semi-arid zone summer rainfall area of 500 to 600 mm precipitation. In the hot-arid zone to the north of the Soutpansberg, however, the rainfall decreases to 200 -300 mm. High precipitation occurs on the Soutpansberg which creates high local run-off. The Basin's mean annual precipitation (MAP) distribution is shown in **Figure 3.5**below.

Note that the region is also within the impact zone of tropical cyclones occurring in the Indian Ocean which may cause high-intensity rainfalls leading to peak run-off events. These events occurred here for example in 1958 (Astrid), 1976 (Danae), 1977 (Emily) and 2000 (Eline) (*Van Bladeren and Van der Spuy, 2000*).

The Mopane Project falls however within the hot-arid zone to the north of the Soutpansberg that has a MAP in the low 300mm range.

The project spans across three quaternary catchments A71J, A71K and A72B, defined in the WR2005 Study (Middleton and Bailey, 2009) as described in **Section 3.5**.

All three quaternary catchments are located in Rainfall Zone A7C. The mean monthly precipitation values are given in **Table 2**below. The maximum monthly rainfall of 20.49% occurs in January and the lowest of 0.31% in August.

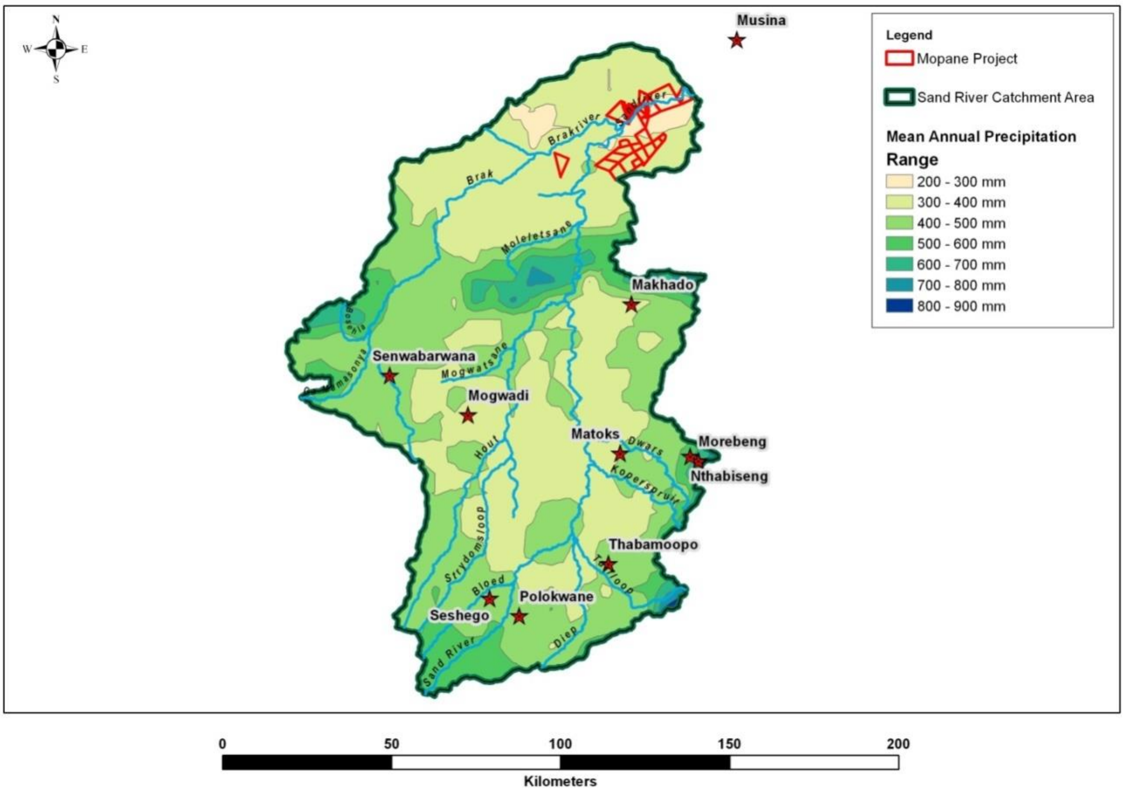

FIGURE 3.3: SAND RIVER BASIN MEAN ANNUAL PRECIPITATION

Table 2: Mean monthly rainfall distribution of site rainfall (Zone A7C)

Rainfall Zone	Mean Monthly Precipitation (% Distribution)											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A7C	7.37	14.96	17.25	20.49	17.07	11.84	5.21	2.04	1.14	0.67	0.31	2.40

(Source: Middleton, B.J.and A.K. Bailey (2009). Water Resources of South Africa, 252005 Study. WRC Rep No TT381. Pretoria)

The absolute monthly rainfall (% distribution x MAP) in the site quaternary catchments are shown in **Table 3**below. The average rainfall for the three catchments have been determined and the maximum rainfall of 71mm occurs in January and the lowest of 1mm in August. The data in the table is shown in the bar chart below (**Error! Reference source not found..6**).The quaternary catchments are shown in **Figure 3.7**.

Table 3: Mean monthly quaternary rainfall (mm)

Quaternary Catchment	Mean Annual Precipitation (mm)	Rainfall Zone	Mean Monthly Precipitation (mm)											
			OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A71J	396	A7C	29	59	68	81	68	47	21	8	5	3	1	10
A71K	305	A7C	22	46	53	63	52	36	16	6	3	2	1	7
A72B	344	A7C	25	51	59	70	59	41	18	7	4	2	1	8
Average	**348**		**26**	**52**	**60**	**71**	**59**	**41**	**18**	**7**	**4**	**2**	**1**	**8**

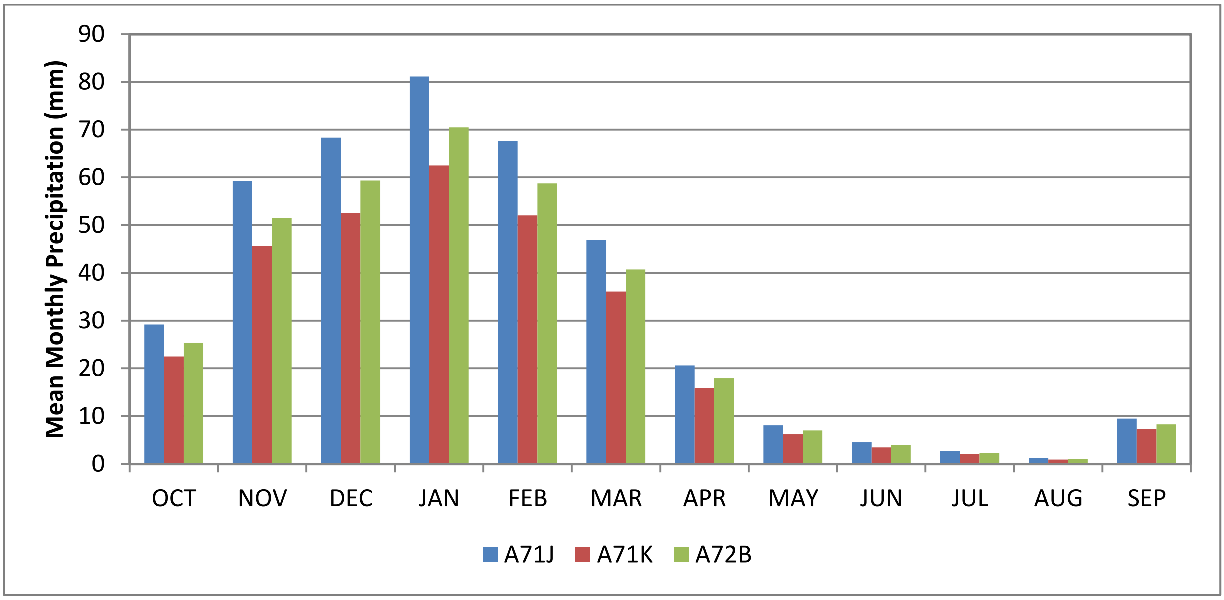

FIGURE 3.4: DISTRIBUTION OF MEAN MONTHLY PRECIPITATION IN MM

The rainfall data that was used in the flood peak determinations was taken from SA Weather Services' rain gauge 765007 at "Bandur", which is only about 20 km west of the site. This station has a record length of 40 years and a MAP of 284 mm. Its mean maximum annual daily rainfall value (or 'M2') is 50 mm. This value is used in one of the flood peak estimation methods, the so-called Alternative Rational Method (Kruger, 2006) where site specific data should preferably be used. The station MAP of 284 mm is 18% less than the average MAP of catchments A71J, A71K and A72B shown in **Table 3**above. This illustrates the variability in rain gauge data which can sometimes not be explained by physical features such as a higher location. In this instance the lower value probably reflects the lower rainfall generally experienced towards the west. Other flood peak estimation methods based on the MAP would use the average values given in **Error! Reference source not found.**.

3.4 Run-off and Evaporation

The quaternary catchments in the region of the proposed development as defined in the WR90 Study (Midgley et al, 1994) are shown in**Figure 3.7**. The Mopane Project area is situated within catchment areas A71J, A71K and A72B. The total net catchment area at the point where the Sand River exits the site, is 12 759 km^2.

The catchment hydrological data of this summer rainfall region are summarized in **Error! Reference source not found.** below. Note that catchments A71J and A72B include endoreic areas, i.e. areas which do not contribute run-off to defined continuous streams. The Mean Annual Runoff (MAR) values are based on the net catchment areas shown in the table.

Run-off data were generated on a quaternary catchment area scale in the WRSM2000 model, an enhanced version of the original Pitman rainfall-run-off model which was calibrated using available long-term runoff records. Note that the MAR in the Sand River is not reflected in the table since it shows the ***naturalized run-off*** generated **within the catchment**. To obtain the present run-off, all surface water uses in the catchment area must be subtracted.

Table 4: Catchment data (from WR2005)

Quaternary catchment	Net area (km^2) A	Mean Annual Precipitation (mm) MAP	Mean Annual Run-off (mm) MAR	Mean Annual (gross) Evaporation (mm) MAE (Zone 1B)	Irrigation area (ha)	Forest area (ha)
A71J	905	396	9.69	1800	286	0
A71K	1668	305	4.49	2000	7	0
A72B	1269	344	5.66	1950	154	0

The naturalized run-off in the Sand River at the outlet of quaternary catchment A71K have been compiled from data in WR2005 and the resultant MAR is 80.96 million m^3/a as shown in **Error! Reference source not found. 5**. The naturalized unit run-off, based on the net catchment area of 12 759 km^2, amounts to 6.3 mm. Note that the DWA Internal Strategic Perspective (ISP) document gives the unit run-off for the Sand River as a mere 1 mm, but this may be based on current conditions, i.e. it includes for abstractions.

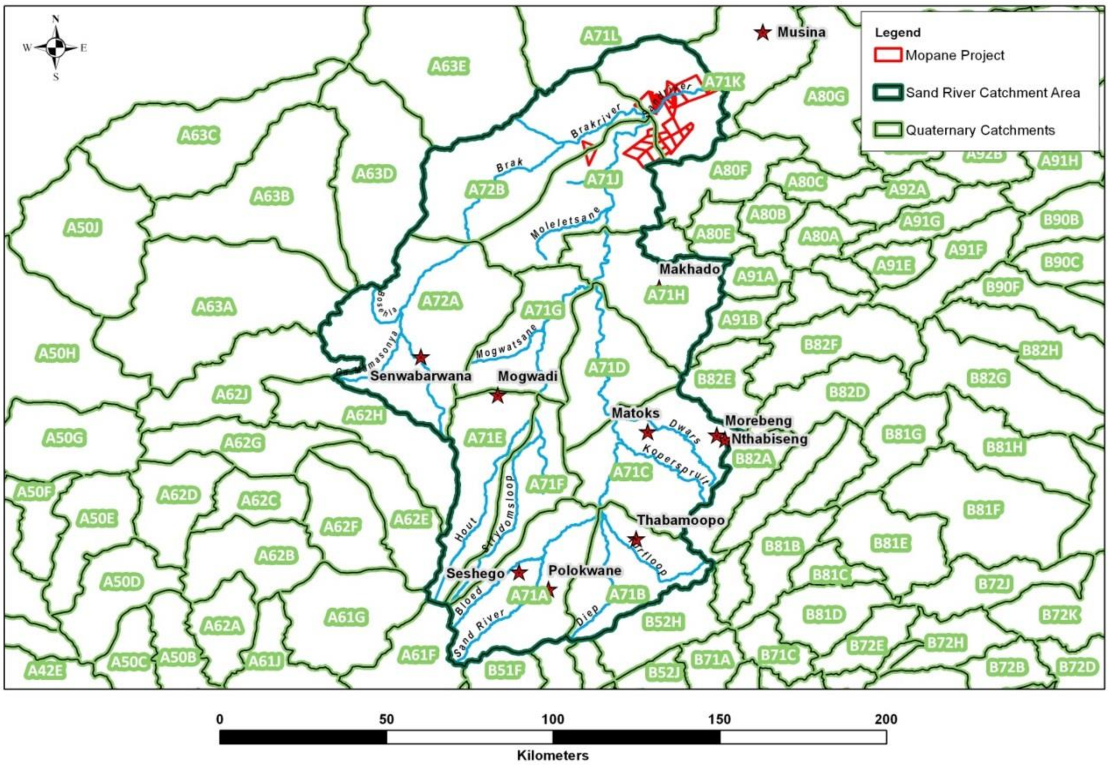

FIGURE 3.5: QUATERNARY CATCHMENTS AFFECTED BY THE PROPOSED DEVELOPMENT

Table 5: Sand River naturalized run-off

Quaternary Catchment (km^2)	Net Catchment Area (km^2)	River(s)	Naturalized MAR (million m^3/a)
A71A	1 144	Sand and Bloed	8.75
A71B	882	Diep and Turfloop	6.25
A71C	1 331	Sand, Dwars and Kopersspruit	7.16
A71D	892	Sand	3.73
A71E	893	Hout	4.01
A71F	683	Strydomsloop	2.63
A71G	875	Hout and Mogwatsane	4.46
A71H	894	Sand	11.37
A71J	905	Sand and Moleletsane	8.77
A72A	1 323	Brak, GaMamasonya and Bosehla	9.14
A72B	1 269	Brak	7.19
A71K	1 668	Sand	7.5
Total Net Catchment Area	**12 759**	**Total MAR (million m^3/a)**	**80.96**

The mean monthly naturalized run-off data for the two major affected catchments, A71J and A71K, is shown in **Table 6**.

Table 6: Simulated average naturalized monthly run-off for quaternary catchments A71J and A71K

Quaternary Catchment	Area (km^2)	Mean Monthly Natural Run-off (mm)												MAR (mm)
		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	
A71J	905	0.14	0.30	0.42	2.37	4.30	1.42	0.19	0.12	0.11	0.11	0.10	0.10	9.69
A71K	1668	0.09	0.19	0.26	0.92	1.93	0.69	0.11	0.07	0.06	0.06	0.06	0.06	4.49

Mean Annual Evaporation data is given in**Table 4**above, while the monthly evaporation pattern (as percentages of the total) is given in **Table 7**below.

Table 7: Monthly evaporation distribution (Source: WR90 Study, Evaporation zone 1B)

Month	Evaporation (%)
October	10.46
November	10.03
December	10.68
January	10.43
February	8.49
March	8.49
April	6.94
May	6.55
June	5.40
July	6.08
August	7.42
September	9.03

3.5 Surface Water

3.5.1 Locality and background information

Error! Reference source not found.3.8 below shows the Jutland and Voorburg Sections in relation to the lower quaternary catchments areas of the Sand River. The Sand River Basin is regarded as by far the driest of the river basins in the Limpopo River Water Management Area (WMA) (*ISP, Limpopo WMA, DWA 2004*). The surface water resources are thus regarded as very limited and there is no scope for construction of dams.

The existing major dams in the catchment are located upstream namely:

- Seshego Dam in the Blood River (Polokwane Local Municipality)
- Hout River Dam (supply to rural villages)
- Turfloop Dam in the south-eastern part of the Basin
- Spies Dam in the Dorps River about 20 km west of Louis Trichardt

- Brak River Dam, west of the Voorburg area.

There is no government developed irrigation scheme but extensive private and commercial irrigation schemes have been developed, mostly in the central reaches of the basin. The bulk of the water requirements are metalmost exclusively by the ample groundwater resources.(*Limpopo WMA Water Resources Situation Assessment, DWA 2002*).

In the upper region of the Basin, Polokwane and other larger towns rely on transfers of water from other WMA's.

The proposed Mopane Project is located in the downstream portion of the Basin, about 50 km (measured along the river) from the Sand River's confluence with the Limpopo River. The Voorburg Section is almost wholly inside Quaternary Catchment A71K, while the Jutland Section is about halfway within each of Catchments A71K and A71J. Hydrological data of the quaternary catchments are given in **Section 3.5.**

The flow in the lower Sand River, its tributaries and minor streams is highly ephemeral. Run-off occurs after rainfall events, with flow in the main stem of longer duration after major, wide-spread rainfall in its catchment area.

