THE DUEL COAL PROJECT

SURFACE WATER ASSESSMENT FOR THE ENVIRONMENTAL IMPACT ASSESSMENT

FEBRUARY 2016

PREPARED FOR:

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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

The Duel Coal Project

Surface Water Assessment

For the Environmental Impact Assessment

February 2016

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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THE DUEL COAL MINE

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 (pre 1996)
DWAF	Department of Water Affairs and Forestry (pre 2009)
DWS	Department of Water and Sanitation
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
Hec-Ras	Hydraulic Engineering Centre's River Analysis System
LOM	Life of Mine
mamsl	metre above mean sea level
mcm	million cubic meters
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
Mtpa	Million ton per annum
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 Jacana Environmentals cc to undertake the surface water assessment as part of the Environmental Impact Assessment for the proposed The Duel Coal Project.

The Duel Coal Project will be referred to as the Study Area.

The Study Area is situated on the remainder of the farm The Duel 186 MT which is approximately 20 km south-west of the town Tshipise, as shown in **Figure 1.1** below. The development is situated within the Makhado Local Municipality which forms part of the Vhembe District Municipality.

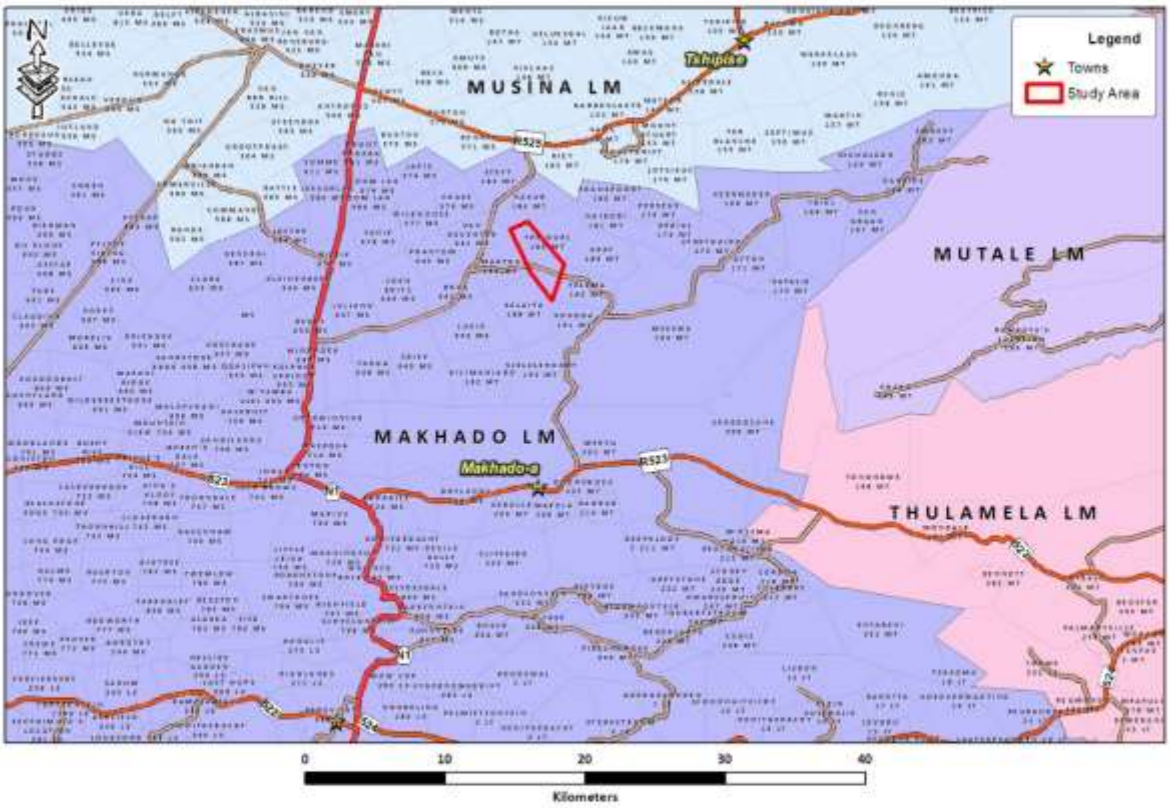


FIGURE 1.1: LOCALITY MAP

The Study Area is located in the Mutamba River basin, which is a tributary of the Nzhelele River. The Nzhelele River, together with the Nwanedzi River, form the secondary catchment area A80, which has been subdivided into nine quaternary sub-catchments (no tertiary sub-divisions were made). The Nzhelele River has its confluence with the Limpopo River about 35 kilometres east of Musina. The Nzhelele Basin covers an area of approximately 425 km^2, which is 1% of the South African portion of the Limpopo Basin.

1.2. SCOPE OF WORK

The objective of the impact assessment is to provide information relating to the site surface water hydrology and includes the following:

- **Climate data** which include Temperature, Winds, Mean Annual Precipitation (MAP), Mean Monthly Precipitation (MMP), Evaporation and Runoff.
- Determination of the 1:100 and 1:50 year recurrence interval **flood peaks** for streams that may be affected by the mining operation.
- **Buffer zones** will be shown, as required by GN704 for streams that directly affects the mining operations, where no accurate survey is available.
- Pre-development **surface water quality**.
- **Ecological Classification**.
- Current surface **water sources and use**.
- Description of expected impacts and mitigation measures.
- Risk assessment of the river systems.

1.3. METHODOLOGY

A description of the environment is essential in that it represents the conditions of the environment before the commencement of mining operations in the Study Area. The impact of the proposed project can be identified, assessed and future changes monitored based on the current conditions.

Regional information on climate, temperature, annual and monthly rainfall, runoff and evaporation, and current land use given in **Section 3** of the report was obtained from available sources to include up to date information as far as possible.

Section 4 discusses the ecological classification of the rivers and streams in the region, which is based on broad-scale patterns of physiography, climate, geology, soils and vegetation as described by (Kleynhans et al. 2005)

The Rational Method with alternative (Alexander) method of calculating rainfall intensity as described in the SANRAL Drainage Manual (2006) was used to determine the flood peaks for the site streams. Only 100 m buffer zones as per GN704 were delineated as part of the hydraulic assessment in **Section 5.** No elevation e.g. survey contours were available at the time of this report.

The major aim of **Section 6** is to describe the expected impacts on surface water quantity and surface water quality that the mining activities will have on the environment. **Section 7** describes the mitigation measures that were proposed to be incorporated to comply with the implementation of the Government Notice 704 requirements in relation to the National Water Act.

Section 8 consists of an risk assessment which was done as a desktop study and should be viewed as a guideline for the professional ecological judgement in terms of surface water quality and quantity for the Study Area.

1.4. PROJECT TEAM

The team consisted of Anna M Jansen van Vuuren PrEng, 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:	36
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 SA Institute of Civil Engineering

Key experience:

Anna van Vuuren is a water engineer working in the field of water supply, stormwater management, hydrology and specialized 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 downstream 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.

Surface water assessment input to EIA/EMP of Makhado Mine. (2010-2012). Involved in floodline studies (for site streams and the Mutamba River) and conceptual design of stormwater systems to divert clean water around pits and plant area, including proposed diversion structure in the Mutamba River along with access bridge hydraulic design.

Client: Jacana Environmentals cc.

2. APPLICABLE LEGISLATION AND GUIDELINES

2.1. SOUTH AFRICAN LEGISLATIVE AND STANDARDS FRAMEWORKS

The methodology followed in the impact assessment is largely prescribed by the legal requirements, as elaborated on in the Department of Water and Sanitation's 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 which deals primarily with the equitable management of the nation's mineral and petroleum resources.
- National Environmental Management Act (NEMA) (Act 107 of 1998) and relevant regulations. The main aim of the NEMA is to provide for co-operative environmental governance by establishing principles for decision-making on matters affecting the environment.
- National Water Act (NWA) (Act 36 of 1998) and relevant regulations.
- Government Notice No. 704 (GN 704) (4 June 1999) on the use of water for mining and related activities aimed at the protection of water resources.
- DWAF's Best Practice Guidelines:
  - H Series dealing with aspects of water management HIERARCHY.
  - G Series dealing with GENERAL water management strategies, techniques and tools.
  - A Series dealing with specific mining ACTIVITIES or ASPECTS.
- South African Water Quality Guidelines (2nded) Volume 1: Domestic Use; Volume 7: Aquatic Ecosystem, DWAF (1996).

Of particular importance to this study is **Government Notice No. 704** which is discussed in ***Section 2.3*** in more detail.

2.2. RELEVANT SECTIONS OF THE NATIONAL WATER ACT (ACT 36 OF 1998)

The following Sections of the NWA described below are regarded as important, but other sections may also be applicable in the proposed development:

Section 1.(1)(xxiv) of the NWA defines 'water course' as follows:

- River or spring;
- A natural channel in which water flows regularly or intermittently;
- A wetland, lake or dam into which, or from which, water flows; and
- any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

Based on the above definition even small, usually dry drainage lines are streams. River channels may be classified according to guidelines by DWA in "*A practical field procedure for identification and delineation of wetlands and riparian areas*" as shown in **Figure 2.1**(taken from *DWA, 2005*). Three sections along the length of a watercourse is defined, with the upper Section A defined as being above the zone of saturation and it therefore does not carry baseflow. They are mostly too steep to be associated with alluvial deposits and are not flooded with sufficient frequency to support riparian habitat or wetlands. This type does however carry storm runoff during fairly extreme rainfall events but the flow is of short duration, in the absence of baseflow. The 'A' watercourse sections are the **least sensitive watercourses** in terms of impacts on water yield from the catchment.

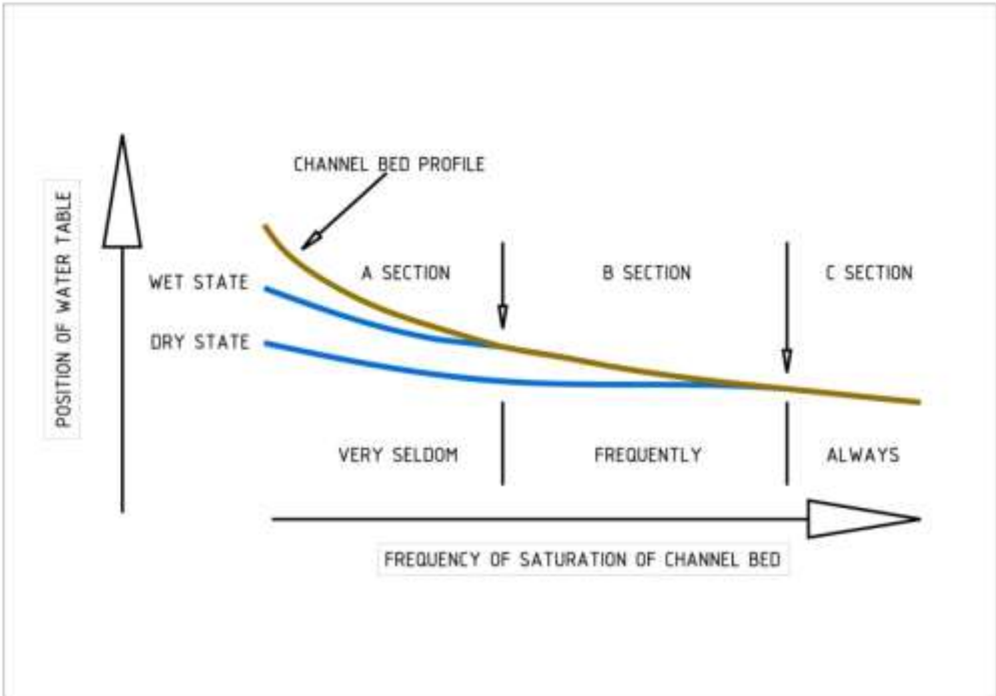


FIGURE 2.1: RIVER CLASSIFICATION (DWA 2005)

The 'B' Sections are those channels that are in the zone of the fluctuating water table and only have baseflow at any point in the channel when the saturated zone is in contact with the channel bed. In this 'B' Sections **baseflow is intermittent**, with flow at any point in the channel depending on the current level of the water table. Because the channel bed is in contact with, or in close proximity to, the water table, residual pools are often observed when flow ceases. The gradient of the channel bed is flat enough in these sections for deposition of material to take place and initial signs of flood plain development may be observed.