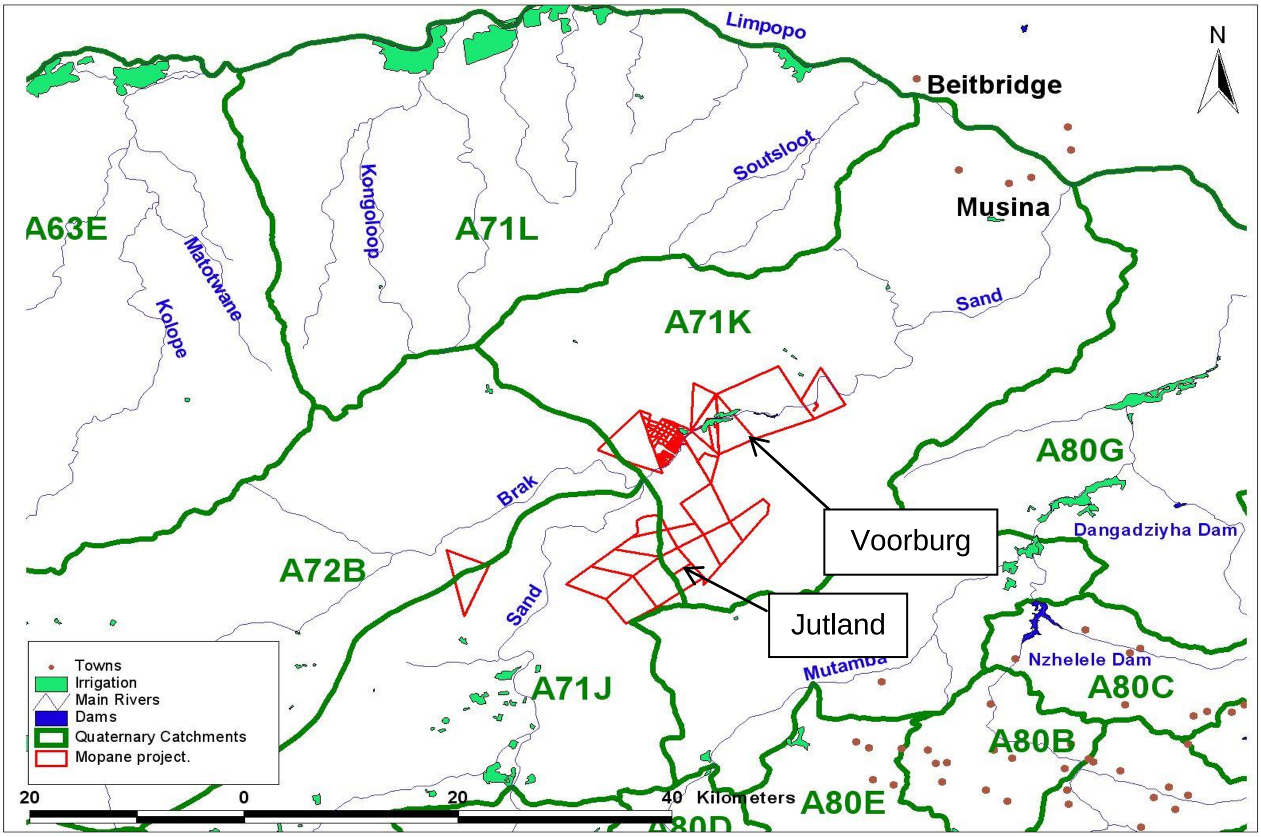

FIGURE 3.6: MOPANE PROJECT IN RELATION TO THE LOWER QUATERNARY CATCHMENTS AREAS OF THE SAND RIVER

3.6.2 Surface water quality

According to the Water Resource Situation Assessment(*DWA, 2002*), the upper and central Sand River receive “large quantities” of industrial and domestic effluent from large towns and high density rural towns along its banks. The mineralogical water quality of the whole of the catchment was thus classified as “marginal”.

In contrast to this assessment, the ISP study (*DWA, 2004*) states that apart from problems with groundwater quality in the Vivo and Dendron areas there are no major water quality problems in the Sand River Key Area (the Key area includes the Sand River Basin and other smaller rivers draining to the Limpopo River).

A Baseline Study of the water chemistry of the Limpopo Basin (*Univ. of Zimbabwe, 2009*) found that in the Vhembe District, which includes the Sand River, nitrate levels increased with groundwater flow towards the Sand River and high levels of nitrate were recorded in both the river and alluvial groundwater during the raining season. It was suggested that the nitrate is from dry land cropping, overgrazed pastures and, in some areas, pit latrines. High fluoride was noted in the area north of the Soutpansberg and has been attributed to high evaporation.

DWA has river water quality monitoring stations at Waterpoort (22°54'37" S 29°26'41" E) which is 64 km upstream of the site and at Dorothy (22°54'37" S 29°26'41" E) which is 17 km downstream of the site.

Table 8: Water quality measured at Dorothy (Station A7H009)

Macro-elements													
Element	Unit	DWA Gauge "Dorothy" : STATION A7H009 in Quaternary Catchment A71K								Aquatic Ecosystem WQT	Drinking Water WQT	Agriculture WQT (irrigation)	Agriculture WQT (livestock)
DATE		12/1997	3/1998	5/2000	11/2000	04/2001	07/2001	11/2001	12/2001				
pH		8.46	8.55	8.49	8.62	8.07	8.6	7.9	8.6		6.0 - 9.0	6.5-8.4	
E.C	mS/m	55.8	75.3	210	319	317	377	32.6	258		150	40	
TDS	mg/l										1000		1000
NO_3	mg/l	0.02	0.02	0.056	0.02	0.02	0.055	0.020	0.055	0.5	6	5	100
F	mg/l	0.27	0.4	0.326	0.347	0.368	0.51	0.27	0.44	0.75	1	2	2
SO_4	mg/l	2	21	155	293	273	321	17	209		400		1000
Cl	mg/l	46	95	343	742	730	866	24	507		200	100	1500
Ca	mg/l	34	32	91	85	94	103	17	73		150		1000
Mg	mg/l	21	25	74	124	112	149	10	87		100		500
Na	mg/l	47	91	193	406	401	453	28	290		200	70	2000
TAL	mg/l	219	247	285	207	248	297	107	227				
HCO3	mg/l												
CO3	mg/l												
P	mg/l												

NOTE: VALUES IN GREEN SHOW CONSTITUENTS WHERE RANGE TESTED NOT FINE ENOUGH TO COMPARE TO TARGET WATER QUALITY RANGE

Table 8above includes the eight most complete set of results of the eleven sets available for "Dorothy" but spans the whole of the sampling period. It shows elevated levels of pH, Electrical Conductivity (EC), chloride, magnesium and sodium when compared to the drinking water and Irrigation Water Quality Target(WQT) Guidelines. This may be attributed to the upstream irrigation activities.

Table 9: Water quality measured at Waterpoort (Station A7H001)

Macro-elements												
Element	Unit	DWA Gauge "Waterpoort" : STATION A7H001 in Quaternary Catchment A71J							Aquatic Ecosystem WQT	Drinking Water WQT	Agriculture WQT (irrigation)	Agriculture WQT (livestock)
DATE		4/2000	12/2001	10/2002	01/2003	04/2004	08/2005	02/2006				
pH		8.2	8.5	8.2	7.9	7.8	7.8	7.7		6.0 - 9.0	6.5-8.4	
E.C	mS/m	70	253	20	36	19	10	10		150	40	
TDS	mg/l									1000		1000
NO_3	mg/l	0.8	0.02	0.07	0.12	0.06	0.04	0.04	0.5	6	5	100
F	mg/l	0.21	0.41	0.13	0.23	0.1	0.05	0.11	0.75	1	2	2
SO_4	mg/l	34	207	6	16	7	2	5		400		1000
Cl	mg/l	105	565	12	41	13	8	6		200	100	1500
Ca	mg/l	34	77	14	23	14	8.5	5		150		1000
Mg	mg/l	22	92	8	8	7	3	3		100		500
Na	mg/l	64	287	7	28	10	4	6		200	70	2000
TAL	mg/l	34	207	6	16	7	2	5				
HCO3	mg/l											
CO3	mg/l											
P	mg/l											
NOTE: VALUES IN GREEN SHOW CONSTITUENTS WHERE RANGE TESTED NOT FINE ENOUGH TO COMPARE TO TARGET WATER QUALITY RANGE												

Table 9 above shows water results of DWA for the most recent seven years as measured at Waterpoort gauge. This station has a long record of monthly sampling but these values were selected to give an indication of more recent water quality, albeit upstream of the site and of the irrigation areas. Elevated levels of pH, EC, chloride and sodium occurred after the extreme flood of 2000 and also in the following year. Instead of a dilution effect, this data may indicate the effect of higher wash-off from contaminated areas.

Table 10: **Mopane Project Water Samples Collected By WSM Leshika**

Macro-elements												
Element	Unit	Mopane project samples taken by WSM Leshika: 27 June 2013							Aquatic Ecosystem WQT	Drinking Water WQT	Agriculture WQT (irrigation)	Agriculture WQT (livestock)
NAME		27	28	29								
pH		8.53	8.18	7.47						6.0 - 9.0	6.5-8.4	
E.C	mS/m	254	208	13.7						150	40	
TDS	mg/l	1697	1269	67						1000		1000
NO_3	mg/l	0.478	-0.017	-0.017					0.5	6	5	100
F	mg/l	0.692	0.286	0.105					0.75	1	2	2
SO_4	mg/l	238	176	-0.04						400		1000
Cl	mg/l	572	522	9.15						200	100	1500
Ca	mg/l	84	94.9	12						150		1000
Mg	mg/l	133	97.2	5.52						100		500
Na	mg/l	387	257	5.97						200	70	2000
TAL	mg/l	451	183	52.5								
HCO3	mg/l											
CO3	mg/l											
P	mg/l											

Figure 3.9 shows the localities of the proposed long term surface water monitoring points. Only three samples (shown as blue balloons in **Figure 3.9**) could be collected in the site visit undertaken in June 2013 due to the dry river or to inaccessibility. Note that sample S28 was collected slightly downstream of the proposed site WAT2 and sample S29 was taken close to site WAT8 at Waterpoort.

The samples taken at Sites 27 and 28 were from slow moving water in shallow ponds and the high EC and TDS values (as reflected in the elevated values for chloride, magnesium and calcium) probably indicate the effect of evaporation.

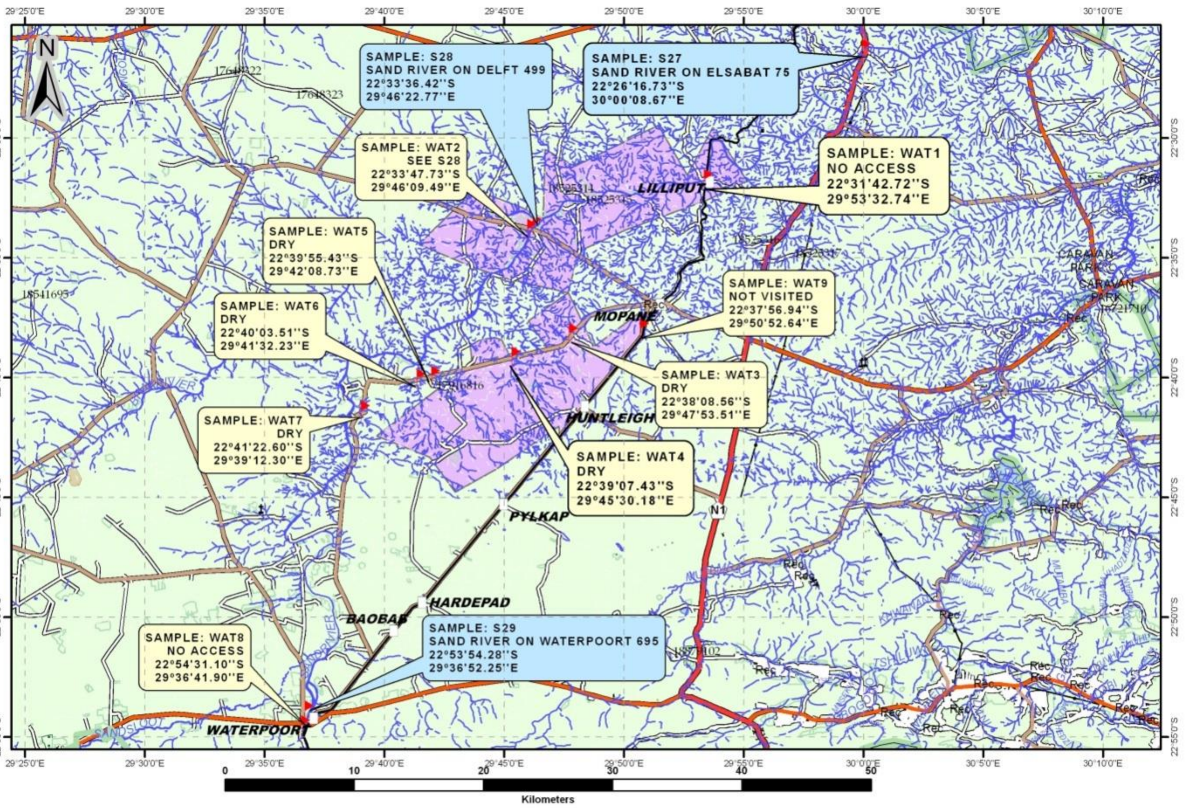

FIGURE 3.7: WATER QUALITY MONITORING POINTS

3.6.3 Current land use and water demands

The Sand River area north of the Soutpansberg is sparsely populated and apart from Musina close to the Limpopo River there are no other major towns within the catchment area.

The farm land is used for cattle and game farming, as well as irrigation from the Sand River alluvial deposits (classified as groundwater use) and from boreholes in fractured aquifers. Not all of the cleared land identified on satellite imagery is currently under irrigation. The extent of irrigation depends, amongst other factors, on the availability of water in the alluvial sand deposits of the Sand River and thus varies from year to year. As shown in **Farms in** the Jutland Section mine application area that were not surveyed for various reasons (Schalk, Stubbs, Mons, Bierman) have no cleared or cultivated lands and are therefore either game or cattle farms with low groundwater abstraction volumes. A conservative estimation of 4 Mℓ/annum abstraction per farm was allocated.

, the cleared land in the Voorburg Section amounts to 416 ha while the irrigated land is only estimated as 141 ha. The cleared land on the Jutland Section totals 46 ha of which only 8 ha is irrigated. This totals 149 ha of irrigation, all located within quaternary catchment A71K, though the WR2005 study indicates (**Error! Reference source not found.**) that only7 ha of irrigation occurs in this catchment. There are 6 ha of cleared fields on the farm Verdun in the Jutland Section within quaternary catchment A71J. Most of the 286 ha under irrigation in A71J as indicated in the WR2005 study (**Error! Reference source not found.)** is thus located in the southern part of the catchment, close to Waterpoort.

Of importance, however, is the possible downstream impact of the mining activity on surface water use. The downstream use is limited to irrigation from the river for a small present development, stock and game drinking water as well as the requirements of riverine vegetation. It must be noted that groundwater sources are also utilized for drinking water by households, cattle and game because of the ephemeral nature of river and stream flows.

The abstraction quantities shown in **Table 11**, in the absence of measured data, are regarded as conservative (i.e. an overestimation based on an abstraction rate of 10 000 m^3/ha/annum, or 1 000 mm gross application).

The total existing abstraction for the Voorburg section is estimated at a maximum of 1 147 Mℓ per annum most of which is abstracted from the alluvial deposits in the Sand River (1 110 Mℓ per annum).

The total existing abstraction for the Jutland area is estimated at 180 Mℓ per annum abstracted from the secondary hard rock aquifers.

Farms in the Jutland Section mine application area that were not surveyed for various reasons (Schalk, Stubbs, Mons, Bierman) have no cleared or cultivated lands and are therefore either game or cattle farms with low groundwater abstraction volumes. A conservative estimation of 4 Mℓ/annum abstraction per farm was allocated.

Table 11: Estimated groundwater use (Source: Mopane Groundwater Study, WSM Leshika, October2013)

Project Section	Farm	Cleared land	ha under irrigation	Water Use kl/day	Water Use Ml/ annum	WARMS (Ml/ annum)	Assessment Method
Voorburg	Ancaster	84	35	755	276	276	sensus
	Banff	90	36	777	283	297	sensus
	Delft	77	40	863	315	99	sensus
	Vera	160	30	647	236	892	sensus
	Voorburg	-	-	76	28	80	sensus
	Krige	-	-	10	4	92	Inferred
	Cavan	-	-	5	2	-	Inferred
	Scheveningen	5	-	10	4	-	Inferred
	TOTAL	**416**	**141**	**3143**	**1147**	**1736**	
Project Section	Farm	Cleared land	ha under irrigation	Water Use kl/day	Water Use Ml/ annum	WARMS (Ml/ annum)	Assessment Method
Jutland	Bellevue	-	-	5	2	-	sensus
	Cohen	-	-	18	7	-	sensus
	Du Toit	-	-	42	15	-	sensus
	Erasmus	-	-	72	26	-	sensus
	Faure	-	-	2	1	-	sensus
	Hermanus	40	2	60	22	-	sensus
	Honeymoon	-	-	9	3	-	sensus
	Jutland	-	-	20	7		sensus
	Pretorius	-	-	45	16	-	sensus
	Verdun	6	6	178	65	4	sensus
	Vrienden	-	-	3	1	-	sensus
	Schalk	-	-	10	4	-	inferred
	Stubbs	-	-	10	4	-	inferred
	Mons	-	-	10	4	-	inferred
	Bierman	-	-	10	4	-	inferred
	TOTAL	**46**	**8**	**494**	**180**	**4**	

Apart from the main stem of the river, the mining development would also impact on the local drainage systems which are described in the following Section.

3.6.4 Drainage system

Error! Reference source not found. shows the major rivers and the general flow direction of the minor drainage system. Since the NWA identifies a "stream" as a feature where water flows, albeit intermittently, all identifiable drainage lines are shown in **Error! Reference source not found.** (Voorburg Section) and **Error! Reference source not found.** (Jutland Section). The 1:100-year flood-line for the Sand River and two tributaries has been determined and is included in **Error! Reference source not found.**.

From the figures it is clear that even though the site is situated in a dry region, surface water flows occur in a defined network. Flow deviations will be required upstream of the mine to ensure that the water quality is maintained. The drainage density is somewhat less in the Jutland Section which is located further away from the Sand River.

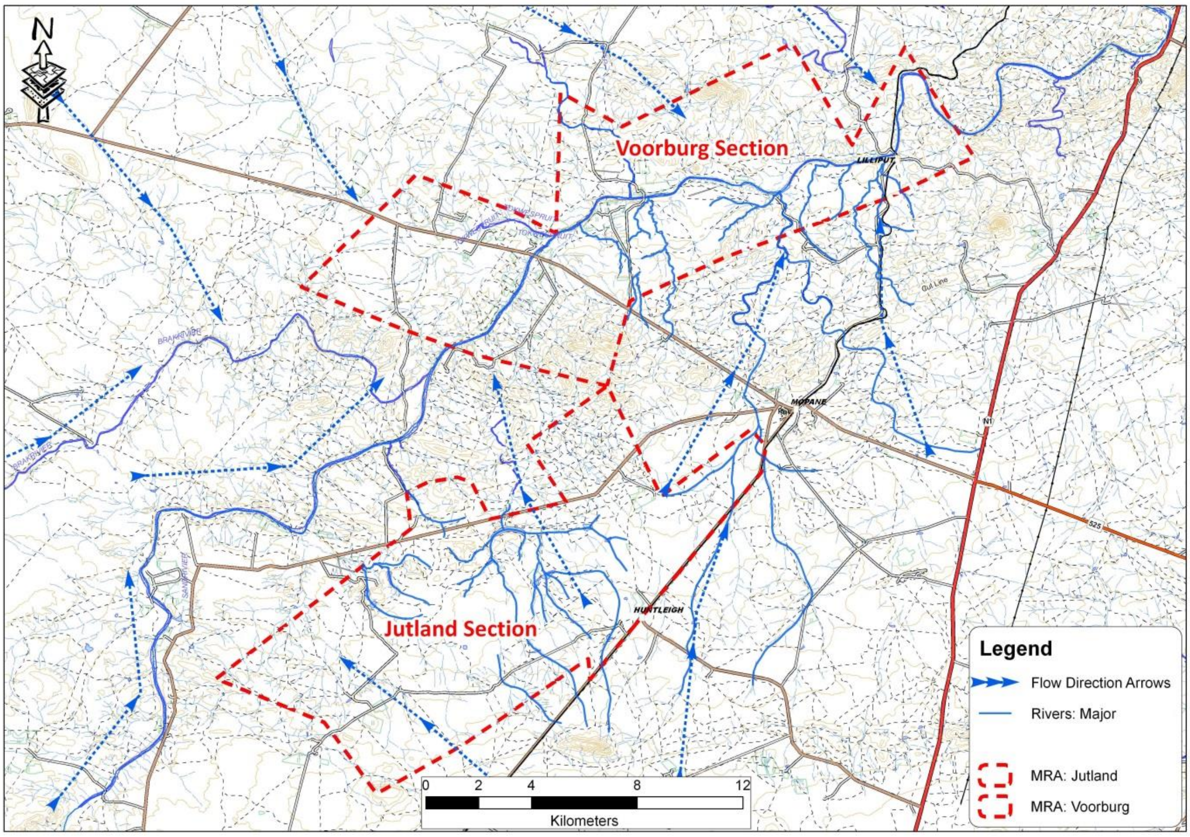

FIGURE 3.8: MAJOR RIVERS AND GENERAL DRAINAGE DIRECTION IN MOPANE PROJECT AREA

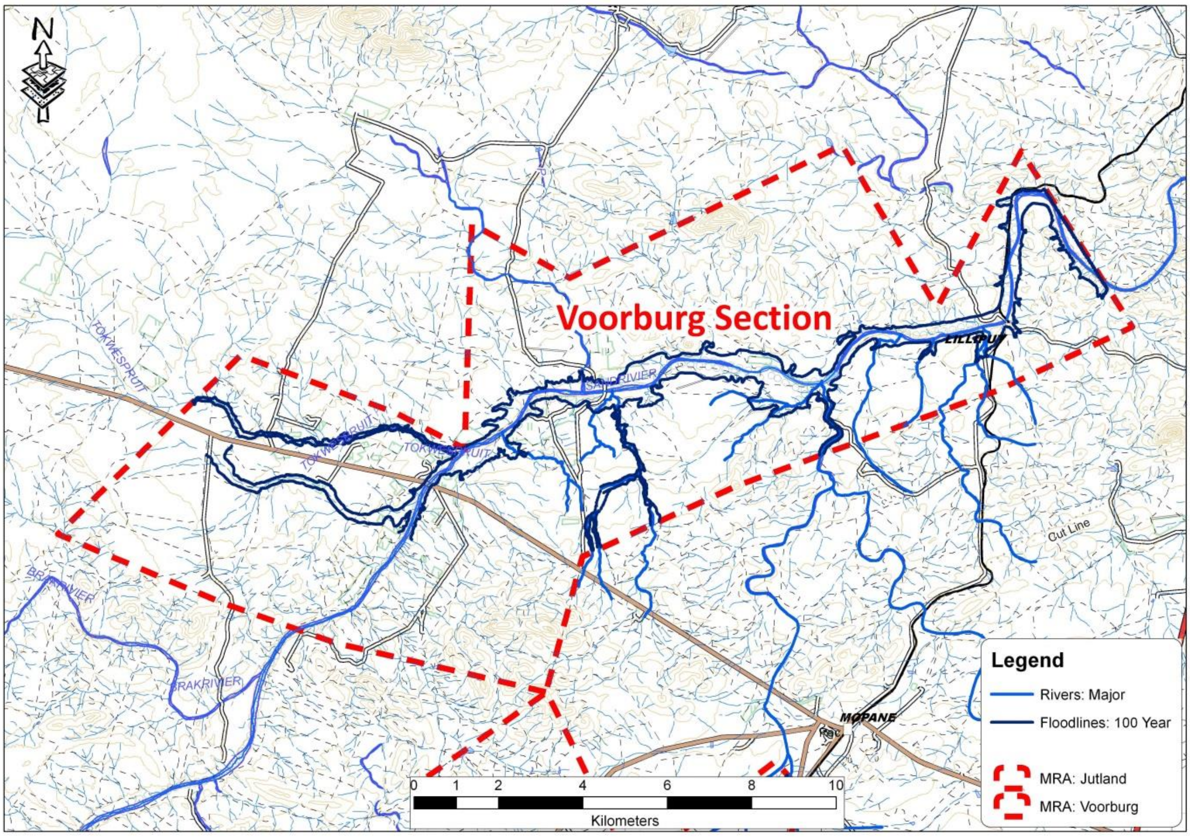

FIGURE 3.9: VOORBURG SECTION DRAINAGE LINES AND MAJOR RIVER FLOOD-LINES

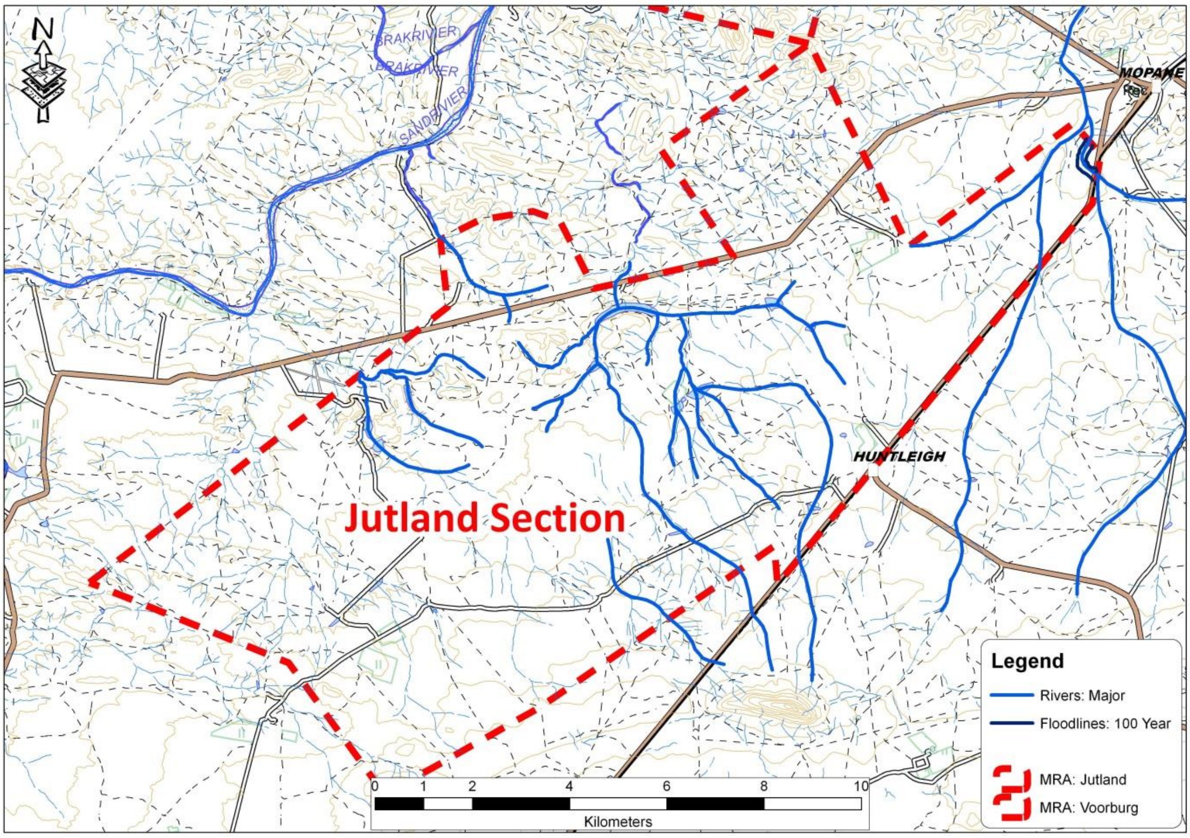

FIGURE 3.10: JUTLAND SECTION DRAINAGE LINES

4. FLOOD PEAK CALCULATIONS

The flood peaks of the Sand River and its major tributaries have been calculated, using the methods described in the SANRAL Drainage Manual (Kruger, 2006). These are generally categorised as deterministic, statistical or empirical methods:

- ***Deterministic methods***include those methods where the flood magnitude (the effect) is derived from an estimate of the catchment characteristics, including rainfall (the cause), for the required annual exceedance probability. Note that these methods have been calibrated according to selected regions and flood events and its application is usually limited to the size of catchment on which they can be applied. Included in this category are the Rational, Unit Hydrograph and Standard Design Flood methods.

- ***Statistical methods***use actual annual series flood peak data, to which a statistical Probability Distribution Function (PDF) is applied. The validity of the result depends on the record length, the quality of the data and the aptness of the applied PDF. A graphical presentation of the data and the fitted curve should be made to select the best PDF, which include the Log-normal, Log-Pearson Type 3 and General Extreme Value functions.

- ***Empirical methods***are calibrated equations that may be partially based on a deterministic relationship, such as the Midgley-Pitman method. Also included in this category is the Regional Maximum Flood method developed by Kovaćs.

  Note that the flood analyses were based on the gross catchment area to include for the possibility that the endoreic catchments may contribute to storm water run-off in large flood events.

4.1 Statistical analysis of the Sand River flood peaks

There is a long term river flow gauge (A7H001, started in year 1958) on the Sand River in the Waterpoort (where the river crosses the Soutpansberg). Although not constructed to measure high flows, the DWA has determined the high flood peaks at this site by other calculations. For example, the 2000 flood peak has been determined as 5 100 m^3/s and published. (*Alexander 2001*). It is, however, not a very reliable gauge in that only 28 years of complete records exist in the 54 years of its existence. An analysis has been carried out (refer to **Error! Reference source not found.**) and the results of the Log-Pearson Type 3 and Log-Normal were selected as reflecting the most probable range of results in Southern African conditions. Their results were transposed to the downstream site at the Voorburg Section by applying the square root of the catchment area ratio and the results are given in **Error! Reference source not found.**.

Table 12: Results of statistical analysis of flood data at Waterpoort (Gauge A7H001) (peak flow rate in m^3/s)

Probability Distribution Function	RECURRENCE INTERVAL (years)				
	1:10	1:20	1:50	1:100	1:200
Log-Normal	631	992	1 660	2 361	3 233
Log-Pearson Type 3	679	1 325	3 023	5 482	9 753
Log-Gumbel	650	1 317	3 284	6 510	12 876
GEV	1 232	1 783	2 642	3 417	4 320

Table 13: Adjustment of statistical results at Waterpoort to the site

Recurrence Interval (years)	At Waterpoort (A=7 703 km^2)		At Voorburg (A=13 155 km^2)	
	Log-Normal	Log Pearson Type 3	Log-Normal	Log Pearson Type 3
2	126	103	165	135
10	631	679	825	887
20	992	1 325	1 296	1 732
50	1 660	3 023	2 169	3 951
100	2 361	5 482	3 085	7 164
200	3 233	9 753	4 225	12 745

4.2 Deterministic methods applied to the Sand River

The flood peaks were also determined by applying deterministic analyses even though not all are fully applicable over such a large catchment area. The Standard Design Flood and the Alternative Rational Methods as described in the SANRAL Drainage Manual (Kruger 2006), using software developed by Sinotech cc (Utility Programs for Drainage, version 1.0.2), were used. The results were also compared to the flood peak estimates based on the Regional Maximum Flood as proposed by Kovaćs (1988).

Note that the impact of cyclones (or tropical weather systems) that occur occasionally in the north eastern parts of the country has been allowed for. The flood peak estimations are partially based on the statistical analyses of site specific rainfall data which includes the high rainfall events.

The flood peaks have been calculated at the point where the river exits the area. The river's catchment data are shown in **Error! Reference source not found.**. The Mean Annual Precipitation (MAP) of 442 mm used (in some of the methods) is the weighted average precipitation over the catchment area, determined by application of the Thiessen polygon method. In order to apply the Alternative Rational Method to the total catchment, the weighted 1:2-year 24-hour rainfall (M2) has also been estimated by this method as 51 mm.

Table 14: Sand River catchment characteristics at the site

DESCRIPTION	VALUE
Gross Catchment area (km^2)	13 155
Mean Annual Precipitation (mm)	442
Mean M2 rainfall value (mm)	51
Length of watercourse to boundary (km)	296.54
Average stream slope (m/m)	0.003
Rational Method Run-off factor	0.248
Veld Type (Unit Hydrograph procedure)	n.a.
SDF Method Drainage Basin No	3
RMF Method K-value	5

The results are summarised in **Error! Reference source not found.**.

Table 15: Estimated peak flows for the Sand River

METHOD USED	Flood peaks per recurrence period (m^3/s)		
	1:50	1:100	1:200
Rational Method with rainfall intensity from Alexander method	1 985	2 789	3 216
Standard Design Flood	4 385	5 834	7 503
Kovaćs RMF method (RMF = 2 450 m^3/s)	6 097	7 168	-

4.3 Selected floods for the Sand River

The final flood peak selection was based on a graphical presentation (**Error! Reference source not found..1**) of the information shown in **Error! Reference source not found.**. In selecting the flood peaks, less weight was given the Kovaćs Method and the results of the Standard Design Flood since both are based on conservative upper envelope curves of observed storm events and tend to always give upper limits in flood peak calculations. On the other hand the Rational Method applied on large catchments tends to under-estimate the larger events. The selected values, as indicated by the green line on the graph, are shown in **Error! Reference source not found.**.

Table 16: Selected flood peaks for the Sand River at Voorburg

FLOOD PEAKS IN m^3/s (for recurrence interval in years)				
1:10	**1:20**	**1:50**	**1:100**	**1:200**
975	1 750	3 000	4 400	9 000

The values above were used to determine the 1:100-year flood-line in the Sand River for the Voorburg Section, using the HecRas software.

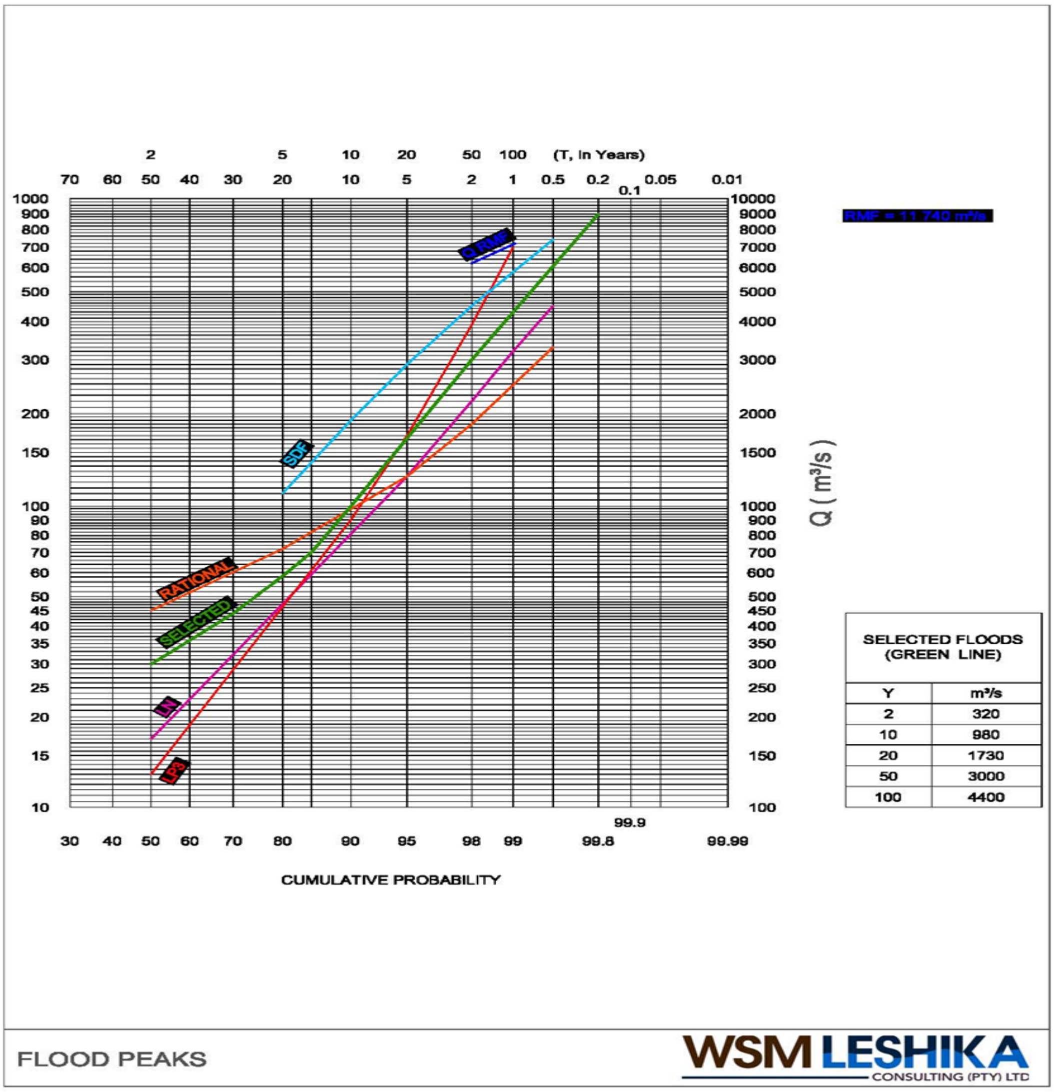

FIGURE 4.1: PRESENTATION OF FLOOD PEAK RESULTS

4.4 Flood peak determination of major tributaries

The flood peaks for the major tributaries of the Sand River were determined by applying the deterministic Alternative Rational Method as described in the SANRAL Drainage Manual (Kruger 2006), using software developed by Sinotech cc (Utility Programs for Drainage, version 1.0.2)

Two major streams, stream V2 and V3 were identified that could be impacted by the mining activities. The two catchment areas were then further divided into sub-catchments to find the peak discharges at points of confluence. Please note that the streams do not have names and was thus labeled e.g. V2R1 etc.