In 'C' Sections the water table is always above river bed level and the river flow is perennial.

Section 19 states that the person who owns, controls, uses or occupies land on which any activity or process is or was undertaken, or any other situation exists which causes, has caused or is likely to cause pollution of a water resource is responsible for taking all reasonable measures to prevent such pollution from occurring, continuing or recurring.

Section 21 broadly defines "water use" to include:

- Taking water from a water resource;
- Storing water;
- Impeding or diverting the flow of a water course;
- Engaging in a stream-flow reduction activity;
- Engaging in a controlled activity identified in s31(1) or declared under s38(1);
- Discharging waste or water containing waste into a water resources through a pipe, canal, sewer, sea outfall or other conduit;
- Disposing of waste in a manner that may detrimentally impact on a water resource;
- Disposing in any manner of water containing waste from or which has been heated in any industrial or power generation process;
- Altering the bed, banks, course or characteristics of a water course;
- Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for human safety; and
- Using water for recreational purposes.

Section 22(1) regulates the use of water:

- Without a license:
  - If the water use is permissible under Schedule 1 of the Act;
  - It the water use is permissible as a continuation of an existing license use (s32-s35);
  - If the water use is permissible in terms of a General Authorization issued under s39;
- If the water use is authorized by a license under the NWA; or
- If the responsible authority dispensed with a license requirement in terms of s22(3).

Section 41 sets out the procedures for applying for a water use license (WUL).

2.3. GOVERNMENT NOTICE NO. 704 (4 JUNE 1999) ON THE USE OF WATER FOR MINING AND RELATED ACTIVITIES AIMED AT THE PROTECTION OF WATER RESOURCES

Summary of the Government Notice:

Mining and associated infrastructure development is guided by the provisos in the GN, particularly regulations 3, 4, 6 and 7, which are described as follows:

- **Regulation 3** – this regulation states that the Minister may in writing authorize 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 conditions determined by him or her.

- **Regulation 4** – this regulation addresses the locality of developments, where estimated flood zone widths are set as buffer zones for development, or zone widths are prescribed. These include the following:

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

- **Regulation 6** – this regulation addresses the capacity requirements of clean and dirty water systems. The relevant issues in this regard include:

  - Clean water systems should not spill into any dirty water system more than once in 50 years.
  - Likewise, any dirty water system should not spill into clean water systems more than once in 50 years.
  - Any dam that forms part of a dirty water system to have a minimum freeboard of 0.8m above the full supply level.
  - 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.

- **Regulation 7** – this regulation addresses the measures to protect water resources and includes the collection and re-use, evaporation or purification of water containing waste; measures to be taken to minimize 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.

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

2.4. WATER QUALITY EVALUATION

In evaluating the Site's pre-development **surface water quality**, use is made of DWS's set of publications "South African Water Quality Guidelines", second edition, 1996. It consists of guidelines for domestic, recreational, industrial and agricultural water uses and guidelines for the protection of aquatic ecosystems.

In this study the guidelines for domestic use, agricultural use and aquatic ecosystems will be used, since communities may use water directly from streams and aquatic life is an important facet of the downstream resources. These three guidelines are considered to have, in general, more stringent water quality requirements than for livestock and game.

As described in the "Guidelines", they are used by the Department of Water and Sanitation as its primary source of information and decision-support to judge the fitness of water for use and for other water quality management purposes. These water quality guidelines differ from the SANS document on Drinking Water Quality Standards (SANS 241) in that the standards give the required limits for drinking water supplies by water supply authorities, produced by treatment works for distribution to households.

For each water quality constituent there is a "**No Effect Range**". This is the range of concentrations or levels at which the presence of that constituent would have no known or anticipated adverse effect on the fitness of water for a particular use, or on the protection of aquatic ecosystems. These ranges were determined by assuming long-term continuous use (life-long exposure) and incorporate a margin of safety.

As a matter of policy, the DWS strives to maintain the quality of South Africa's water resources such that they remain within the No Effect Range. For this reason, the "**No Effect Range**" in the South African Water Quality Guidelines is referred to as the **Target Water Quality Range (TWQR)**. It is included, and highlighted as such, in the water quality criteria provided for each of the constituents in the guidelines. It should be noted that the Target Water Quality Range specifies good or ideal water quality instead of water quality that is merely acceptable.

The fitness for use of water can range from being completely unfit for use to being 100 % or ideally fit for a specific use. The narrative descriptions commonly used to express judgements about the fitness of water for use are:

- ideal; 100 % fit for use; desirable water quality; target water quality range (TWQR);
- acceptable;
- tolerable, usually for a limited time period only;

- unacceptable for use;
- completely unfit for use

The assumptions underlying the development of the guidelines must be taken into account, particularly when making judgments about the fitness of water which needs to be used for a short duration only.

Note that in evaluating the water quality for aquatic life where multiple species may occur, the **impact on the species in the community** must be determined. When the Aquatic TWQR is exceeded, the measurement should be compared to the Chronic Effect Value (CEV), which is defined as follows: *"Concentrations at which there is expected to be a significant probability of measurable chronic effects to up to 5% of the species in the aquatic community"*. If exceeded, the chronic effects will be more widespread. The Acute Effect Value (AEV) is defined as that concentration of a constituent above which there is expected to be a significant probability of acute toxic effects to up to 5% of the species in the aquatic community. If such an effect persists for even a short while, or too often, it can quickly cause the death and disappearance of species or communities from the aquatic ecosystem.

2.5. REQUIREMENTS OF THE NWA AND GN704

Based on requirements in the NWA and GN704, the first step in the surface water study is to estimate the flood peaks along affected drainage lines and to determine the associated flood zone widths. Flood peak estimation is undertaken through application of methods such as the Rational Method or through statistically analyzing available flood data. Site topographical surveys are used in flood modelling software for the determination of flood widths for the stipulated floods as per the recommendations above. The results of this exercise are described in **Section 6** of this report. The potential impacts of the proposed development on surface water are described in **Section 7**.

Current surface water quality data is collected as the baseline data which may be used to establish water quality resource objectives once the ecological classifications of the affected rivers and streams have been accepted.

By overlaying the proposed development on the site map, the layout of an adequate stormwater management system was determined and conceptually designed, thereby limiting the impact that the Study Area may have on the surface water sources.

2.6. LICENCING REQUIREMENTS

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

Art 21: Licences will 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 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 m³, the dam must be registered with DWS. If classified as a category 2 dam, it must be designed and the construction monitored by an Approved Professional Person (APP) appointed by DWS.

3. DESCRIPTION OF THE ENVIRONMENT

A description of the environment is essential in that it represents the conditions of the environment before the commencement of construction in the Study Area. The impact of the proposed project can be identified, assessed and future changes monitored based on the current conditions.

The information presented in this Section was collected from desktop studies and supplemented with a site visit to the Study Area.

3.1. REGIONAL CLIMATE

The northern part of the Limpopo Province is situated in a dry savannah sub region, characterized by open grasslands with scattered trees and bushes. The Soutpansberg mountain range is a major regional topographic feature and it extends in an east-west direction for a distance of approximately 130 km. The regional climate is strongly influenced by this 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 region is characterized by Warm Temperate to Arid Climate conditions as classified by the 2012 CSIR Köppen-Geiger map for South Africa (Conradie and Kumirai, 2012).

The climate for the region varies from warm summers with dry winters (Cwa) in the south and in close proximity to the Soutpansberg Mountains to Hot Semi-Arid and Arid (Bsh & Bwh) conditions north of the mountains. The regional climate conditions are shown in **Figure 3.1** below.

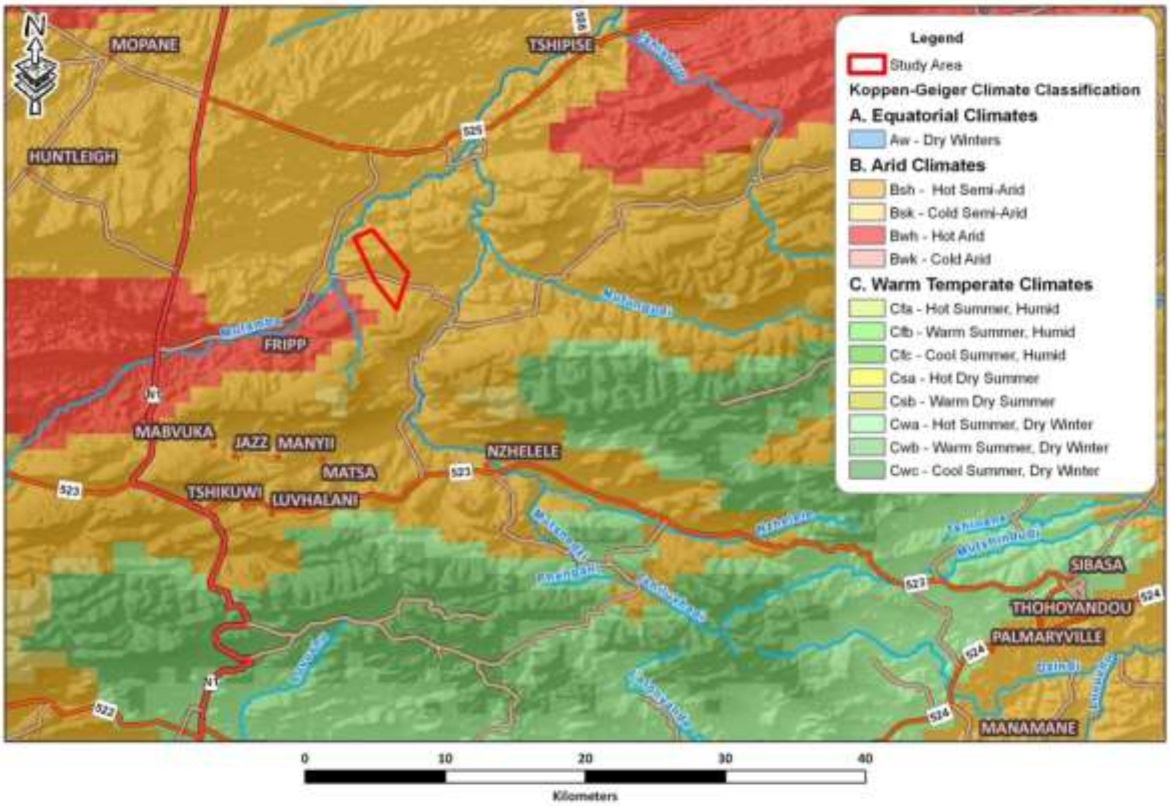


FIGURE 3.1: KÖPPEN-GEIGER CLIMATE

3.2. TEMPERATURE

Average monthly minimum and maximum temperatures for the Tshipise weather station (No. 0766277 1) some 5 km north-east of the Study 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, **Figure 3.2** and **Figure 3.3**, indicate the maximum and minimum annual temperature for the region that was obtained from their natural resources atlas on climate.