The catchment areas of the Site streams are shown in **Figure 4.2** below.

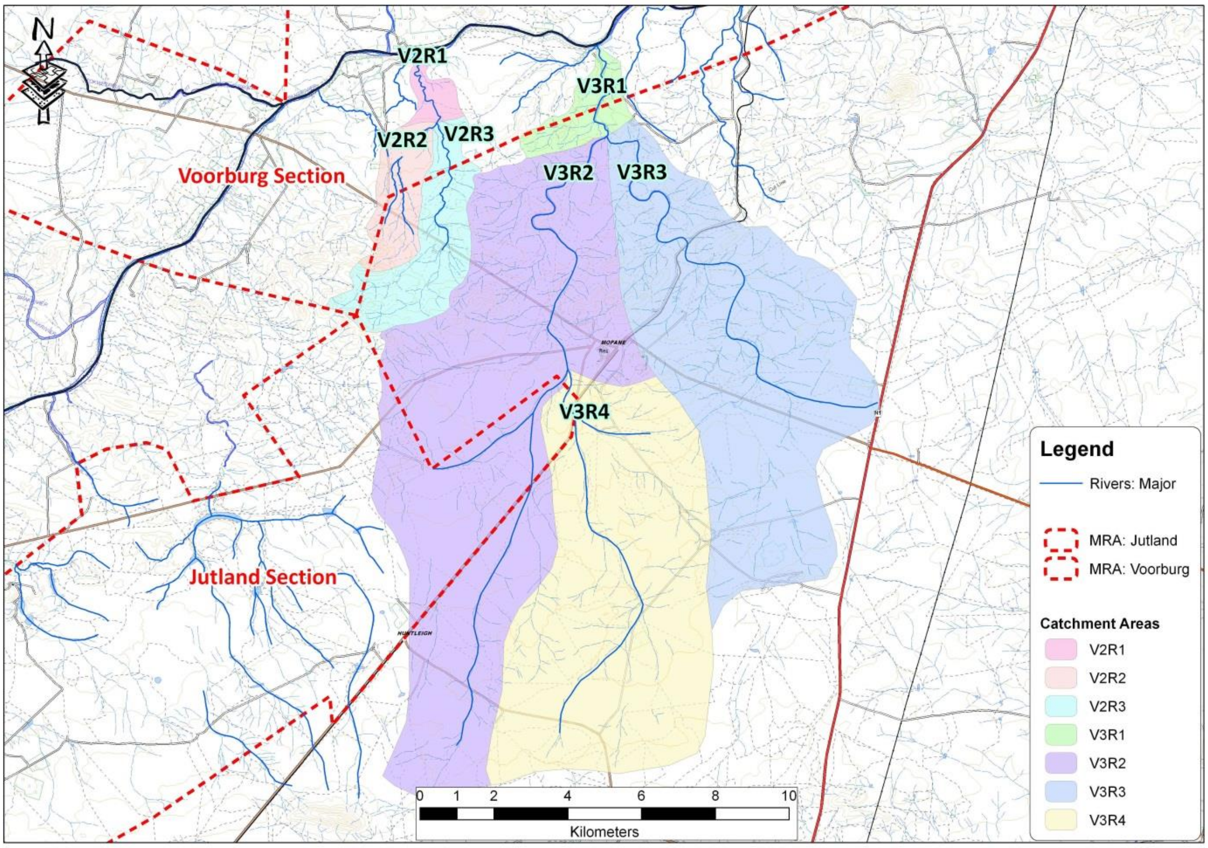

FIGURE 4.2: CATCHMENT

Applying the catchment data given in **Table 17**below, the flood peak estimates were obtained and are also shown in **Table 17**.

Table 17: Catchment data and calculated flood peaks for the selected streams

DESCRIPTION	V2R1	V2R2	V2R3	V3R1	V3R2	V3R3	V3R4
Catchment area (km2)	14.86	4.61	8.76	160.95	110.26	47.05	67.53
Length of watercourse to boundary (km)	10.29	5.46	7.50	23.02	19.82	14.16	11.18
Average stream slope (m/m)	0.00700	0.01001	0.00658	0.00736	0.00816	0.00659	0.00775
Runoff factor	0.267	0.268	0.284	0.292	0.285	0.295	0.279
50 Year Flood Peak (m3/s)	35.5	17.9	26.4	238.5	202.1	97.6	155.8
100 Year Flood Peak (m3/s)	49.3	24.8	36.7	331.1	280.6	135.5	216.3

Figure 4.3 below shows the 1:100 year floodlines of the major streams in relation to the mining areas.

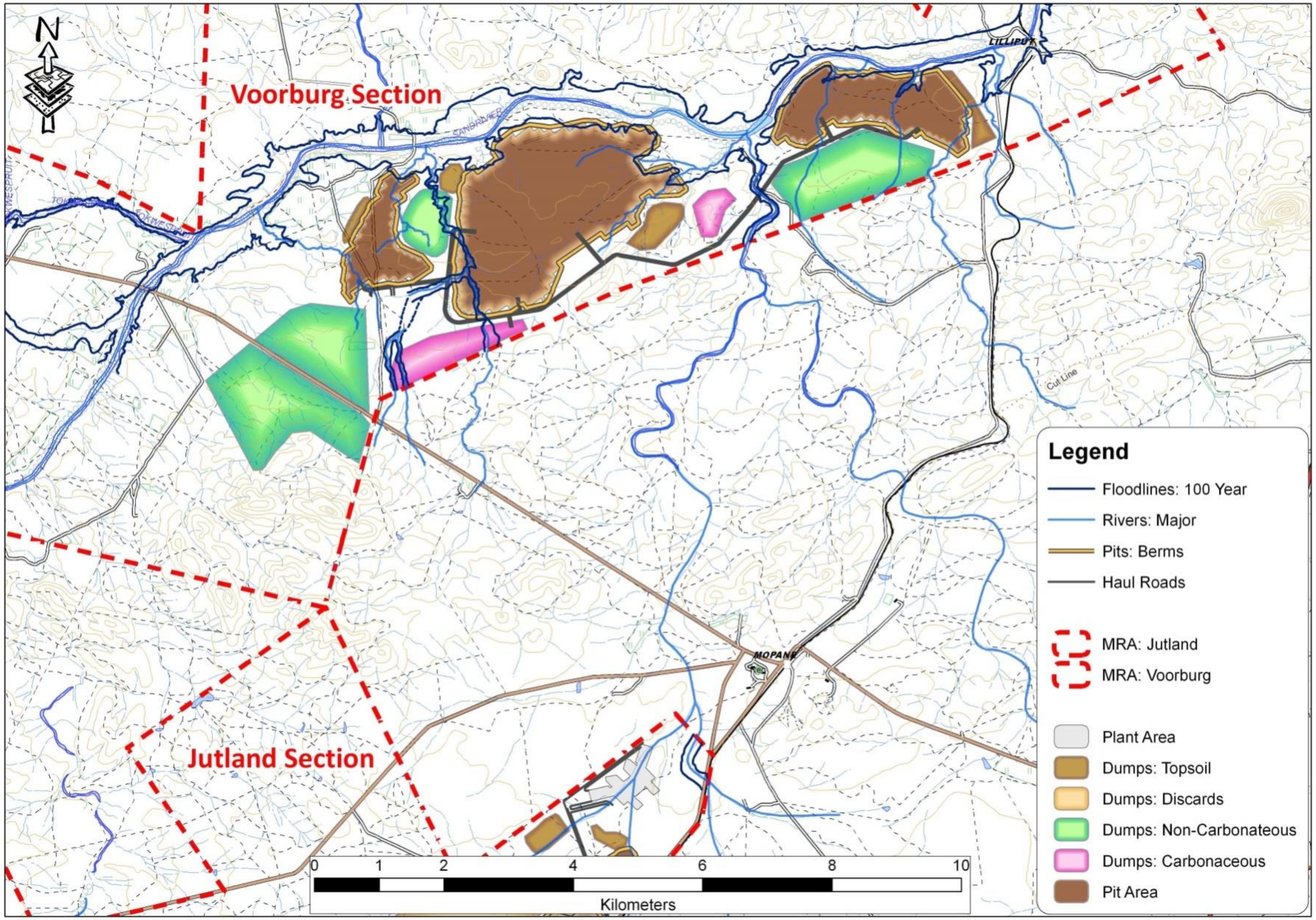

FIGURE 4.3: 100 YEAR FLOODLINES OFTHE MAJOR STREAMS

5. ECOLOGY OF THE RIVERS AND STREAMS IN THE REGION

The information below was sourced from Kleynhans, Thirion&Moolman (2005) and the section on ecostatus of the aquatic environment from the Mopane Scoping Report (June 2013).

5.1 Eco-regions

The Mopane Project falls within the Limpopo Plain Eco-Region1.01 as shown in**Figure 5.1** below.

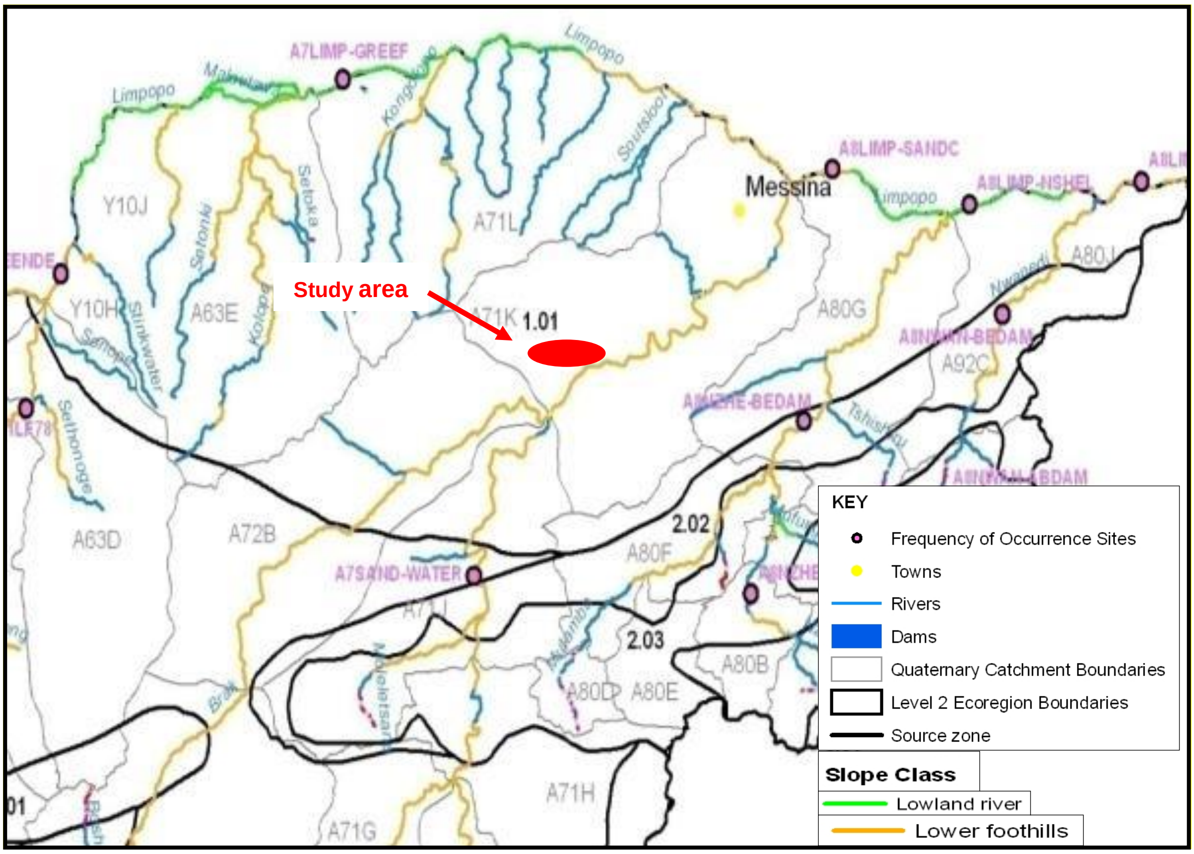

FIGURE 5.1: LOCATION OF THE STUDY AREA IN ECO-REGION 1.01

The characteristics of this eco-region are shown in **Table 18** below.

Table 18: Characteristics of Eco-Region 1.01 (Kleynhans, Thirion&Moolman 2005).

MAIN ATTRIBUTES	**SOUTPANSBERG 1.01** (dominant types in bold)
Terrain Morphology: Broad division	**Plains; Low Relief; (limited)** Plains; Moderate Relief; (very limited) Lowlands; Hills and Mountains; Moderate and High Relief; Closed Hills; Mountains; Moderate and High Relief;
Vegetation types (Primary)	Sour LowveldBushveld; Soutpansberg Arid Mountain Bushveld; **MopaneBushveld (very limited)** Patches AfroMontane Forest.
Altitude (m a.m.s.l.)	300-1700
MAP (mm)	200 to 1000
Coefficient of variation (% of annual precipitation)	<20 to 40
Rainfall concentration index	55 to >65
Rainfall seasonality	Mid summer
Mean annual temp (°C)	16 to >22
Mean daily max temp (°C) February	22 to 32
Mean daily max temp (°C) July	16 to >24
Mean daily min temp (°C) February	14 to >20
Mean daily min temp (°C) July	4 to >10
Median annual simulated runoff (mm) for quaternary catchment	<5 to 200; >250 (limited)

5.2 Status of river systems in the area

Water resources are generally classified according to the degree of modification or level of impairment. The classes, used by the South African River Health Program (RHP), are presented in **Table 19** below and will be used as the basis of classification of the systems in future field studies.

Table 19: Classification of river health assessment classes in line with the RHP

Class	Description
A	Unmodified, natural
B	Largely natural, with few modifications
C	Moderately modified
D	Largely modified
E	Extensively modified
F	Critically modified

Studies undertaken by the Institute for Water Quality Studies assessed all quaternary catchments as part of the Resource Directed Measures for Protection of Water Resources. In these assessments, the Ecological Importance and Sensitivity (EIS), Present Ecological Management Class (PEMC) and Desired Ecological Management Class (DEMC) were defined and it serves as a useful guideline in determining the importance and sensitivity of the aquatic ecosystems.The results are summarised in **Table 20**.

Table 20: Summary of the ecological status of quaternary catchments A71J, A71K and A72B based on Kleynhans (1999)

Catchment	Resource	EIS	PEC	DEMC
A71J	Sand River	Low/Marginal	Class B	D: Resilient system
A71K	Sand River	Moderate	Class B	C: Moderately sensitive system
A72B	Brak River	Low/ Marginal	Class B	D: Resilient system

The Class B PEC rating reflects a largely natural stream.

6. STORMWATER DRAINAGE SYSTEMS

6.1 Background

In general, the storm water control measures intend to secure the dirty areas (i.e. haul roads, dirty stockpile areas, open pit area and process plant area) and to divert clean upslope water past the mine. In terms of the proposed new development, a conceptual layout of the required system has been done, based on the requirements in the Best Practice Guideline G1: Stormwater Management, DWAF, August 2006, using the available mining layoutsas at September 2013.

The two mining sections of Voorburg and Jutland are located south of the Sand River, with the Voorburg Section bordering on the river and Jutland some 8 km further south. The eastern section of the southern border of Jutland is next to the railway line to Musina. With the general drainage pattern in the area towards the Sand River from a higher ridge to the south, the northwards running streams or drainage lines intersect the mining area. The mining layout and major drainage lines are shown in **Figure 6.1** and the southern ridge is indicated by the two high points of Pylkop (993 mamsl)and Tshitangai(861 mamsl), with the mine sites at about 600 to 700 mamsl.

Note that the conceptual layouts do not take the timeline into account as it only shows the structures and systems required towards the end of the mining period. Over the life of a pit, intermediate systems may be installed to shorten flow paths. We have assumed that no drainage structures may cross over rehabilitated zones and therefore allowed for long diversion structures around the continuous pits. Furthermore, we have included mostly the major systems required to contain dirty water and divert clean water around sensitive areas. In the operational phase, more nominal sized conduits and ponds may be required which are not indicated in the conceptual, small-scale layout.