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. Temperature ranges from 0.9°C to 39.9°C and the area is generally frost free.

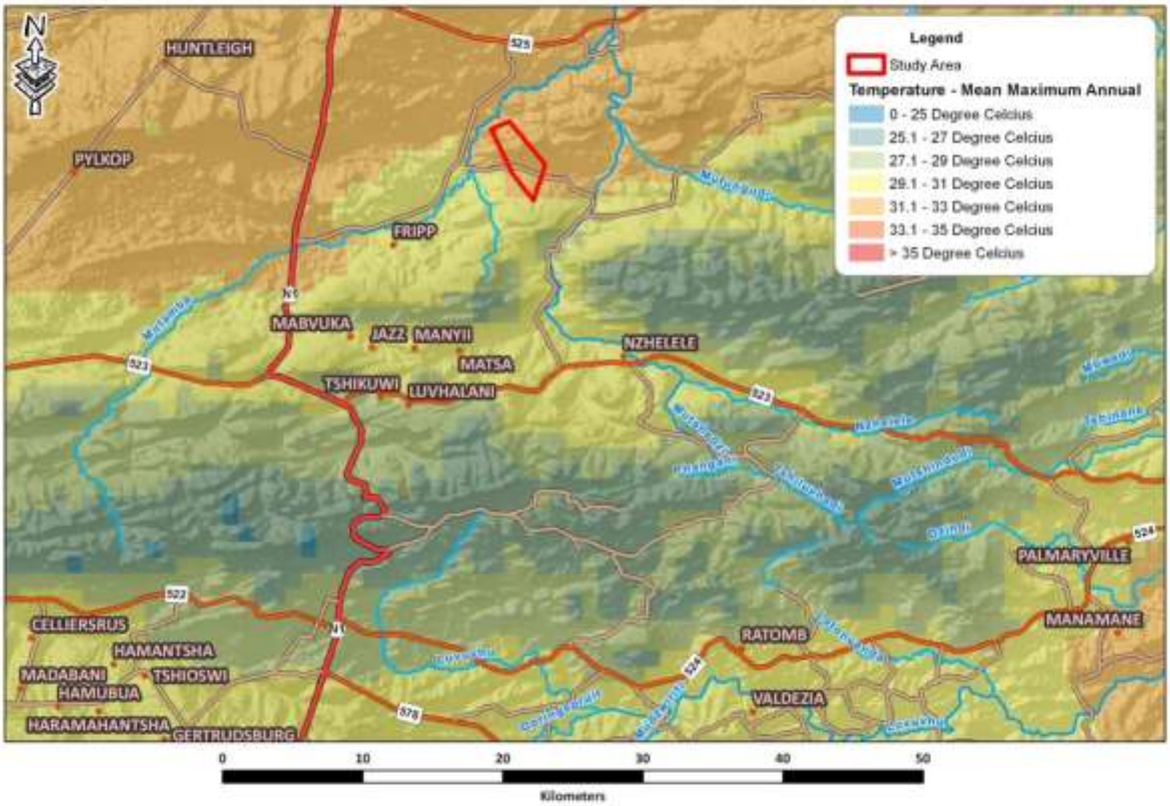


FIGURE 3.2: MEAN ANNUAL MAXIMUM TEMPERATURE

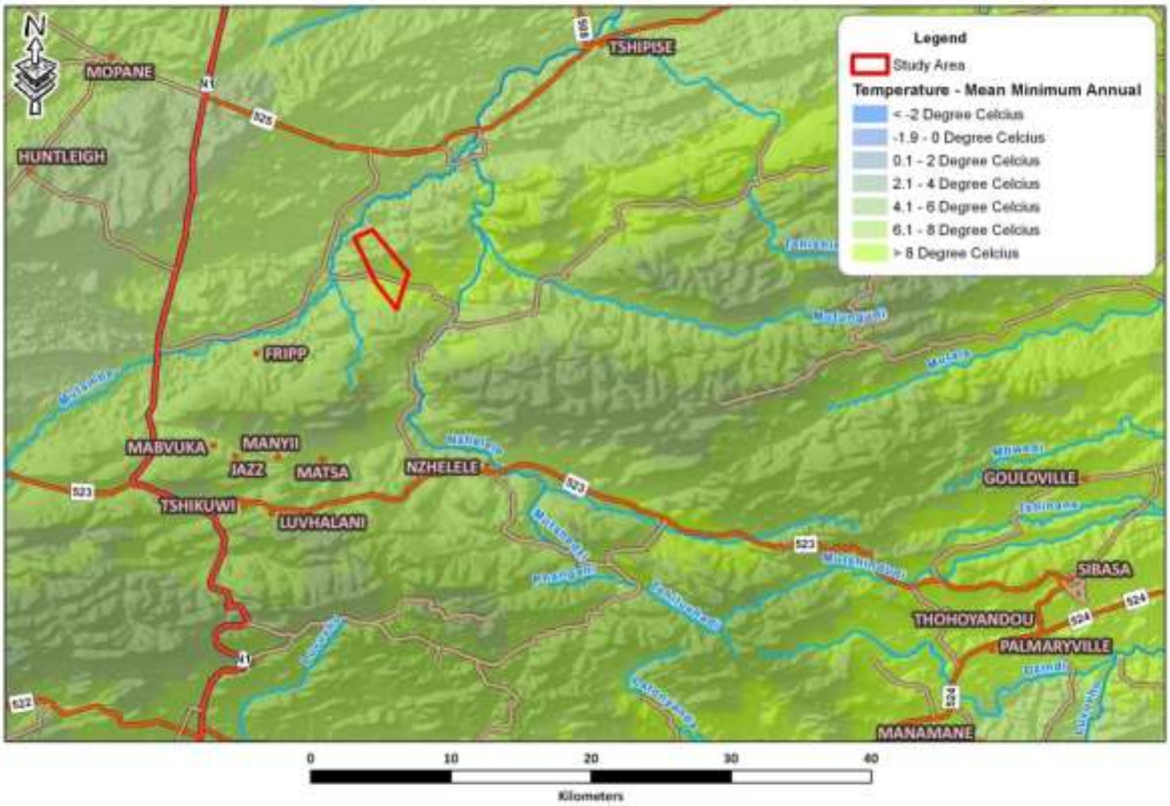


FIGURE 3.3: MEAN ANNUAL MINIMUM TEMPERATURE

3.3. MEAN ANNUAL PRECIPITATION AND MEAN MONTHLY RAINFALL

The mean annual precipitation (MAP) distribution for the region is shown in **Figure 3.4** below and varies from 1600-1700 mm south of the Soutpansberg Mountains to 200-300 mm north of the mountains near Tshipise.

With the Study Area located within the **hot semi-arid region (**as described in **Section 3.1),** the rainfall is in the order of 300-500 mm per annum. The area experiences summer rainfall which occurs in the form of heavy thunderstorms or soft rain. Being in the hot and semi-arid region, high evaporation rates are experienced.

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 Study Area span across the quaternary catchment A80F as defined in the WR2005, Study (*Middleton and Bailey, 2009*) which is described in **Section 3.5** and shown in **Figure 3.5** below**.**

The quaternary catchment is located in Rainfall Zone A8A. The mean monthly precipitation values are given in **Table 2** below. The maximum monthly rainfall occurs in January and the lowest in August. The monthly distribution pattern of rainfall in the quaternary catchment is shown in **Table 3.**