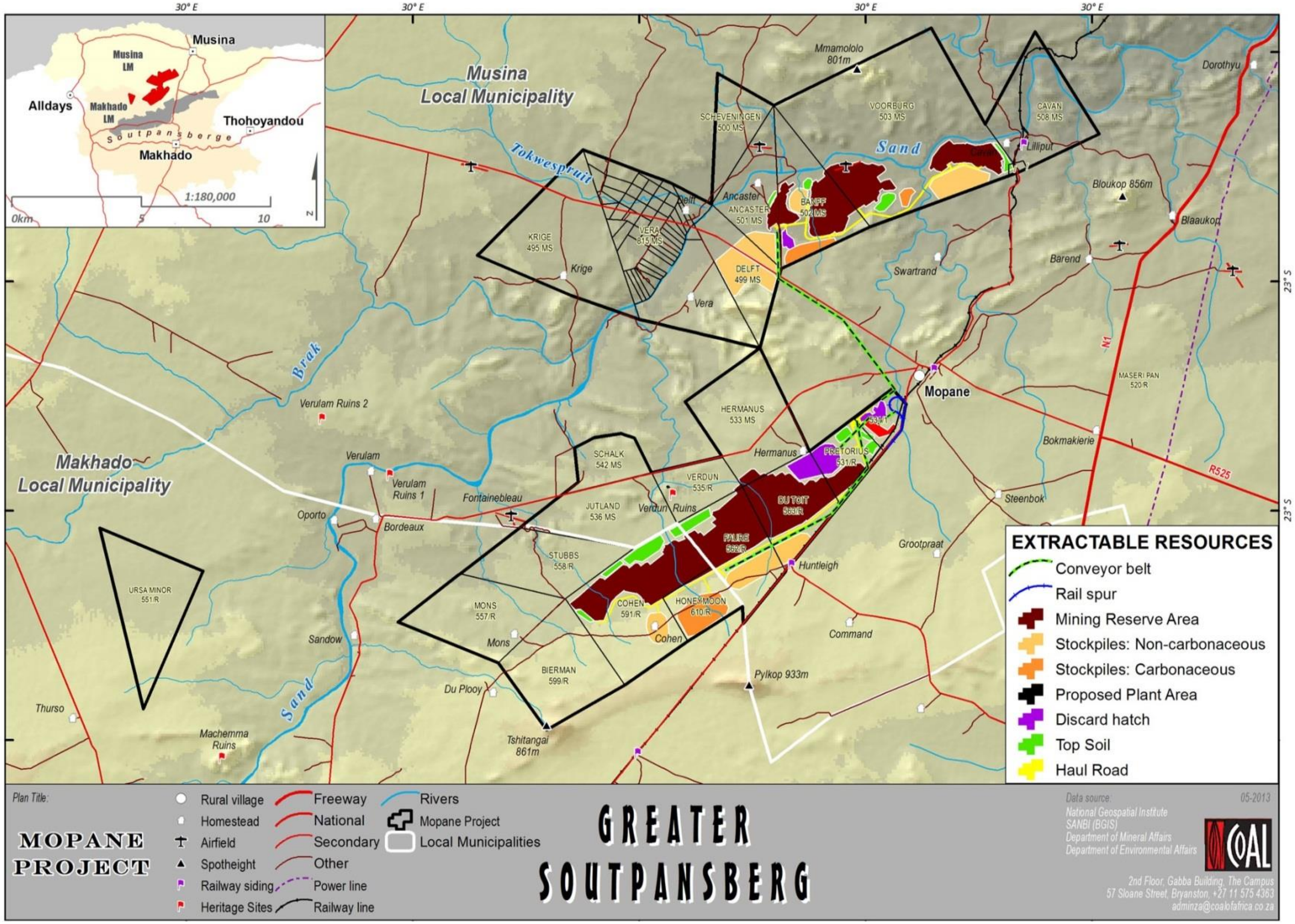

FIGURE 6.1: MINING LAYOUT

The non-carbonaceous dumps all require paddocks (or a form of silt trap) at the toe to prevent the transport of sediment to streams and rivers. If feasible, the tops of the dumps should be dished and/or provided with a low berm on the edge to retain rainwater which should evaporate quickly in the hot, dry summers. In this climate where there may not always be enough water in dry spells to establish and/or maintain vegetation on the sides of the dumps, erosion down the slopes will occur and should be controlled. This can be achieved by providing relatively flat side slopes and back-slope terraces at carefully selected intervals.

The carbonaceous stockpiles should all be provided with impermeable liners and dirty water collector drains to discharge into the dirty water system leading to holding ponds.

The locality of the carbonaceous, non-carbonaceous and topsoil stockpiles are generally not positioned to be hydraulically favorable, meaning that the current placement of the stockpiles would create numerous additional ponds, berms and canals. Therefore it is proposed that the footprints of the stockpiles be reshaped hydraulically so that the extent of the footprints acts as drainage basins that allow dirty stormwater runoff to converge to a single point at a lower elevation within the footprints and at the same time diverting clean stormwater runoff around the footprints back to its natural flow paths.

A brief description of the stormwater systems envisaged is given in the following sections.

6.2 Stormwater management system required at VoorburgSection

Figure6.2 below shows the extent of the mining activities at the Voorburg Section.

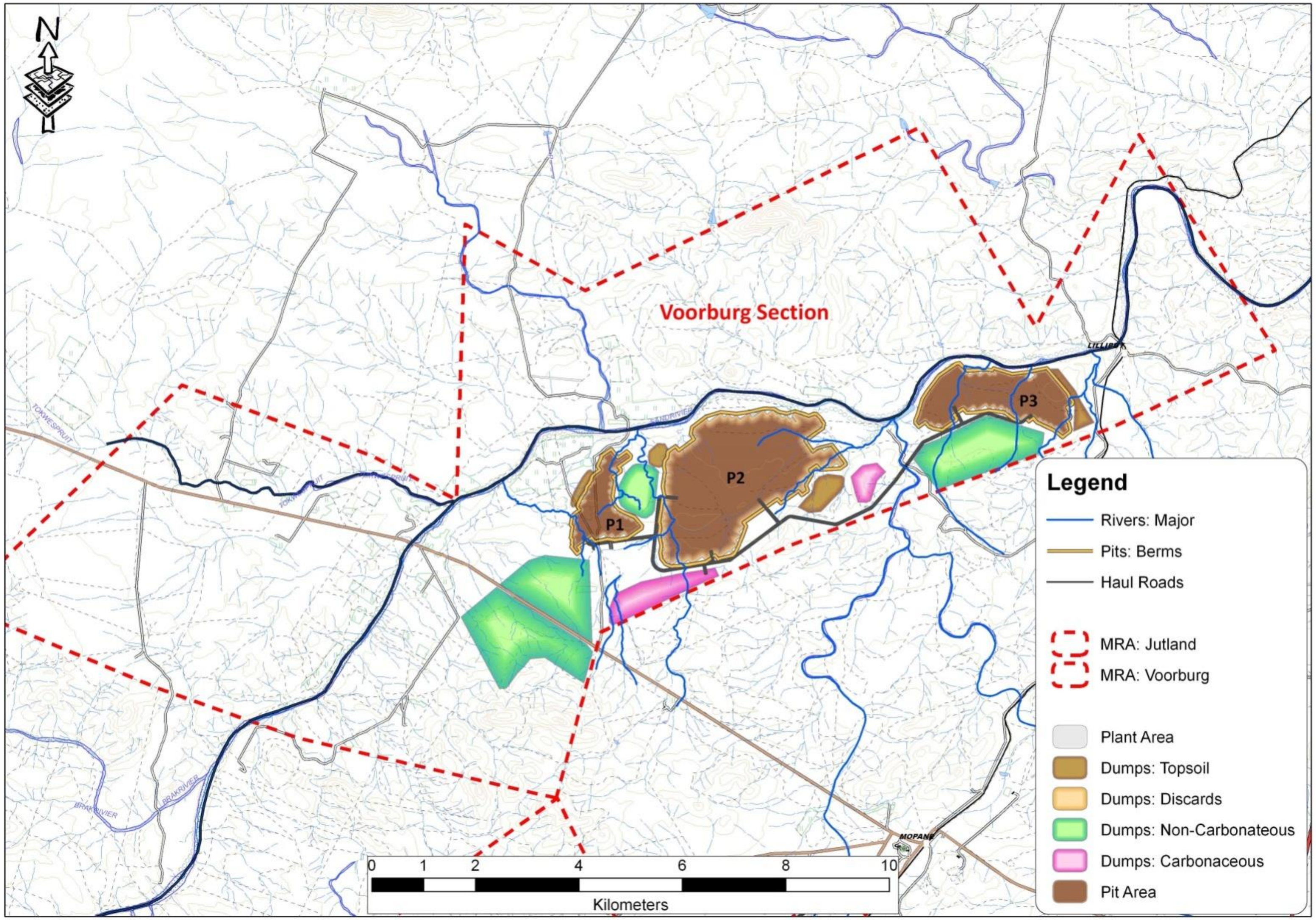

FIGURE 6.2: VOORBURG MINING ACTIVITIES

6.2.1 West pit (P1)

Please refer to**Figure 6.3** below that shows the current layoutof the proposed mining infrastructure at the West Pit (P1).

Impacts on Current Layout

Two small, non-perennial drainage lines, streams V1 and V2, traverse Pit 1. The southern boundary of the pit is located higher up the slopes than the northern boundary. The proposed clean water cut-off berm around the pit will suffice to divert flow around the pit, except where the pit impedes on the natural flow path of stream V1. This will create the need for a clean water pond to be constructed as the topography would not allow for the stream to be diverted around the pit.

The pit also impedes on the stream V2L, which will cause the stream to be deemed redundant. However, by diverting the stream around the pit via a clean water canal into stream V2R the stream is retained.

On the eastern side of the pit the proposed non-carbonaceous stockpile NC3 will impede on streams V2L and V2R, which will also cause for the abolishment of the entire stream V2. The stockpile should rather be relocated to save the streams.

On the western end of the pit the proposed non-carbonaceous stockpile NC2 will also impede on the natural flow path of stream V1 and we suggest that it be relocated to allow the upper reaches of stream V1 to fully utilize the remaining catchment area to collect clean water.

The topsoil stockpile west of Pit 1 as well as the topsoil stockpile north-west of Pit 2, as shown in **Figure 6.3** below, currently does not impact any major drainage line nearby. However both of them are shaped and positioned in such a way that they would permit the construction of more than one pollution control pond. Therefore it is proposed that both of them be hydraulically shaped and positioned to minimize the need for excessive mitigation measures.

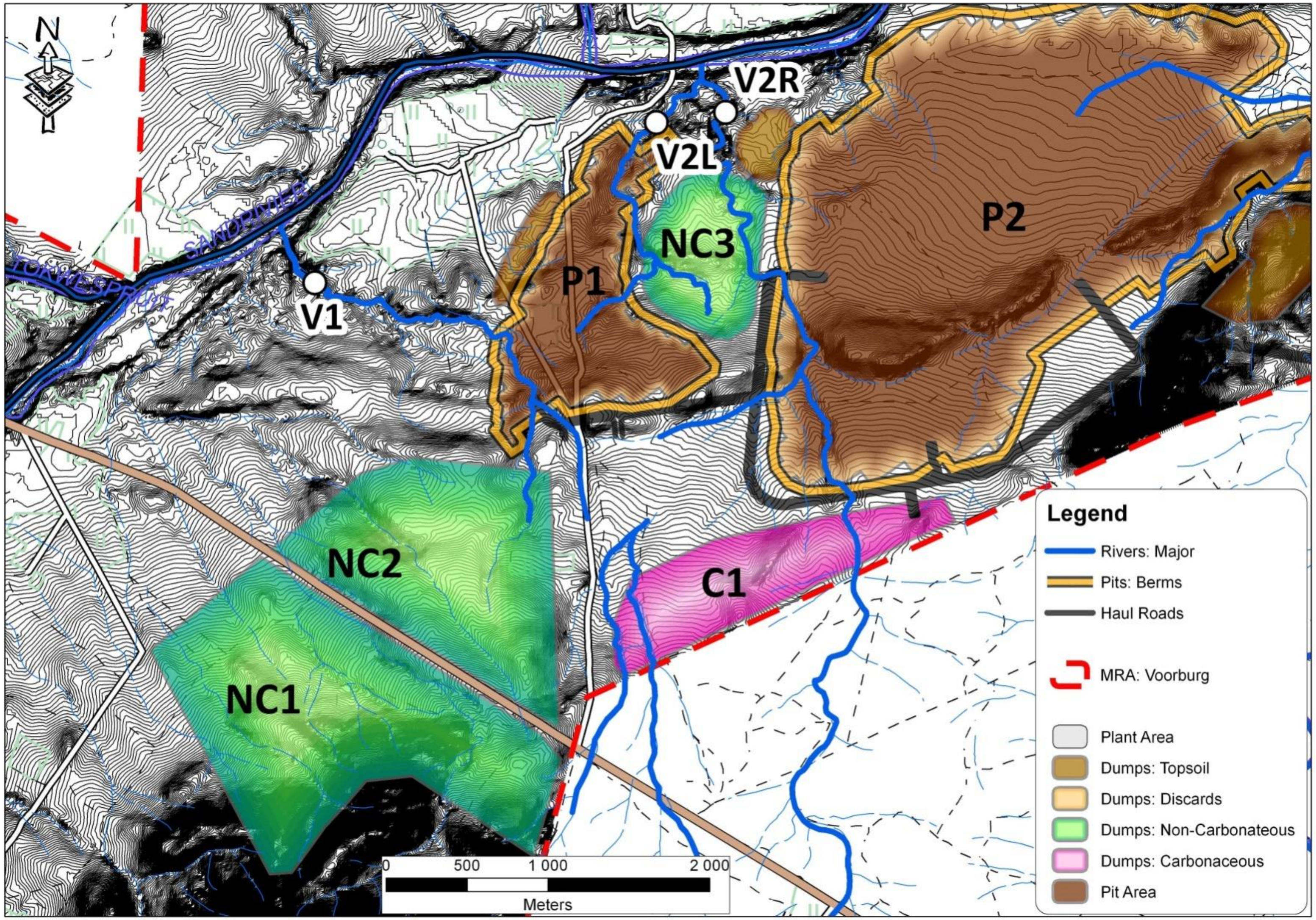

FIGURE 6.3: CURRENT VOORBURG MINING INFRASTRUCTURE – WEST PIT

Proposed Mitigation of Mining Activities

Except for the footprint of the pit, all carbonaceous, non-carbonaceous and topsoil stockpiles will have to be relocated and the footprints of the stockpiles will also have to be reshaped hydrologically to minimize the number of detention ponds needed, to aid in the collection of dirty water runoff and also to have a minimal impact on the existing streams.

Please refer to**Figure 6.4** below that shows the proposed relocated and reshaped stockpiles as well as the two diversion canals along with the 1:100 year floodlines of the Sand River and stream V2R.

6.2.2 Central pit (P2)

Please refer to **Figure 6.5** below that shows the current layout of the proposed mining infrastructure at the Central Pit (P2).

Impacts on Current Layout

Two non-perennial streams, V2 and V3, occur within the pit area. Stream V2 will be obliterated by the pit and therefore needs to be diverted via a clean water canal along the proposed haul road. The locality of the carbonaceous stockpile C1 will also impede on the natural drainage lines of stream V2R and therefore needs to be relocated to allow the streams to traverse through the site area.

Both of the tributaries of stream V3L will become redundant due to the proposed pit activities and no alternative is proposed.

The topsoil stockpile TS3 as well as the carbonaceous stockpile C3 does not pose any impact on streams and therefore is only recommended to be hydrologically reshaped for better drainage characteristics.

Proposed Mitigation of Mining Activities

Except for the footprint of the pit, all carbonaceous, non-carbonaceous and topsoil stockpiles will have to be relocated and the footprints of the stockpiles will also have to be reshaped hydrologically to minimize the number of detention ponds needed, to aid in the collection of dirty water runoff and also to have a minimal impact on the existing streams.

It is proposed that stream V2L be diverted, via a clean water canal CW1, along the north-eastern boundary of Pit 1 to discharge into stream V2R.

It is also proposed that stream V2R be diverted, via a clean water canal CW2, along the proposed haul road, south-west of Pit 2, up to the nearest point where the stream can be released back to its natural flow path.

Please refer to **Figure 6.6** below that shows the proposed relocated and reshaped stockpiles, proposed clean water diversion canals as well as the 1:100 year floodlines of the Sand River and streams V2R and V3R.