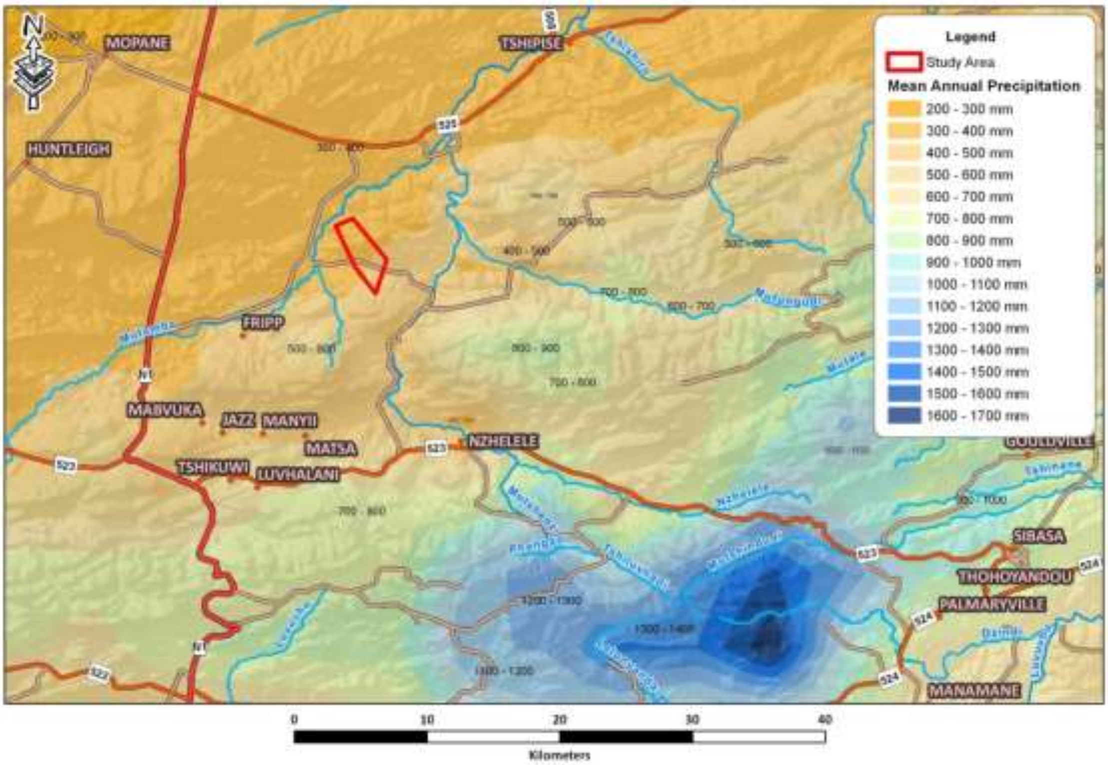


FIGURE 3.4: MEAN ANNUAL PRECIPITATION

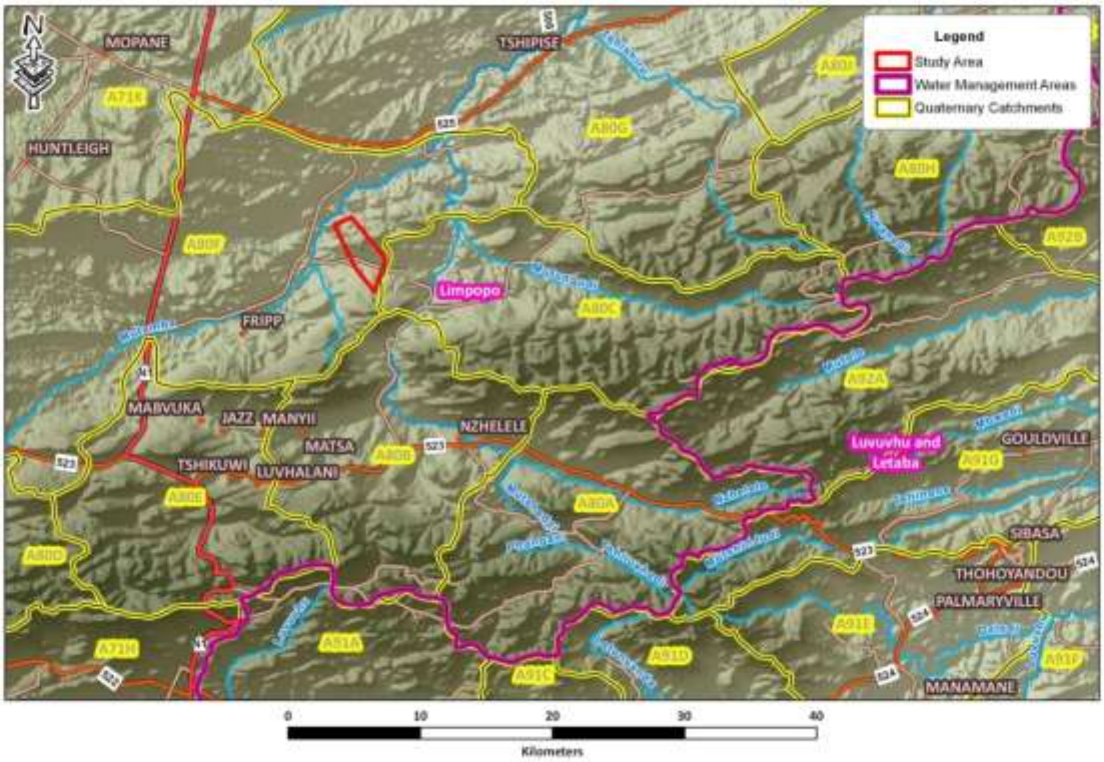


FIGURE 3.5: QUATERNARY CATCHMENTS

TABLE 2: MEAN MONTHLY RAINFALL DISTRIBUTION OF SITE RAINFALL ZONE A8A

Rainfall Zone	MeanMonthlyPrecipitation(%Distribution)											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A8A	6.46	11.81	15.17	20.17	18.66	13.16	5.40	2.29	1.63	1.66	1.15	2.43

(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's quaternary catchments are shown in **Table 3** below. The average rainfall for the catchment has been determined and the maximum rainfall of 78 mm occurs in January and the lowest of 4 mm in August. The data in the table is shown in the bar chart below **(Figure 3.4)**.

TABLE 3: MEAN MONTHLY QUATERNARY RAINFALL (mm)

Quaternary Catchment	MeanAnnual Precipitation (mm)	Rainfall Zone	MeanMonthlyPrecipitation (mm)											
			OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A80F	388	A8A	25	46	59	78	72	51	21	9	6	6	4	9

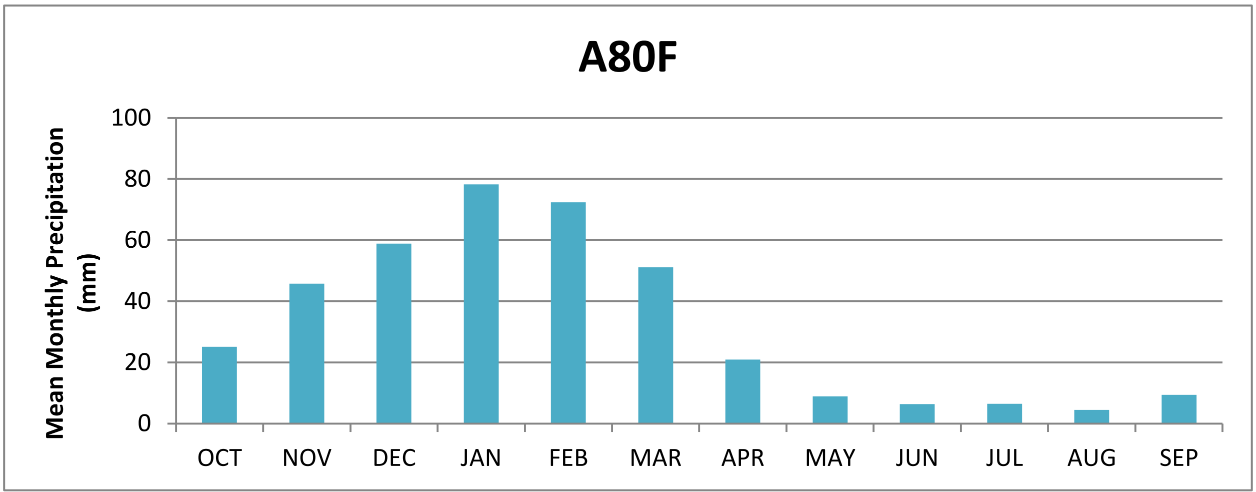


FIGURE 3.6: DISTRIBUTION OF MEAN MONTHLY PRECIPITATION (mm)

3.4. RUNOFF AND EVAPORATION

3.4.1. MUTAMBA RIVER BASIN RUNOFF

The DWS has delineated the country's river systems into 22 major drainage basins, referred to as 'Primary' catchment areas. Each basin has subsequently been subdivided into secondary, tertiary and quaternary catchment areas. The Limpopo River Basin was designated as river basin 'A' and Study Area is within this basin. It is situated mainly within the Nzhelele River Sub-Basin, which is a tributary of the Limpopo River. The upper reaches of the Nzhelele River, including its tributary the Mutamba River, originate from the Soutpansberg Mountain range in the vicinity of Makhado, approximately 50 km south of the Study Area. The Mutamba River drains a substantially dry bushveld area, an area north of the mountains, which is drier than the feeder areas of the Nzhelele River.

The catchment hydrological data of this summer rainfall region are summarized in **Table 4** below. The MAR value is based on the net catchment area shown in the table.

The Mutamba River flows into the Nzhelele River downstream of the Nzhelele dam, at the outlet of catchment A80F. The unit runoff in the Mutamba River is shown in **Table 5** below**.**

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, since there are no reliable long term measured flow data for most of the catchment. Note that the present day MAR 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) OF THE MUTAMBA RIVER

Quaternary catchment	Net area (km^2) A	Mean Annual Precipitation (mm) MAP	Mean Annual Run-off (mcm) MAR	Mean Annual (gross) Evaporation (mm) MAE (Zone1B)	Irrigation area (km^2)	Forest area (ha)
A80D	128	622	6.16	1450	0.51	0
A80E	247	622	11.98	1450	0.51	0
A80F	491	388	4.06	1750	0	0
TOTAL	**866**		**22.20**		**1.02**	**0**

Source: WR2005 Study (Middleton and Bailey, 2009)

The naturalized monthly run-off in the Mutamba River has been compiled from data in WR2005 and the resultant MAR is 22.20 million m^3/a as shown in **Table 5.**

TABLE 5: MUTAMBA RIVER NATURALIZED RUN-OFF (mcm = million cubic metres)

River	Area	Mean Monthly Natural Runoff (mcm)												Mean Annual Natural Runoff (mcm)
		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	
A80D	287	0.11	0.16	0.33	1.02	1.66	1.47	0.58	0.26	0.19	0.15	0.13	0.10	6.16
A80E	251	0.22	0.32	0.64	1.98	3.20	2.85	1.13	0.50	0.37	0.31	0.25	0.21	11.98
A80F	294	0.05	0.09	0.22	0.95	1.31	1.04	0.25	0.04	0.03	0.03	0.03	0.03	4.06
TOTAL		**0.37**	**0.57**	**1.19**	**3.95**	**6.17**	**5.36**	**1.96**	**0.80**	**0.59**	**0.49**	**0.41**	**0.34**	**22.20**

Source: WR2005 Study (Middleton and Bailey, 2009)

The spatial representation of the regional Mean Annual Runoff as defined in the WR2005 Study (*Middleton and Bailey, 2009*) is shown in **Figure 3.7** below**.**

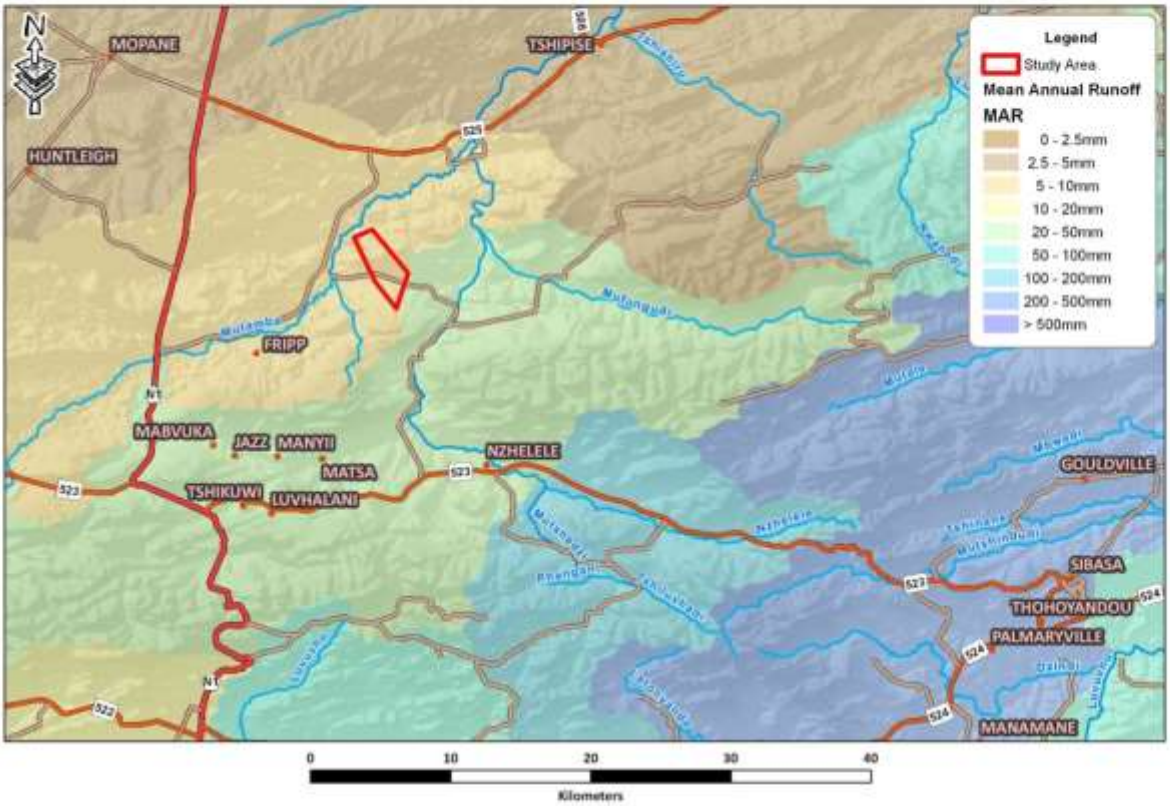


FIGURE 3.7: REGIONAL MEAN ANNUAL RUNOFF (mm)

3.4.2. EVAPORATION

Mean Annual Evaporation data is given in **Table 4**, while the monthly evaporation pattern (as percentages of the total) is given in **Table 6** below.

The spatial representation of the regional Mean Annual Evaporation as defined in the WR2005 Study (*Middleton and Bailey, 2009*) is shown in **Figure 3.8** below**.**

TABLE 6: MONTHLY EVAPORATION DISTRIBUTION

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

Source:WR90, evaporation zone 1B,based on data from Albasini Dam

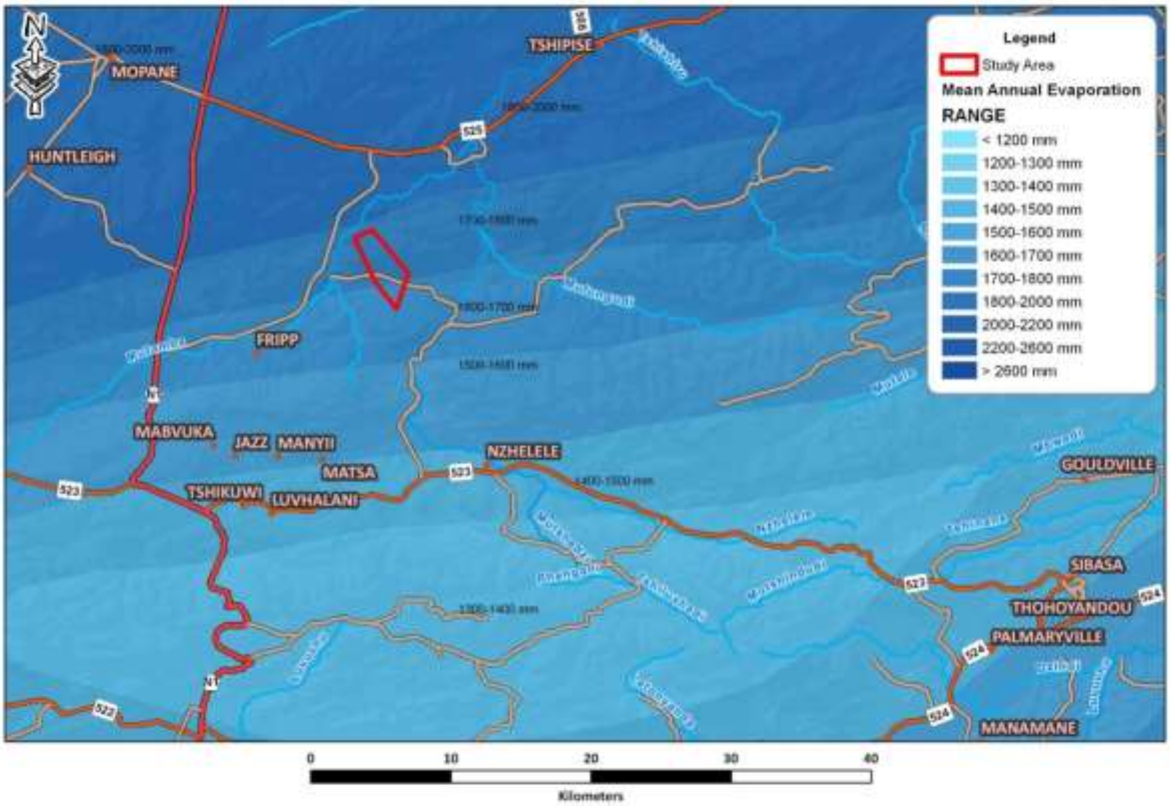


FIGURE 3.8: REGIONAL MEAN ANNUAL EVAPORATION (mm)

3.5. SURFACE WATER

3.5.1. LOCALITY AND BACKGROUND INFORMATION

There are no DWS registered dams in the Mutamba River catchment.

Although it is known that surface water is utilized for irrigation from the lower reach of the Mutamba River just before the confluence of the Nzhelele River, the WR2005 indicate that there is no irrigation areas within the quaternary catchment A80F. The water requirements of households and livestock (including game) are supplied mainly by the Nzhelele RWS bulk pipeline from the Phiphidi Weir, 2km south of the Nzhelele Dam.

Hydrological data of the quaternary catchment is given in **Section 3.3** and **Section 3.4** of this report.

3.5.2. STREAM CLASSIFICATION

The classification of streams is described in **Section2.2**.

Section A channels occur on the foothill slopes in the northern part of the Study Area, also along the smaller streams lower down.

The Mutamba River is classified as only a Section B stream. According to the DWS's guidelines, the “B” Sections are those channels that are in the zone of the fluctuating water table and only have baseflow at any point in the channel when the saturated zone is in contact with the channel bed. In these B Sections, baseflow is intermittent with flow at any point in the channel depending on the current height of the water table. Because the channel bed is in contact with, or in close proximity to, the water table, residual pools are often observed when flow ceases. The gradient of the channel bed is flat enough in these Sections for deposition of material to take place and initial signs of flood plain development may be observed.

3.5.3. SURFACE WATER QUALITY

There are no published surface water quality data for the Mutamba River. DWS collects water quality data at the dams on the Nzhelele River system, upstream from Nzhelele Dam. This information is not deemed applicable since the Study Area falls within the Mutamba River basin.

During a site visit to the Study Area conducted in September 2014, no additional surface water quality samples could be taken since the riverbeds (including the Mutamba River) were completely dry, even with rainfall reported a week earlier.

Water quality sampling on the Mutamba River was done by WSM Leshika Consulting (Pty) Ltd, as part of the EIA phase surface water assessments of the Makhado Colliery Project back in 2009 and the Greater Soutpansberg Generaal Project back in 2013. The results from these studies were used for this report.

All but two of the monitoring points are located in the Mutamba River and its major upstream tributary, the Kandanama River. The other two points are in the Nzhelele River just upstream (Smon-13) and downstream (Smon-2) of its confluence with the Mutamba River (refer to **Figure 3.9**). Due to the arid nature of the area, streams and the rivers are mostly dry and surface flow only occurs after significant downpours. The surface flow after storms events are also often of short duration and therefore the sampling sets do not include all monitoring points. The test results of the samples collected between 2009 and 2011 are shown in **Table 7.**

In January 2013 an extreme rainfall event occurred in the northern Limpopo region. In the region over 300 mm of rain was measured in 6 days. The Mean Annual Precipitation (MAP) as measured by the upstream weather station at Mutamba Ranch is only 304 mm. The runoff after this event where the MAP occurred in less than one week was of sufficiently long duration to enable collection of the first full set of surface water samples. The test results are shown in **Table 8** (*WSM Leshika Consulting, 2013*).

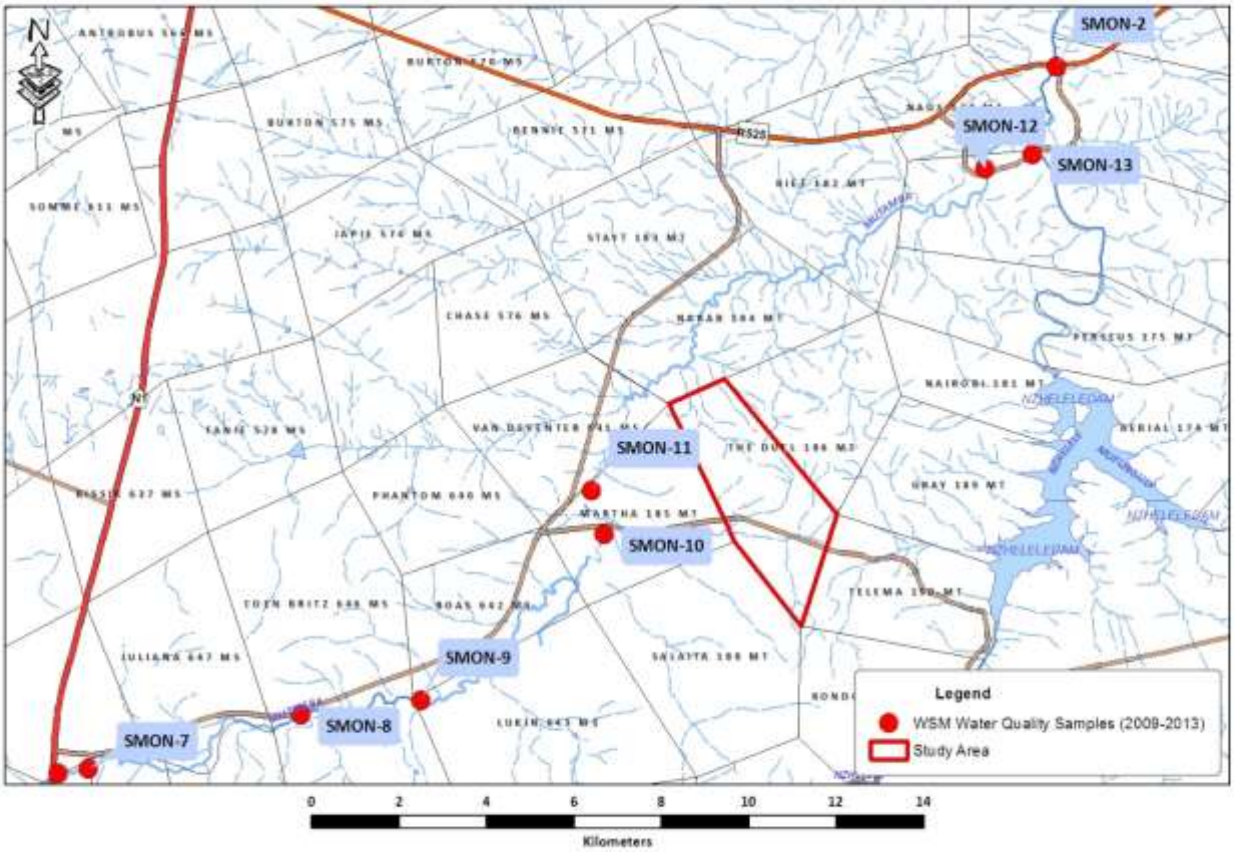


FIGURE 3.9: LOCALITY OF LONG TERM SURFACE WATER MONITORING POINTS

The 2009/2011 results indicate fairly pristine water at the monitoring points except for elevated levels of nitrate. In contrast, the 2013 values indicate an increase in Nitrate, Sulphate and Chloride constituents, resulting in a decrease in water quality at Smon-11. The value at Smon-13 in the Nzhelele River upstream of the Mutamba River confluence is acceptable. The values at Smon-2 downstream of the confluence are on par with the Mutamba River values. There is only a small area of irrigation development upstream of Smon-13 of about 50 ha which may indicate that Smon-13 values reflect the Nzhelele Dam quality.