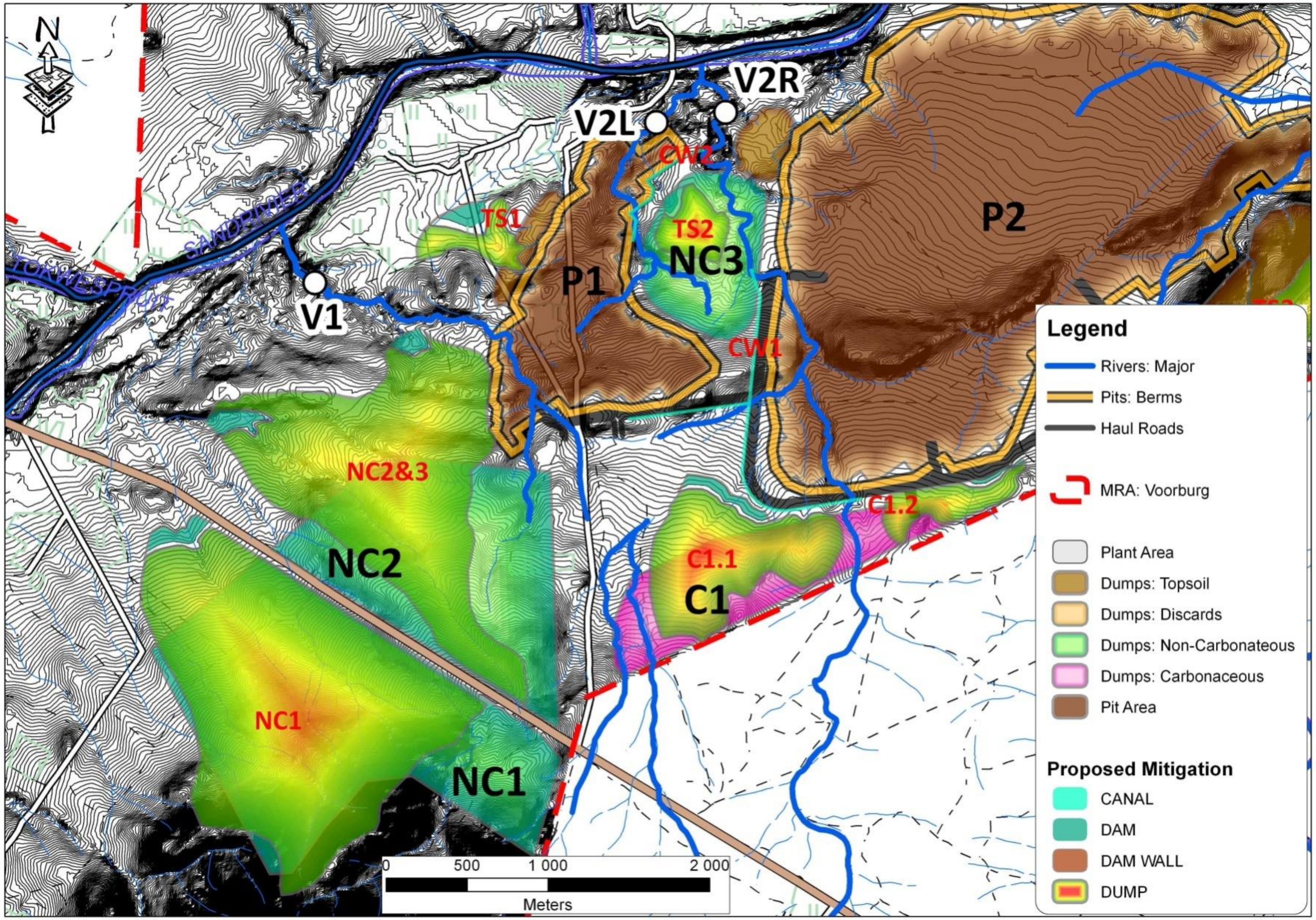

FIGURE 6.4: PROPOSED RELOCATED VOORBURG MINING INFRASTRUCTURE – WEST PIT

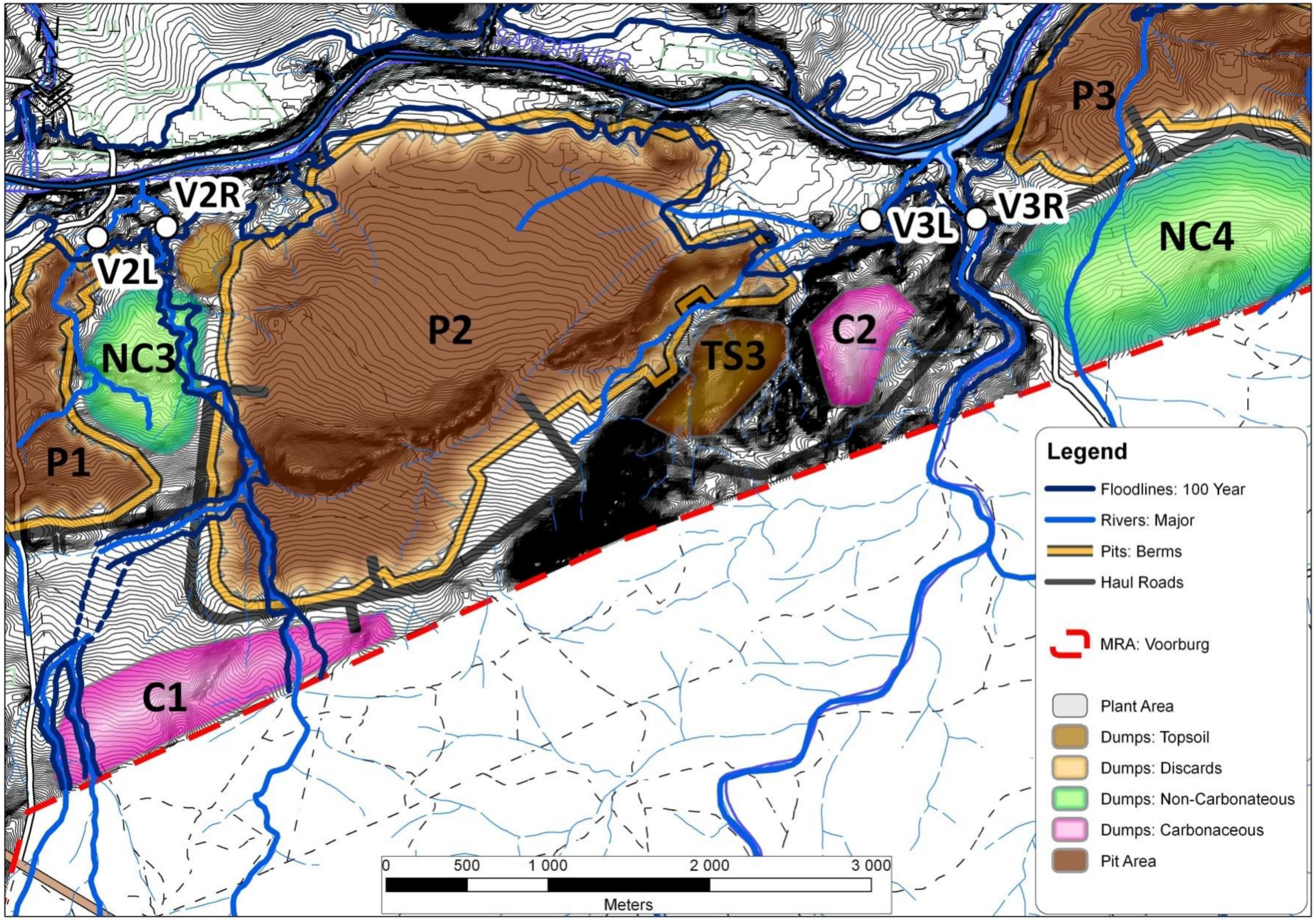

FIGURE 6.5: CURRENT VOORBURG MINING INFRASTRUCTURE – CENTRAL PIT

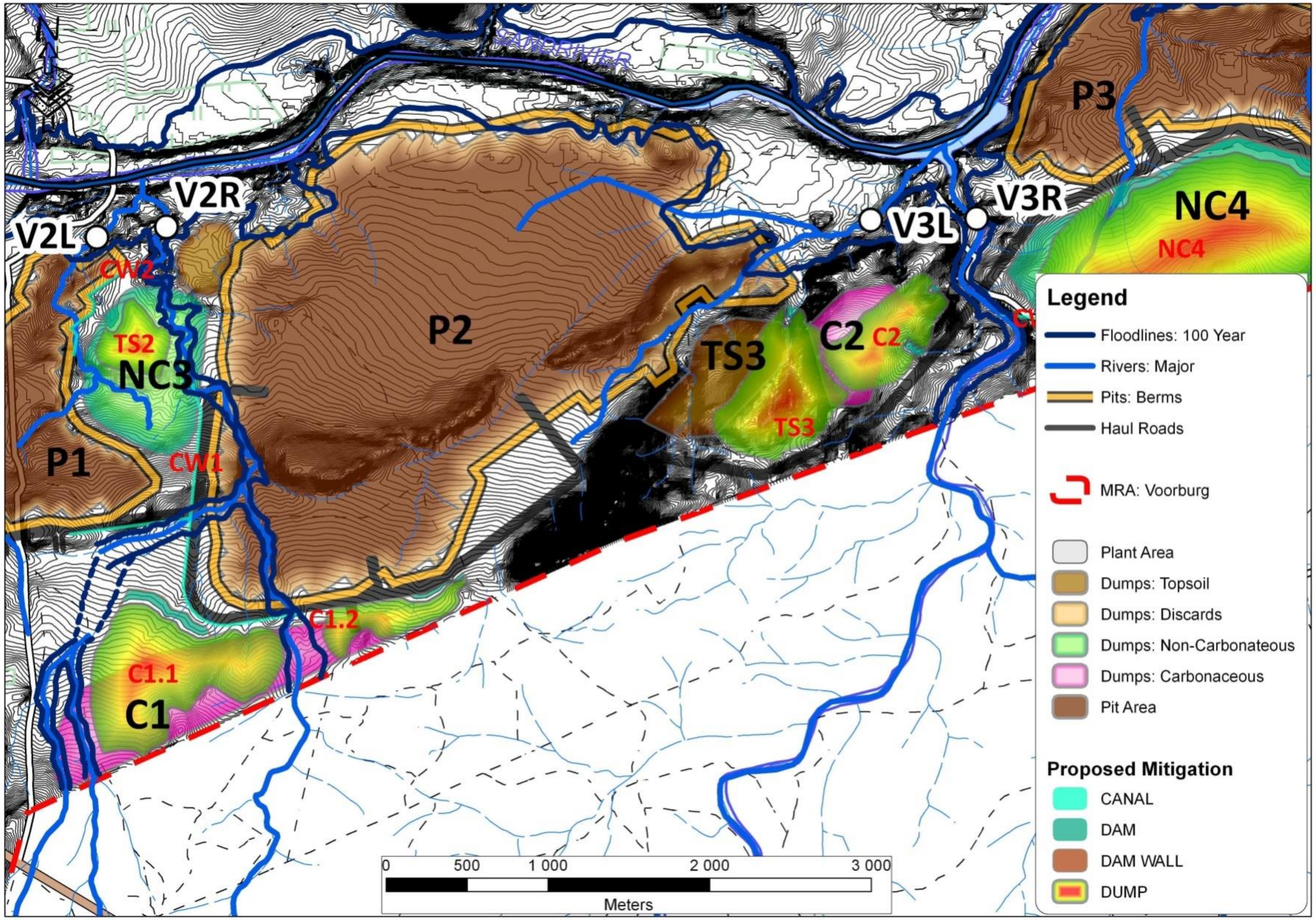

FIGURE 6.6: PROPOSED VOORBURG MINING INFRASTRUCTURE – CENTRAL PIT

6.2.3 East pit (P3)

Please refer to**Figure6.7** below that shows the current layout of the proposed mining infrastructure at the East Pit (P3).

Impacts on Current Layout

Stream V3R will not be affected by any mining activity apart from the proposed haul road for the Voorburg Section.

Three non-perennial streams, V4, V5 and V6, exist within the pit area. Stream V4 will be destroyed by the proposed pit excavation, as well as the placement of the non-carbonaceous stockpile NC4. Clean water runoff therefore needs to be diverted via a canal into the stream V3R.

Stream V5 will be totally abolished by the pit area and the placement of non-carbonaceous stockpile NC4 and no alternative is proposed as the topography of the area and the locality of the pit will not allow for the stream to be diverted.

Stream V6L will be impeded by the proposed pit activities and no diversion of the stream is possible due to the locality of the pit and the topography of the area. However a clean water dam just upstream from the pit area is proposed. This will require that the non-carbonaceous stockpile NC4 be reshaped to prevent disturbance of V6L.

With the disappearance of stream V6L, the topsoil stockpiles TS4 & TS5 will not have a major impact on the streams and therefore it is only recommended that these be reshaped to obtain better drainage patterns.

Proposed Mitigation of Mining Activities

Except for the footprint of the pit, it is proposed that all carbonaceous, non-carbonaceous and topsoil stockpiles be relocated. In addition, the footprints of the stockpiles should be reshaped to minimize the number of detention ponds needed, to aid in the collection of dirty water runoff and also to have a minimal impact on the existing streams.

Please refer to**Figure 6.8** below that shows the proposed relocated and reshaped stockpiles as well as the 1:100 year floodline of the stream V3R.

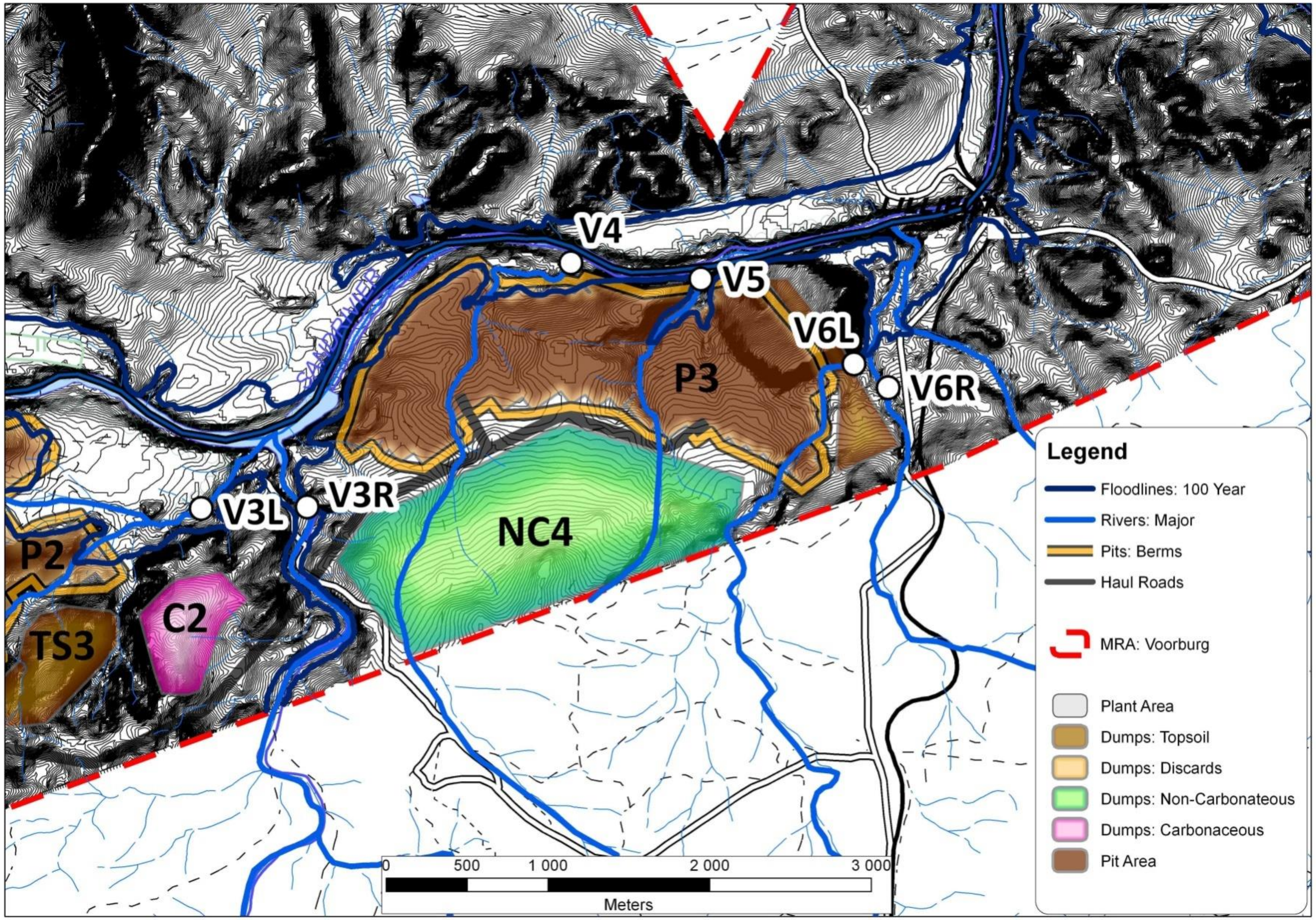

FIGURE 6.7: CURRENT VOORBURG MINING INFRASTRUCTURE – EAST PIT

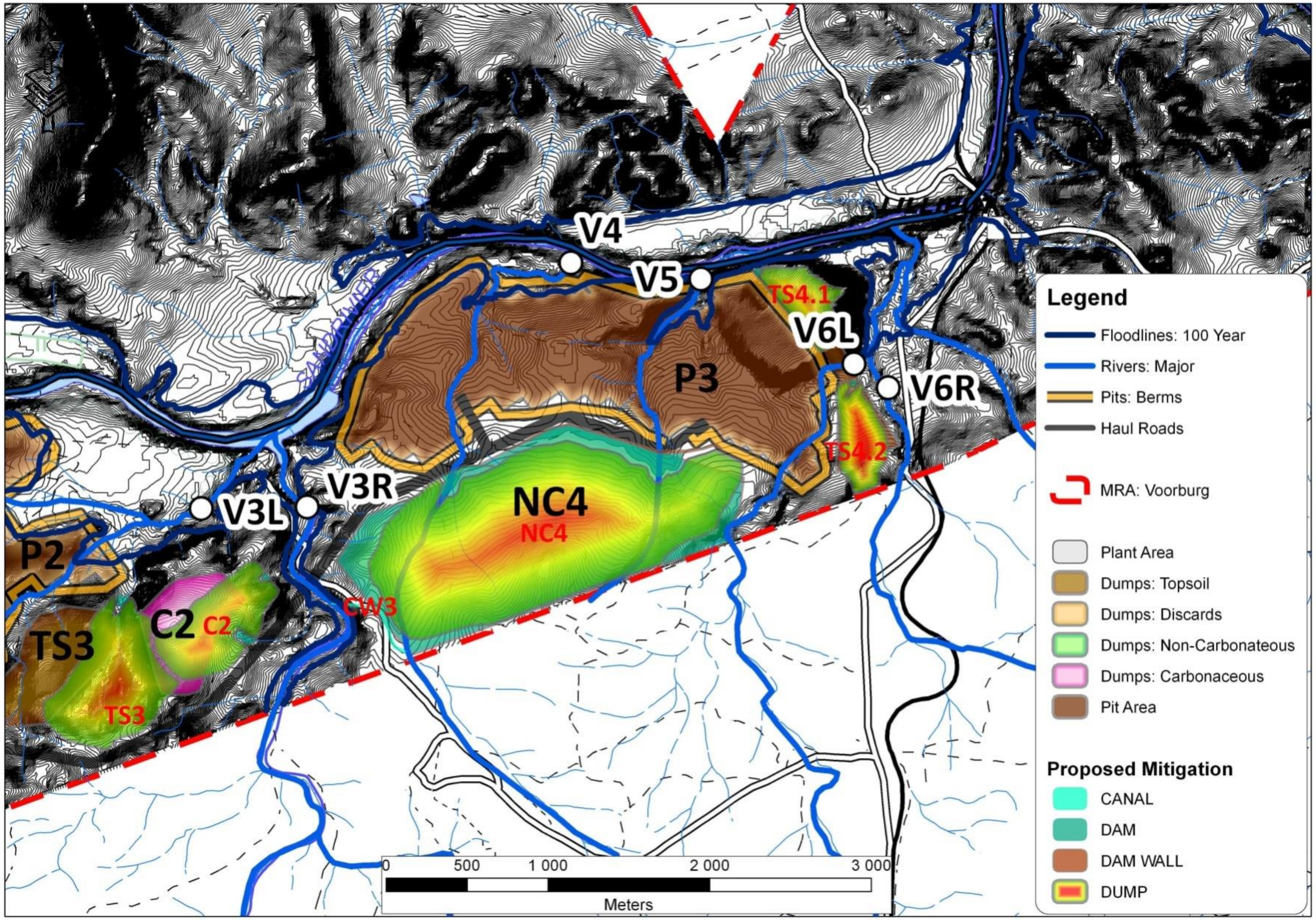

FIGURE 6.8: PROPOSED VOORBURG MINING INFRASTRUCTURE – EAST PIT

6.2.4 Sand River Flood line

As can be seen from the all the above figures in this section, parts of the pit footprints protrude the calculated 1:100 year floodline for the Sand River. The protrusion typically occurs where smaller tributaries or streams discharges into the Sand River.The requirements of Government Notice 704 (GN704) state that mining activities may not be located within the 1:100 year floodline or within a horizontal distance of 100 meters from any watercourse or estuary, whichever is the greatest.