TABLE 7: MUTAMBA RIVER WATER QUALITY DATA 2009/11

Macro-elements

Element	Unit	Monitoring Results 2009 to 2011								Aquatic Ecosystem WQT	Drinking Water WQT	Agriculture WQT (irrigation)	Agriculture WQT (livestock)
Figure Ref No													
WSML Number		Smon-6	Smon-6	Smon-8	Smon-9	Smon-9	Smon-10	Smon-10	Smon-11				
DATE		03/2009	12/2011	12/2011	03/2009	05/2011	05/2011	12/2011	05/2011				
pH		8.3	7.5	8.1	8.4	7.20	7.2	8.2	7.3		6.0 - 9.0	6.5-8.4	
E.C	mS/m	26.1	12.2	25.1	29.9	13.6	8.8	21.1	34.5		150	40	
TDS	mg/l	238	91	228	194	105	72	174	320		1000		1000
NO_3	mg/l		0.8	1.1		2.64	31.68	1.3	1.32	0.5	6	5	100
F	mg/l	0.5	<0.2	0.20	0.3	0.30	0.10	0.20	0.80	0.75	1	2	2
SO_4	mg/l	12	11	29	11	17	15	17	59		400		1000
Cl	mg/l	25	7	30	31	10	11	14	38		200	100	1500
Ca	mg/l	16	12	42	21	18	12	30	20		150		1000
Mg	mg/l	9	7	19	10	7	6	15	7		100		500
Na	mg/l	18	7	19	21	6	4	15	46		200	70	2000
TAL	mg/l		56	96		44	28	100	52				
HCO_3			56	96		44	28	100	52				
CO_3	mg/l		<5	<5		<5	<5	<5	<5				
P	mg/l		<0.025	<0.025		0.6	7.2	<0.025	0.3				

TABLE 8: MUTAMBA RIVER WATER QUALITY DATA 2013

Macro-elements

Element	Unit	Monitoring Results 2013									Aquatic Ecosystem WQT	Drinking Water WQT	Agriculture WQT (irrigation)	Agriculture WQT (livestock)
Figure Ref No														
WSML Number		Smon-6	Smon-7	Smon-8	Smon-9	Smon-10	Smon-11	Smon-12	Smon-13	Smon-2				
DATE		Jan 13												
pH		7.9	8.2	8.2	8.3	8	8	8	8	8.2		6.0 - 9.0	6.5-8.4	
E.C	mS/m	8.3	18.8	22.8	23.3	19.1	160.9	64.9	37.7	146.5		150	40	
TDS	mg/l	64	122.2	148.2	151.5	124.2	1045.9	421.9	245.1	952.3		1000		1000
NO_3	mg/l	0.2	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	0.5	6	5	100
F	mg/l	<0.2	0.11	0.15	0.13	0.13	5.8	0.89	0.35	1.4	0.75	1	2	2
SO_4	mg/l	<5	13.75	32.18	28.46	5.66	301.98	28.4	25.52	99.94		400		1000
Cl	mg/l	<5	13.9	12.5	12.8	5.5	144.4	60.9	17.5	142.4		200	100	1500
Ca	mg/l	18	13.59	16.48	15.92	17.57	62.07	28.63	17.3	33.36		150		1000
Mg	mg/l	9	5.72	6.75	6.35	6.02	17.4	21.32	8.27	31.95		100		500
Na	mg/l	3	13.06	20.2	19.81	11.27	282.21	80.27	48.92	268.62		200	70	2000
TAL	mg/l													
HCO_3														
CO_3	mg/l													
P	mg/l	5.9	0.45	0.52	0.36	0.17	0.16	0.12	0.64	0.3				

Micro-biological tests were conducted on samples taken in the Mutamba River in March 2009 and in May 2011 and the test results are given in **Table 9**. The results are evaluated against the health risk levels for drinking water (DWA, 1996) and it showed faecal coliform contamination at health risk levels for all samples, with the higher values occurring in the main stem of the Mutamba River (Smon9 to Smon 11). With the river mostly dry, the first major rainfall event of the wet season will wash nutrients and microorganisms down so that high levels of microbiological contamination may occur.

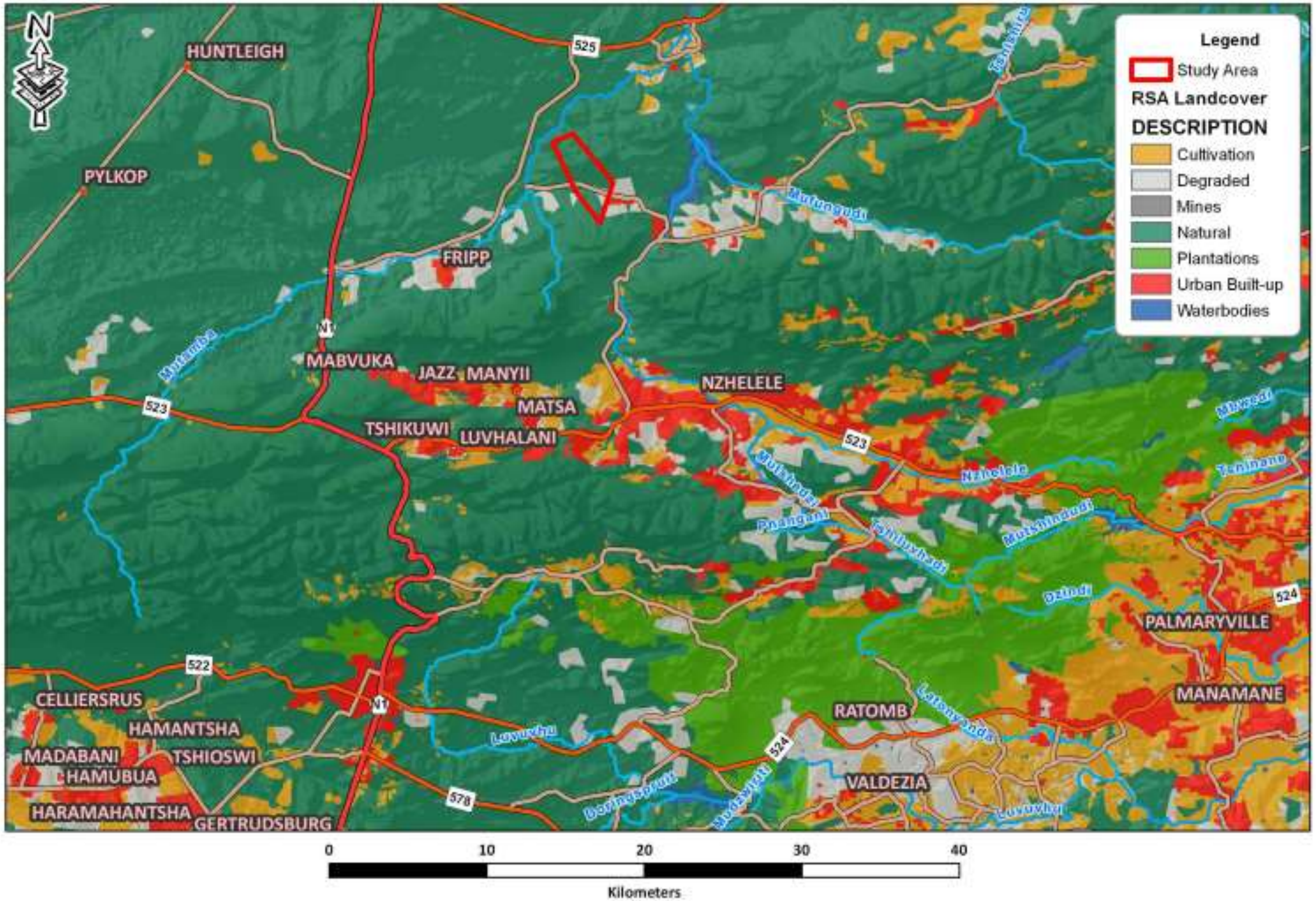
TABLE 9: RESULTS OF MICROBIOLOGICAL TESTS

									Target Water Quality Range for Drinking Water		
ANALYSES	UNIT	DATE	Smon1	Smon6	Smon3	Smon9	Smon10	Smon11	Negligible risk	Slight risk	Health risk
Faecal Coliform	/100 mℓ	Mar-09	-	5200	-	6000	-	-	0	0 -10	>10
		May-11	330	-	90	2900	26000	3600			

3.5.4. CURRENT LAND USE AND WATER DEMANDS

The South African National Biodiversity Institute (SANBI) offers a variety of spatial biodiversity planning information through their Biodiversity GIS (BGIS) website. The National Land Cover dataset of 2009 was used to present the land cover of the region and is shown in **Figure 3.10** below. The Study Area is located south of the Mutamba River.

The overall population density of the region beyond the Soutpansberg Range is low. The greater majority of present land use consists of game and cattle farming, with the operating of guest lodges and hunting the major activities, and rangelands that are grazed by domestic livestock or wild animals.



FIGURE

3.10: LAND COVER

3.5.5. CURRENT DRAINAGE SYSTEM

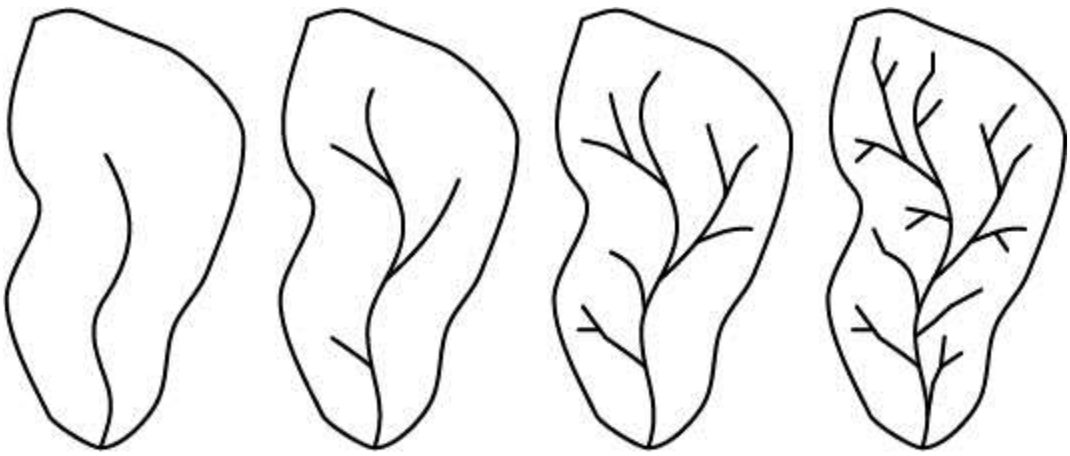
The aim of this section is to establish a broad understanding of the current drainage environment of the Study Area and to establish a frame of reference in developing runoff factors when flood peak calculations are done as discussed in **Section 5**.

3.5.5.1. DRAINAGE DENSITY

Drainage basins have many different characteristics that influence how quickly or slowly the main river within them responds to a period of intense rainfall.

A high drainage density reflects a highly dissected drainage basin with a relatively rapid hydrologic response to rainfall events, while a low drainage density means a poorly drained basin with a slow hydrologic response.

As a rule, the higher the drainage density the more quickly water drains to a river and the higher the erodibility potential of the surface materials.



Drainage Density			
Low	Intermediate to Low	Intermediate to High	High

The illustration above shows four different types of drainage densities that was used to describe the drainage density of the catchments associated with the Study Area.

It is clear from **Figure 3.11** below that the southern portion of the Study Area has an intermediate to low drainage density. This gives an indication that the infiltration capacity of the ground cover may be high and lower than typical runoff volumes can be expected.

The northern portion has an intermediate to high drainage density, indicating a more impermeable ground cover and higher than typical runoff volumes can be expected.