Figure 6.9 below shows the 1:100 year floodline as well as the 100 meter buffer zone for the Sand River within which it is proposed that no mining activity will take place. The calculated floodline is wider than the buffer zoneand it therefore controls the extent of mining activities. However, the aquatic assessment recommended a 100m buffer from the edge of the riparian zone (wetlands), in this instance the Sand River floodline that implies that no mining activities should take place within 100m from the edge of the 1:100 year floodline. It is therefore propose that the footprints of the pits be reduced to adhere to the applicable legislation, unless a WULA is obtained which will allow the construction of competent flood diversion structures

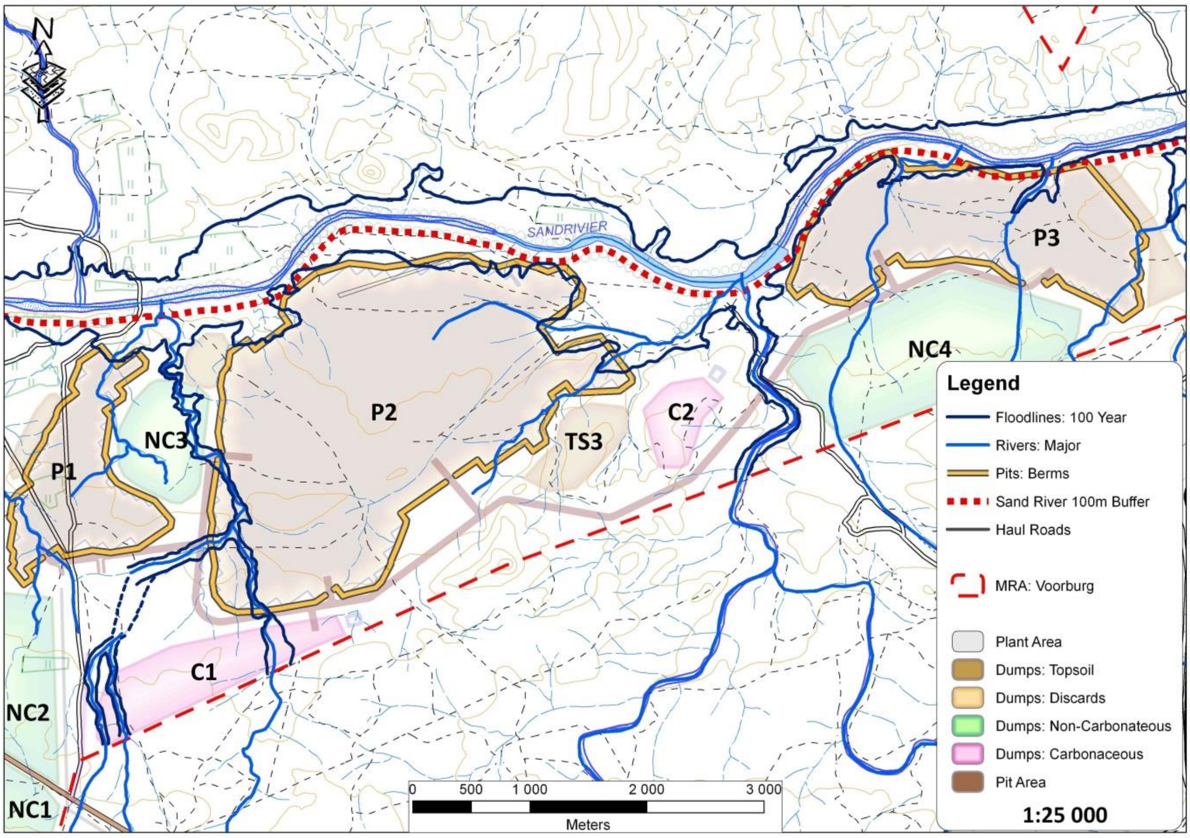

FIGURE 6.9: SAND RIVER 1:100 YEAR FLOODLINE AND 100M BUFFER

6.3 Stormwater management system required at JutlandSection

Figure 6.10 below shows the extent of the Jutland Section.

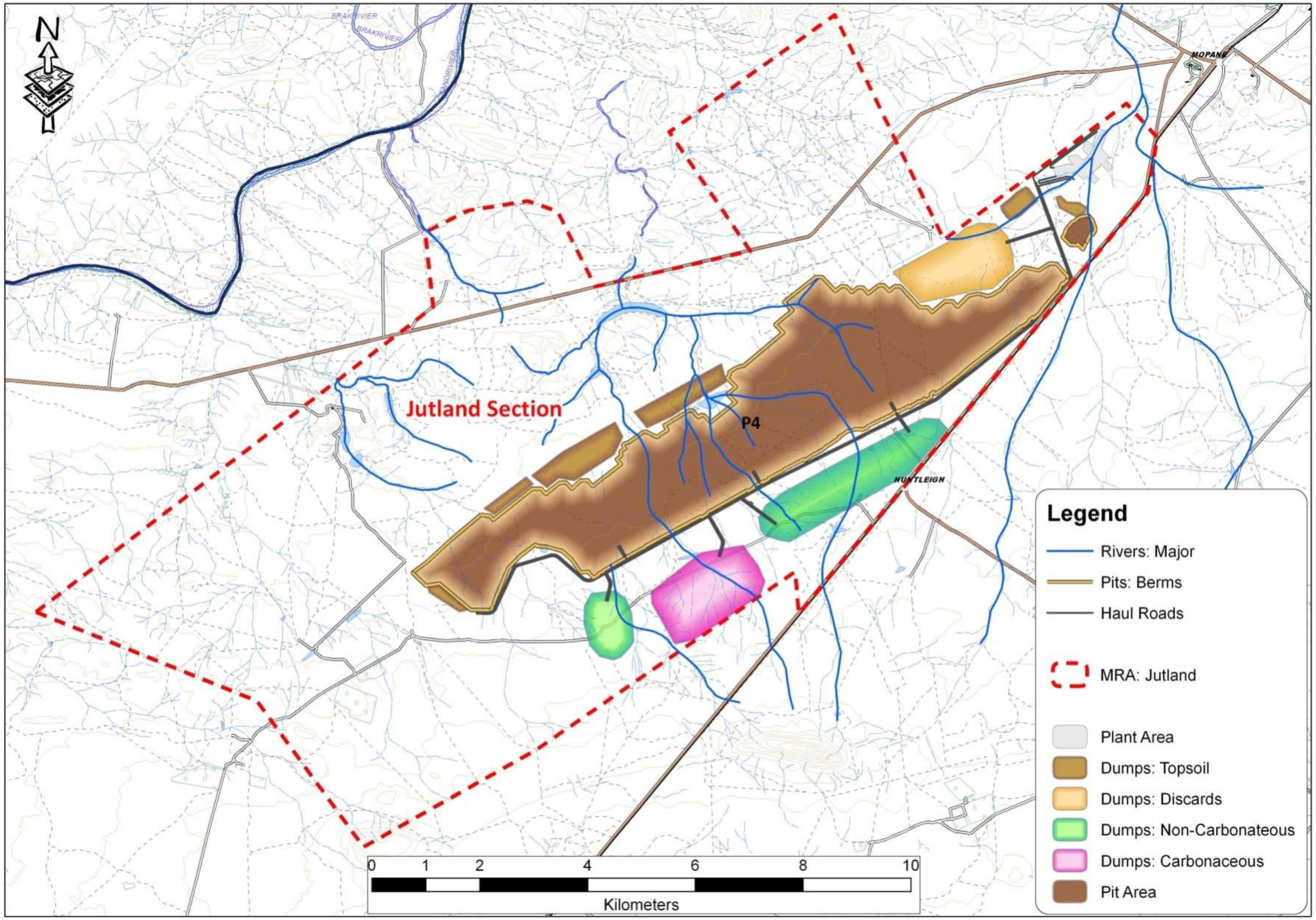

FIGURE 6.10: JUTLAND MINING ACTIVITIES

6.3.1 WestPit (P4)

Please refer to **Figure 6.11** below that shows the current layout of the proposed mining infrastructure at the West Pit (P4).

Impacts on Current Layout

Streams J1, J2, J3 and J4 will become redundant due to the mining activities. Therefore it is proposed that the non-carbonaceous stockpile NC5 and NC6 as well as the carbonaceous stockpile C3 be relocated and hydrologically reshaped to either allow these streams to accumulate clean stormwater in suitable ponds or to divert the stormwater via a clean water canal north-westwards into stream J7.

Proposed Mitigation of Mining Activities

Except for the footprint of the pit, all carbonaceous, non-carbonaceous and topsoil stockpiles will have to be relocated and the footprints of the stockpiles will also have to be reshaped hydrologically to minimize the number of detention ponds needed, to aid in the collection of dirty water runoff and also to have a minimal impact on the existing streams.

It is proposed that streams J1, J2 and J4 be diverted into aclean water canal flowing north-eastwards to stream J7 as shown in **Figure 6.12** below.

Please refer to **Figure 6.12** below that shows the proposed relocated and reshaped stockpiles as well as the proposed clean water canal.

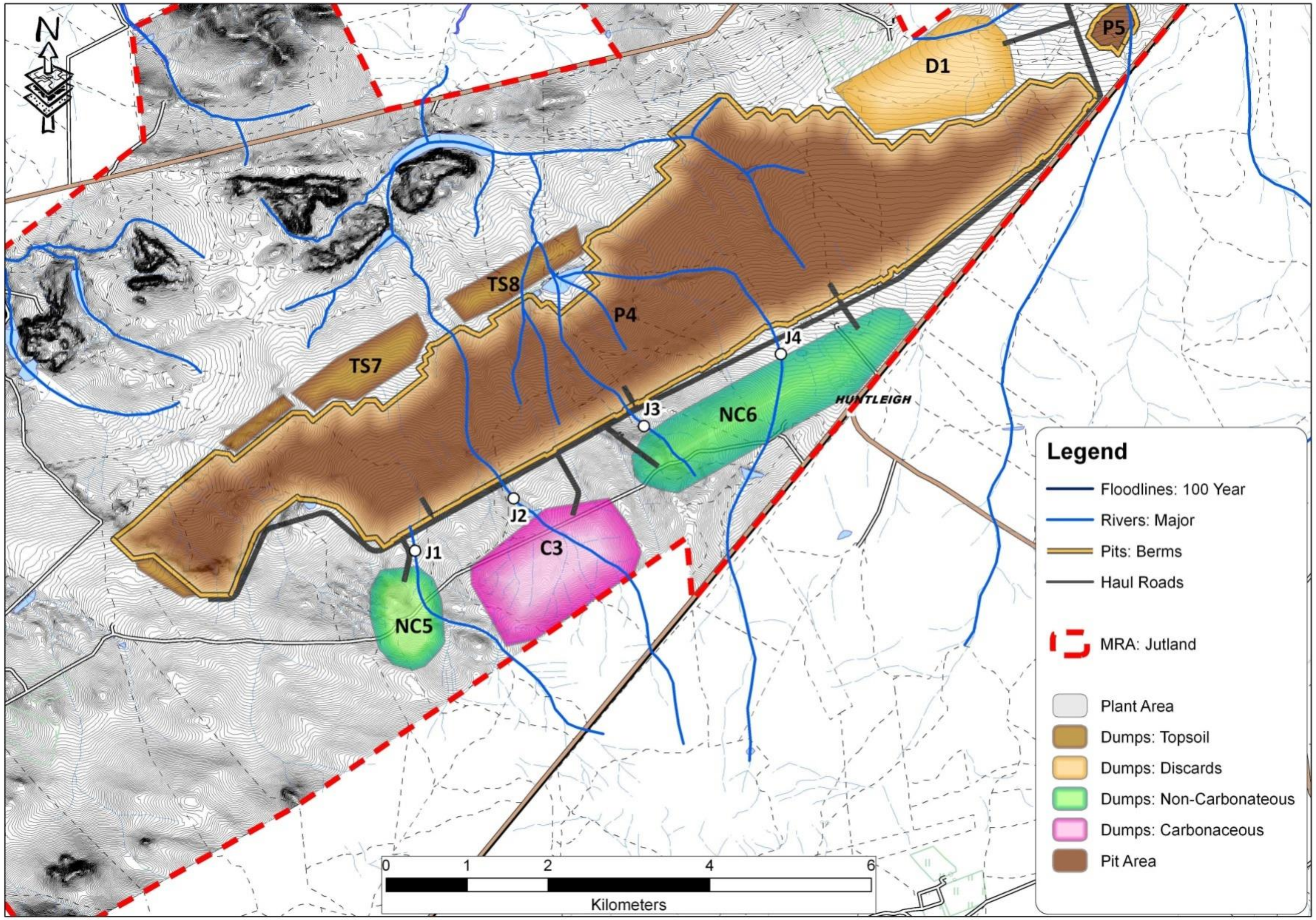

FIGURE 6.11: CURRENT JUTLAND MINING INFRASTRUCTURE – WEST PIT

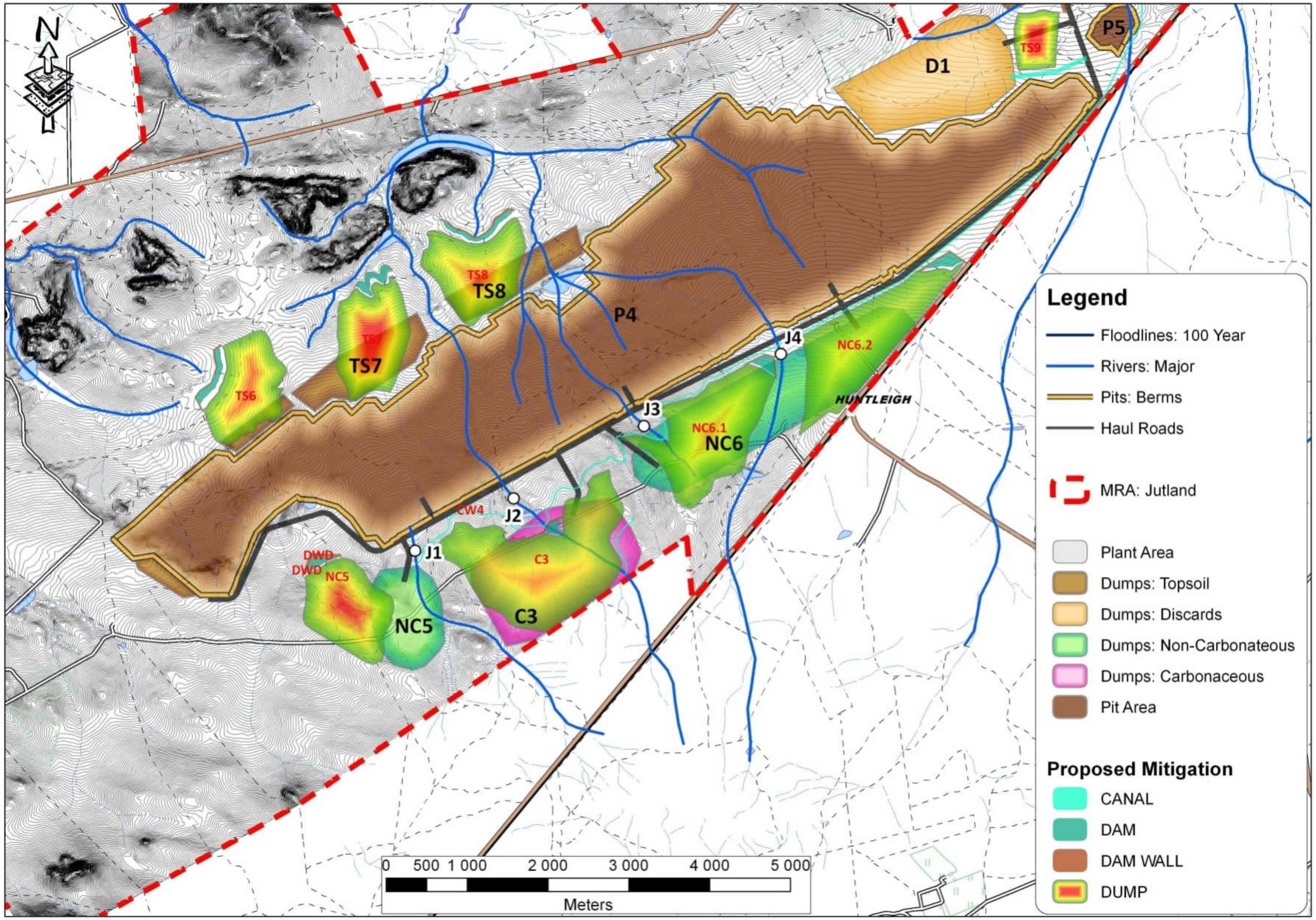

FIGURE 6.12: PROPOSED JUTLAND MINING INFRASTRUCTURE – WEST PIT

6.3.2 EastPit (P5), Plant Area (PA), Discards (D) and Railway Loop

Figure 6.13 below shows the current layout of the proposed mining infrastructure at the East Pit (P5).