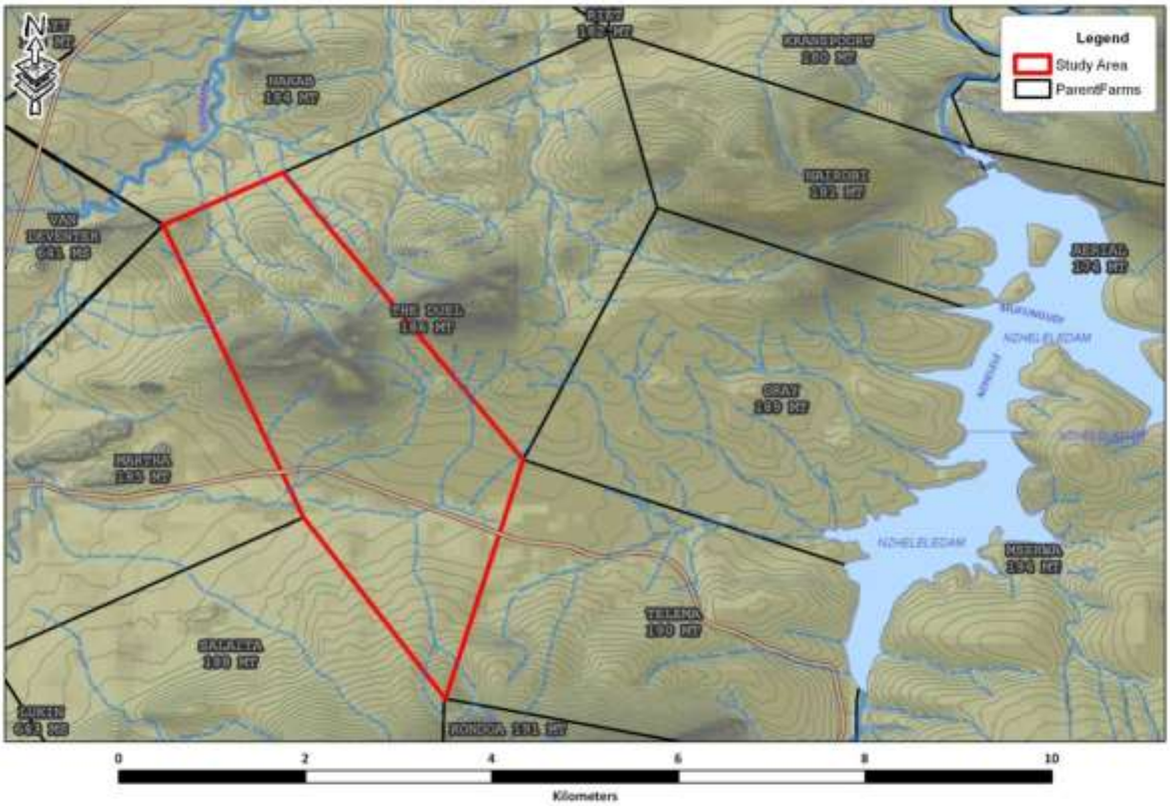


FIGURE 3.11: DRAINAGE LINES

3.5.5.2. GENERAL SLOPES

The Study Area is located at the foot of the Soutpansberg Mountain Range in a low-gradient, plateau-like surface, cut by irregular valleys and hills as shown in **Figure 3.12** below.

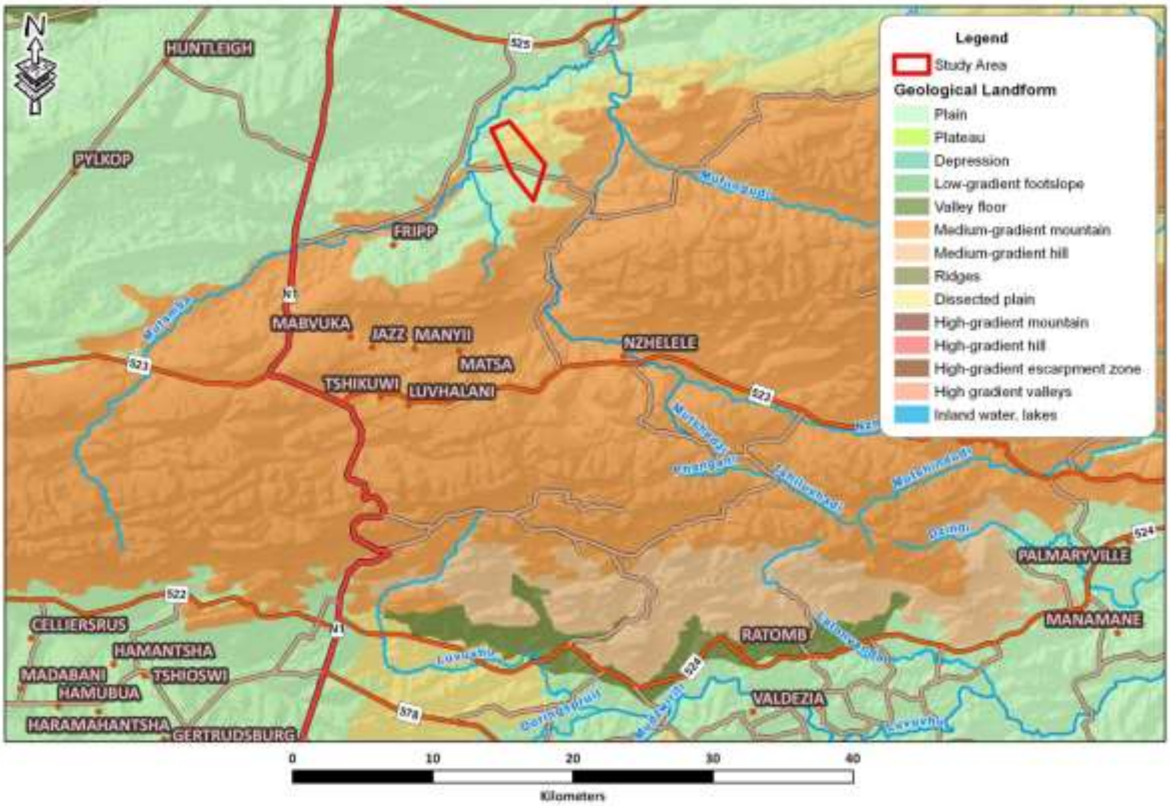


FIGURE 3.12: GEOLOGICAL LANDFORM

3.5.5.3. DRAINAGE PATTERN

The following lists some of the most common drainage patterns that rivers and/or streams follow and is graphically illustrated in **Figure 3.13** below:

Dendritic. This type of river or stream forms a spreading, treelike pattern, usually in horizontal sediments or in crystalline rocks.

Rectangular. These rivers and streams form a compact, perpendicular network of channels, usually with the channels predominantly lying in two directions.

Trellis. Trellis drainage patterns have one dominant direction, with secondary streams perpendicular to the main river. Trellises closely resemble rectangular drainage patterns, but are more elongated (along the main river) and less compact.

Radial. Radial drainage patterns are just what their name implies: rivers or streams radiating from a central point.

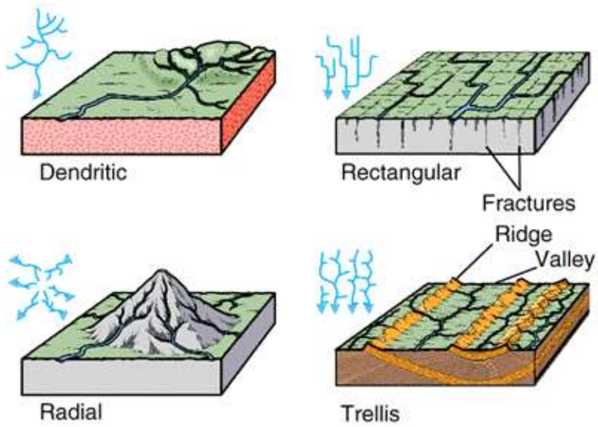


FIGURE 3.13: DRAINAGE PATTERN

The general drainage pattern of the rivers and streams in and around the study area is dentric of nature.

3.5.5.4. GENERAL VEGETATION

The vegetation density influences drainage density by binding the surface layer, thus preventing overland flow from concentrating along definite lines and from eroding small rills which might become small channels. The vegetation slows down the rate of overland flow, and stores some of the water for short periods of time.

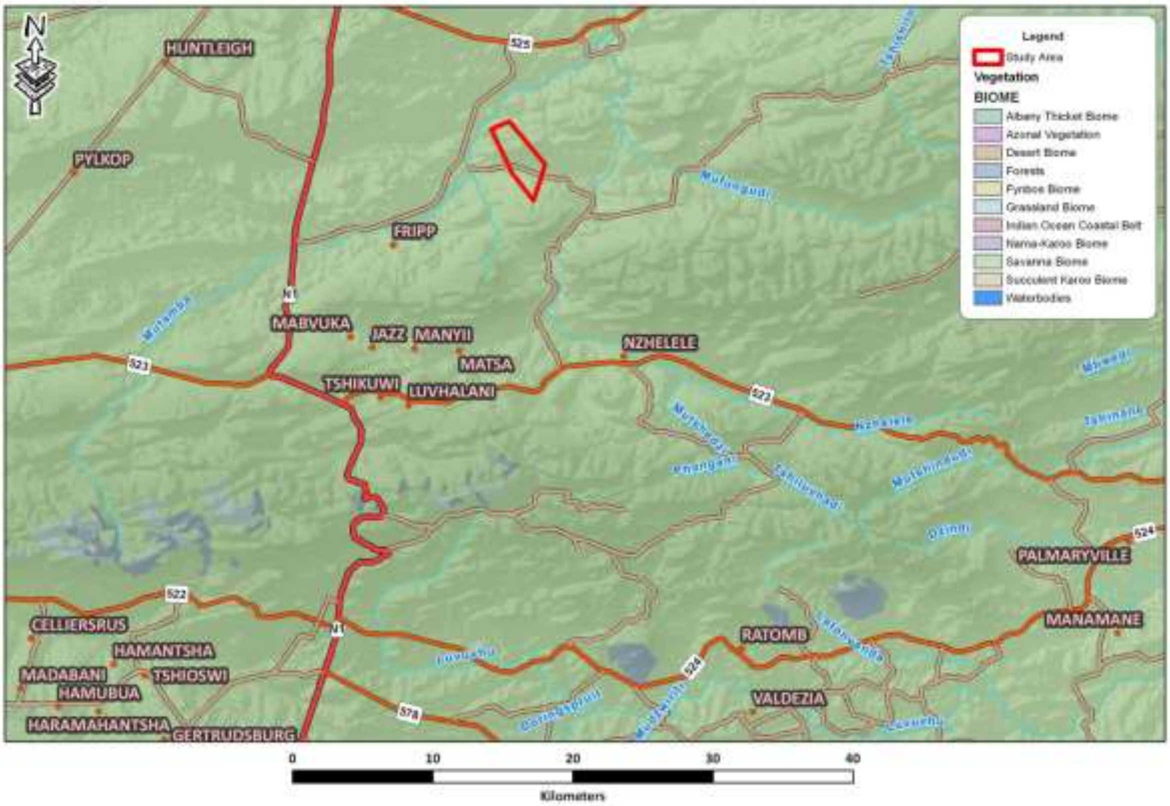


FIGURE 3.14: GENERAL VEGETATION

The Study Area is located in a region covered by the Savanna Biome vegetation group as shown in **Figure 3.14** above, with Musina Mopane Bushveld and Soutpansberg Mountain Bushveld as the main vegetation types.

The Savanna Biome is the largest Biome in southern Africa, occupying 46% of its area, and over one-third of the area of South Africa. It is well developed over the lowveld and Kalahari region of South Africa and is also the dominant vegetation in neighboring Botswana, Namibia and Zimbabwe.

The typical vegetation occurring within the study area is characterized by medium to high shrub dominated savannah, with scattered trees and a dense field layer.