Impacts on Current Layout

Three streams, J5, J6 and J7 were identified that will be impacted on by the current mining activities.

Stream J5 will be affected by the proposed pit activities and proposed plant area. It is proposed that the stream be diverted around the pit area as well as the plant area to join stream J7. This will however increase the flood inundation area within the proposed railway loop area.

The topsoil stockpile TS10 will not impede on the natural flow path of stream J5, but however it isrecommended that the stockpile be hydrologically shaped to aid in dirty water runoff collection.

Stream J6 emanates within the footprint of the discards stockpile D1 and is also impeded by the topsoil stockpile TS9 and the proposed plant area PA. It is suggested that the stream be deemed as redundant.

Stream J5 should be diverted and a dirty water dam be constructed at the lowest point along the proposed haul road which would accumulate dirty water runoff from the discard stockpile D1 as well as the topsoil stockpile TS9. Therefore it is also required to relocate the topsoil stockpile TS9 and haul road access to discard stockpile D1.

Due to the abovementioned proposed mitigation measures, the remainder of stream J6 will be become redundant and no further alternatives for the proposed plant area were envisaged.

Proposed Mitigation of Mining Activities

Please refer to**Figure 6.14** below that shows the proposed relocated and reshaped stockpiles as well as the 1:100 year floodline of stream J7, the plant area and proposed clean water canal.

The footprints of the pit and the discard stockpile D1 do not require any relocation,however, all topsoil stockpiles will have to be relocated. The footprints of the stockpiles should be reshaped to minimize the number of detention ponds needed, to improve the collection of dirty water runoff and also to have a minimal impact on the existing streams.

The haul road giving access to discard stockpile D1 also needs to be relocated as high as possible to allow topsoil stockpile TS9 to be relocated to a more hydrologically convenient position in order to drain towards the same dirty water dam as is proposed for discard stockpile D1.

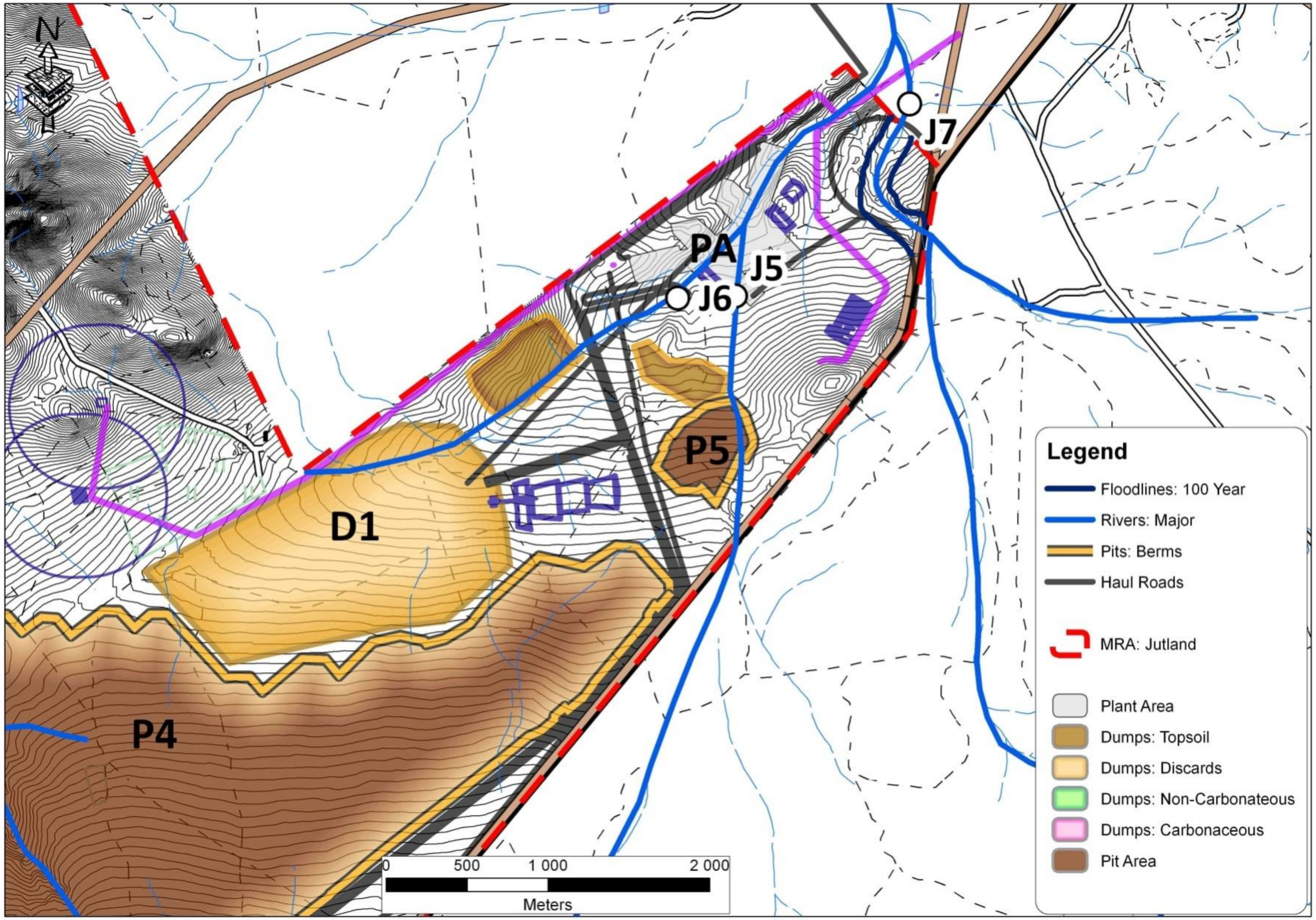

FIGURE 6.13: CURRENT JUTLAND MINING INFRASTRUCTURE – EAST PIT

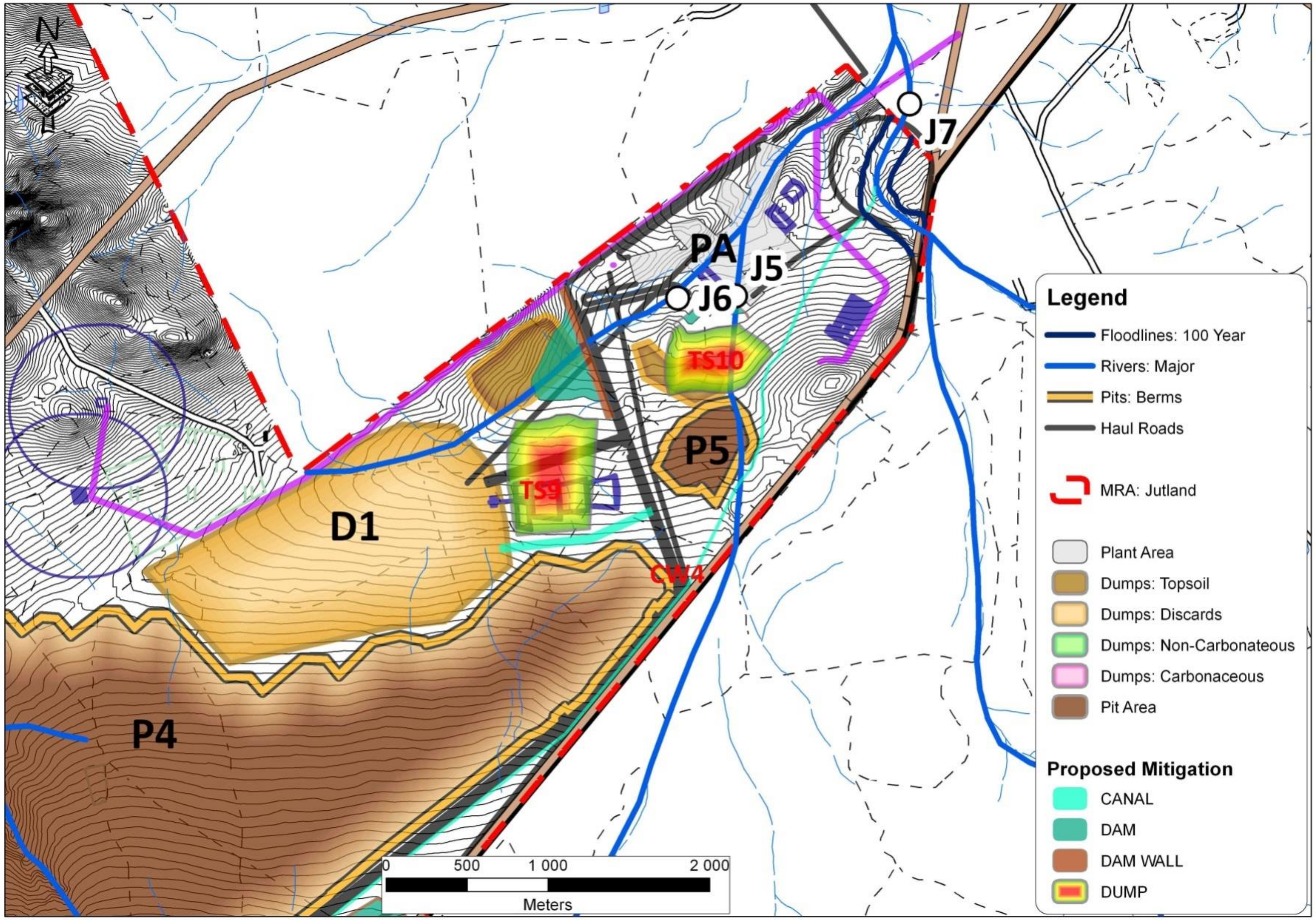

FIGURE 6.14: PROPOSED JUTLAND MINING INFRASTRUCTURE – EAST PIT

7. IMPACT OF THE PROPOSED DEVELOPMENT ON SURFACE WATER

Section 6above described the localized impacts and proposed mitigation measure, whereas this section along with **Section 8** gives an overall generalizedperspective of the impacts expected and mitigation requirements.

7.1 Impact of the proposed development on site streams and drainage lines

The Sand River and its site streams are shown in **Figure 6.2**and **Figure 6.10** as well as the outline of the opencastpits. With the drainage northwards towards the Sand River, the open pits span across a number of streams and unless diverted, runoff to the river will be reduced.

In addition, unless proper measures are taken, polluted runoff will affect the streams and the Sand River. The following areas are considered to be polluted:

- Areas of carbonaceous materials mining and haulage including pits, haul roads, tips and loading areas.
- Areas of carbonaceous materials storage such as coal stockpiles, carbonaceous materials stockpiles and dumps, including discards and other carbonaceous spoils from the pit excavations.
- Plant areas
- Areas of potential hydrocarbon pollution, such as fuelling areas, workshops and fuel or lubricant storage areas

Dirty water collection drains should be concrete lined to ensure minimal seepage into soils and aquifers. Water from these drains is then led via silt traps into pollution control dams from where it is re-cycled for re-use in the plant. The impact will be limited to a reduction in runoff, as discussed in **Section 7.2** below.

The fuelling areas, workshops and fuel or lubricant storage areasshould be concrete lined and bunded to collect any hydro carbon spillage to re-cycle containers.

The conceptual stormwater drainage layout as described in **Section 6**indicates that a total of 13 streams/drainage lines are disturbed by the mining activities. The runoff volumes and water quality of re-routed streams would not be materially affected, provided that scour of bed material is prevented so as to minimise turbidity during flood conditions. Lining of the canals and/or energy dissipating structures may be required at steep slopes.“Armorflex” lining or similar should be provided on steep sections the prevent scour by the associated high velocities and where required the side walls of flow control berms should be stabilised by a layer of soil cement to prevent scour.

7.2 Impact of the proposed mining development on surface water runoff

A vital part of the stormwater system is the prevention of pollution by separating dirty water areas from clean stormwater systems. Therefore polluted runoff from the plant areas and dumpshas to be collected in dirty water systems for storage and re-use as prescribed by law. If the system is properly implemented and maintained, the impact of the "dirty water" areas will be limited to a reduction in runoff.

Rainwater falling on the open portions of the pits will be collected as dirty water and be re-used. Likewise, seepage and surface water runoff from the carbonaceous dumps will be collected as dirty water.

The total reduction in runoff shown in **Table 21** is for the worst case scenario at the end of the life of the mine, assuming that no rehabilitation of the pits has been done and the carbonaceous dumps and plant areas retain polluted runoff.In this case the cumulated impact is a reduction in annual runoff of 147 541 m^3/annum, or 2.0% of the MAR of the downstream quaternary catchment A71K of the Sand River Basin.

Table 21: Estimated impact of proposed mine on surface water runoff in quaternary catchment area A71K (based on worst case scenario with no rehabilitation in place)

DESCRIPTION	AFFECTED AREA (ha)	% OF SITE AREA	RUNOFF INTERCEPTED* (m^3/a)	% OF MAR of A71K
Opencast mining (all pits)	2 825	80.0	126 842	1.7
Plant dirty water area, plus haul roads	132	3.7	5 927	0.08
Carbonaceous dump area	329	9.3	14 772	0.2
TOTAL FOR SITE	**3 286**	**93.0**	**147 541**	**2.0**

* Based on 4.49 mm runoff, the average for A71K

However, as described in **Section 1.4**, the pits will be *continuously rehabilitated* as mining progresses and the open areas are kept relatively small, namely 600 ha per pit. The actual affected area for two pits being mined simultaneously, would thus reduce from 3 286 ha to 1 661ha. This would half the impact to 1.0% of the A71K runoff.

It should be noted that as described in **Section 3.6.3**, the current water use from the Sand River in the vicinity of the proposed mine is limited to small portions of irrigation, using water from boreholes or well points in the sand bed of the river which is regarded as groundwater. The sand bed is replenished by runoff events in the main river and from the tributaries and thus a small reduction in yield of 1% and less of the sand aquifer immediately downstream of the mining area may occur.

7.3 Potential impacts of utilizing or developing a surface water supply source

As described in **Section 3.6.3**, the Sand Rivercannot be utilised as a surface water source. The water requirement for the Mopane Project, at the peak production rate, is estimated to require 7 600 m^3/day. At this stage, thewater supply will probably be from the following sources:

- Groundwater (boreholes and seepage into the pits)
- Stormwater runoff impounded on site
- An external source piped to site

It is recognised that stormwater is a seasonal event and its contribution to the demand will be small and inconsistent. It has therefore not been included as a source in the water-supply scheme.

7.4 Other impacts

Water quality: in the operational phase only major events or failures in the stormwater management system will lead to pollution. In the long term, decant may occur which will cause pollution.

Hydrocarbon spills: outside of the areas where special precautions are taken, spills may occur, e.g. engine failure leaking oil.

Spillage of product may occur from the railway and conveyor systems

8. PROPOSED MITIGATION MEASURES

- Diversion of streams and drainage lines: The water quality of re-routed streams should be maintained by preventing scour of bed material, therebyminimising turbidity during flood conditions. Lining of the canals and/or energy dissipating structures may be required at steep slopes.

- Impact of the proposed mining development on surface water runoff quantity: The area of the open pits should be kept as small as possible to minimize the reduction in runoff of the Sand River.

- Impact of the proposed mining development on surface water runoff quality: By adhering to the requirements of GN 704 and implementing a design along the guidelines provided in the Best Practice Guidelines, the water quality will not be polluted by mining activities. However, care should be taken in the mining development phase to restrict the clearing of land to the minimum required. In this phase, while erosion control measures are being implemented, the highest risk of erosion damage occurs. This will lead to high turbidity levels and increased sediment in the drainage lines and streams.

- In the event of major floods causing failure of the system, the dilution effect mayminimise the impact.

- Other types of failures should be prevented by proper management and maintenance of the system.

- Impact of the dirty water areas on water quality: By adhering to the requirements of GN 704 and following the best practice guidelines, as would be required in the licensing application, dirty water is contained and water available after evaporation losses will be re-used.

- In case of accidental spillages, especially of hydro carbons and of coal, specialized equipment should be available on site to mop up the pollutants before irreversible damage is caused. Else, specialized contractors may be used to fulfill this function.

- Off-setting the loss of wetlands: The creation of small impoundments at the head of stream diversions, where appropriate, may be considered. These low structures (earth or gabion embankments) will lower the approach velocity and contain sediment, thereby delivering relatively clean water at acceptable velocities into the canal system. In time wetlands will be formed behind the embankments.

- Impact of surface water use: At this stage of the investigations, the large-scale development of a surface water source for use by the mine does not appear feasible. Therefore surface water use would be limited to the direct rainfall on open pits, increased evaporation loss and a small quantity to be stored for use in the dirty water areacontrol dam.

- Limiting erosion at drainage structures, e.g. design and install appropriate outlet structures to retard the flow velocity.

AM JANSEN VAN VUUREN PrEng
October 2013

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