3.5.5.5. GENERAL SOILS

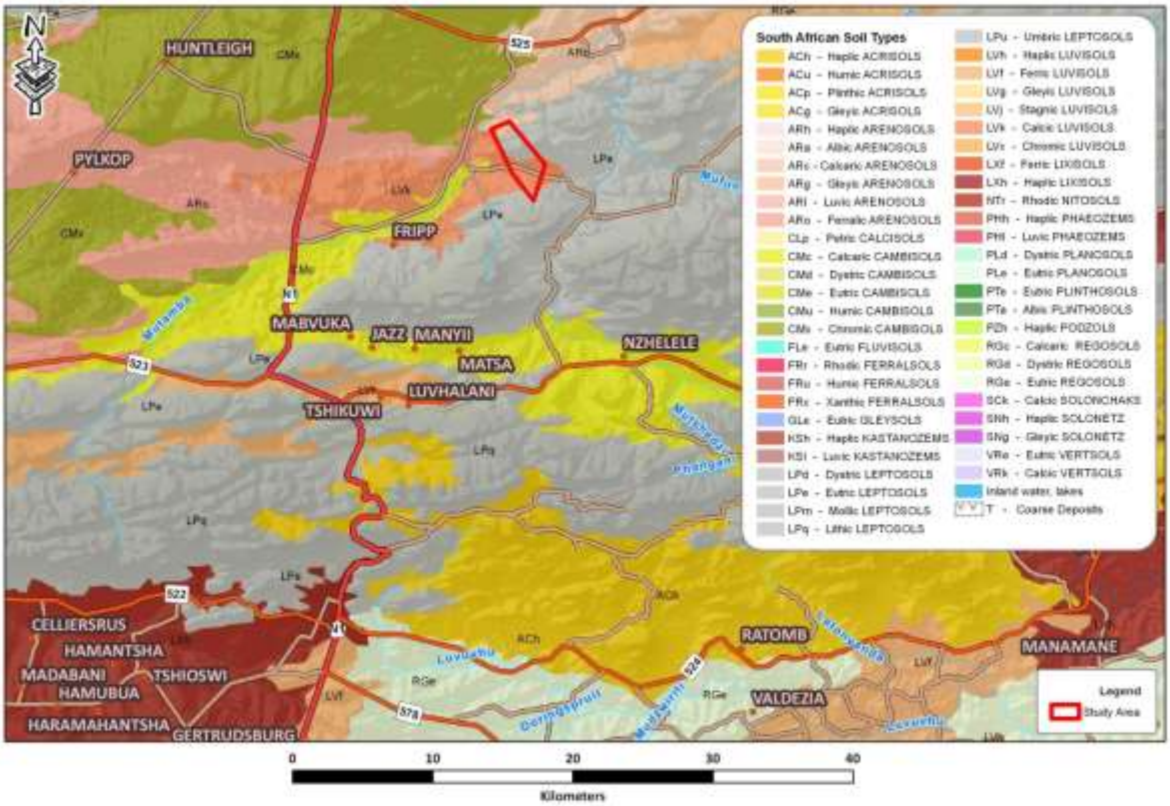


FIGURE 3.15: GENERAL SOILS

The soil types within the study area are shown in **Figure 3.15** above and are also discussed below:

Leptosols. Shallow soils over hard rock or highly calcareous material but also deeper soils that are extremely gravelly and/or stony. Leptosols are generally free draining soils.

Luvisols. Soils in which clay is washed down from the surface soil to an accumulation horizon at some depth. The soils are most common in flat or gently sloping land in cool temperate regions and in warm regions with distinct wet and dry seasons. Most Luvisols are well drained but shallow ground water may occur in depression areas.

Arenosols. Coarsly textured soils that hold a much greater proportion of their available water at low suctions than finer soils. Areonosols are permeable to water and has a high infiltration rate.

Cambisols. Cambisols in arid tropics are found in young deposition areas and also in erosion areas where they form after genetically mature soils such as Luvisols have eroded away. Cambisols are medium textured and have good structural stability, a high porosity, a good water holding capacity and good internal drainage.

3.5.5.6. HYDROLOGICAL SOILS

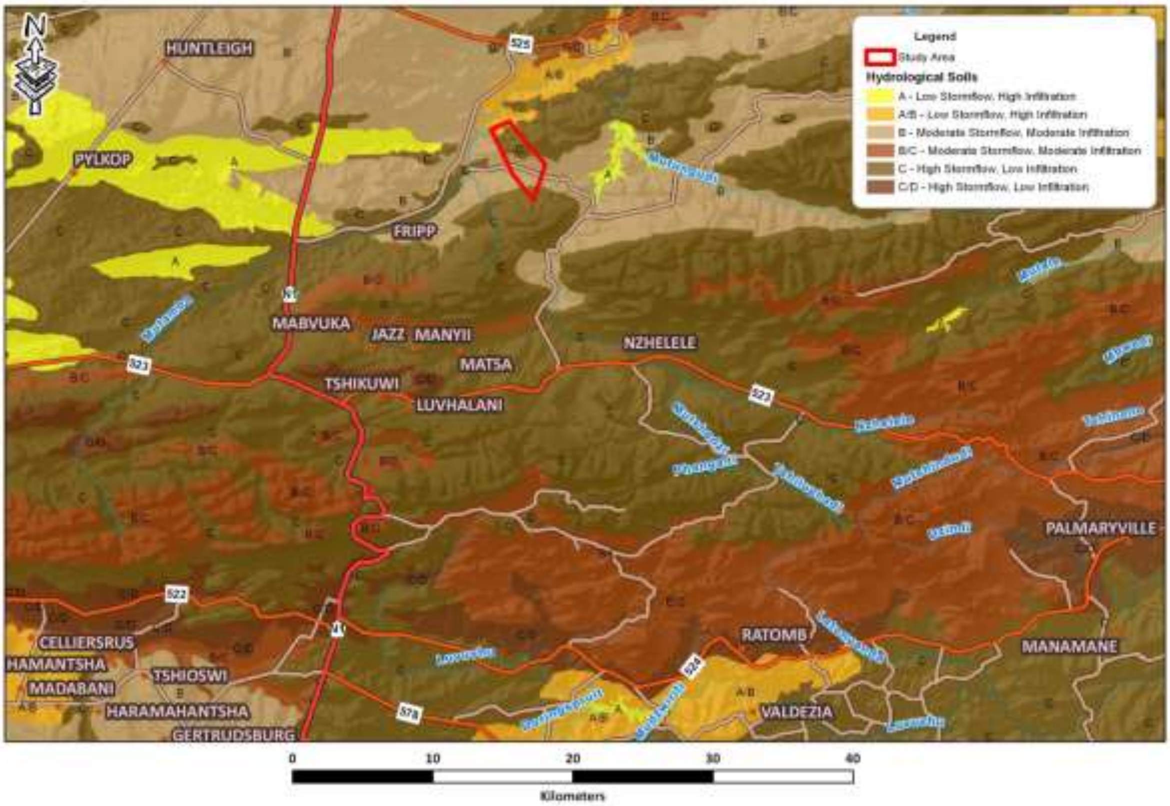


FIGURE 3.16: HYDROLOGICAL SOILS

To date the hydrological soil grouping in South Africa has had to be determined from an in-depth knowledge of South Africa's agriculturally based soil classifications or, alternatively, from fieldwork.

Prof. R.E. Schulze from the School of Agricultural, Earth and Environmental Sciences from the University of Kwazulu-Natal in South Africa established, through a number of steps of reverse-engineering and knowledge on soil water content at permanent wilting point of the more than 500 South African soils, a set of working rules on determining the hydrological soil groups for South Africa. He then generated a detailed map of the various hydrological soil groupings which was also used to identify the hydrological soil properties for the Study Area as shown in **Figure 3.16** above.

The hydrological properties of the soils found in the northern parts of the Study Area has high stormflow capability and low infiltration characteristics and the hydrological properties of the soils found in the southern parts of the Study Area has moderate stormflow capability and moderate infiltration characteristics.

3.5.5.7. SUMMARY

In summary it is evident that the Study Area's environment has a drainage system with moderate to high stormflow characteristics, a relatively flat and permeable topographical profile and spread out drainage lines.

This indicates that the regime of water runoff for the Study Area tend to infiltrate the soils and become shallow subsurface flow more so than surface water runoff at lower rainfall intensities. Higher rainfall intensities will tend to have a lower infiltration and higher surface water run-off potential.

Based on (P.S. Rossouw, 2015, p 45-46) "numerous ephemeral streams are encountered. These represent watercourses with a distinct channel that is continuous and contains regular or intermittent surface flows. These watercourses lack base flow and permanent wetland features as they only support surface flow for a short period of time after sufficient rainfall events. It can be argued that these drainage lines or watercourses should still be regarded as important landscape features based on international literature:

- The role and functions of headwater streams within catchments and their linkages with downstream aquatic systems are not thoroughly understood (Gomi et al., 2002).
- Recent research, however, ascribes increasing importance to these systems regarding catchment and water resource management (Berner et al., 2008).
- Headwater drainage lines are crucial systems for nutrient dynamics as a link between hillslopes and downstream watercourses (Gomi et al., 2002).
- They are directly linked to downstream aquatic systems and have a direct bearing on the health and functioning of larger aquatic systems, especially regarding water quality of downstream aquatic systems (Gomi et al., 2002; Dodds and Oaks 2008).
- Seasonal streams and wetlands are usually linked to the larger network through groundwater even when they have no visible overland connections.
- The large spatial extent of headwater channels in the total catchment area makes these systems important sources of sediment, water, nutrients and organic matter for downstream systems (Gomi et al., 2002)."

4. ECOLOGY OF THE RIVERS AND STREAMS IN THE REGION

4.1. ECOREGIONS

Ecoregional classification is a hierarchical procedure that involves the delineation of ecoregions with a progressive increase in detail at each higher level of the hierarchy, i.e. essentially the same characteristics are used at the various levels, but with more detail as one moves to a higher level in the hierarchy. In addition, the characteristics that are more or less important can vary from one place to another. In other regions, patterns in hydrology, vegetation, soils, and land-use follow distinct differences in bedrock or surficial geology (Omernik pers. comm. 1998).

The principle of river typing is that rivers grouped together at a particular level of the typing hierarchy will be more similar to one another than rivers in other groups.

The primary (so-called 'Level 1') DWS Ecoregions (Kleynhans et al. 2005) are based on broad-scale patterns of physiography, climate, geology, soils and vegetation across the country. There are 31 Ecoregions across South Africa, including Lesotho and Swaziland. DWS Ecoregions have most commonly been used to categorise the regional setting for national and regional water resource management applications, especially in relation to rivers.

Each primary ecoregion is also sub-divided into smaller sub-regions or sub-catchments as Level 2 ecoregions which contains general attributes that are mostly related to the rivers and streams of the particular sub-ecoregion.

The Study Area falls within the Soutpansberg primary ecoregion which is sub-divided into four distinct sub-ecoregions or Level 2 ecoregions. The Study Area falls within the third division of the Level 2 classification as shown in **Figure 4.1** below.

The Soutpansberg primary ecoregion is a mountainous area characterised by moderate to high relief and vegetation consisting mainly of Bushveld types but with patches of Afromontane Forest. The Blouberg to the west of the Soutpansberg is included in this region. The characteristics of the sub-ecoregion are shown in **Table 10** below.

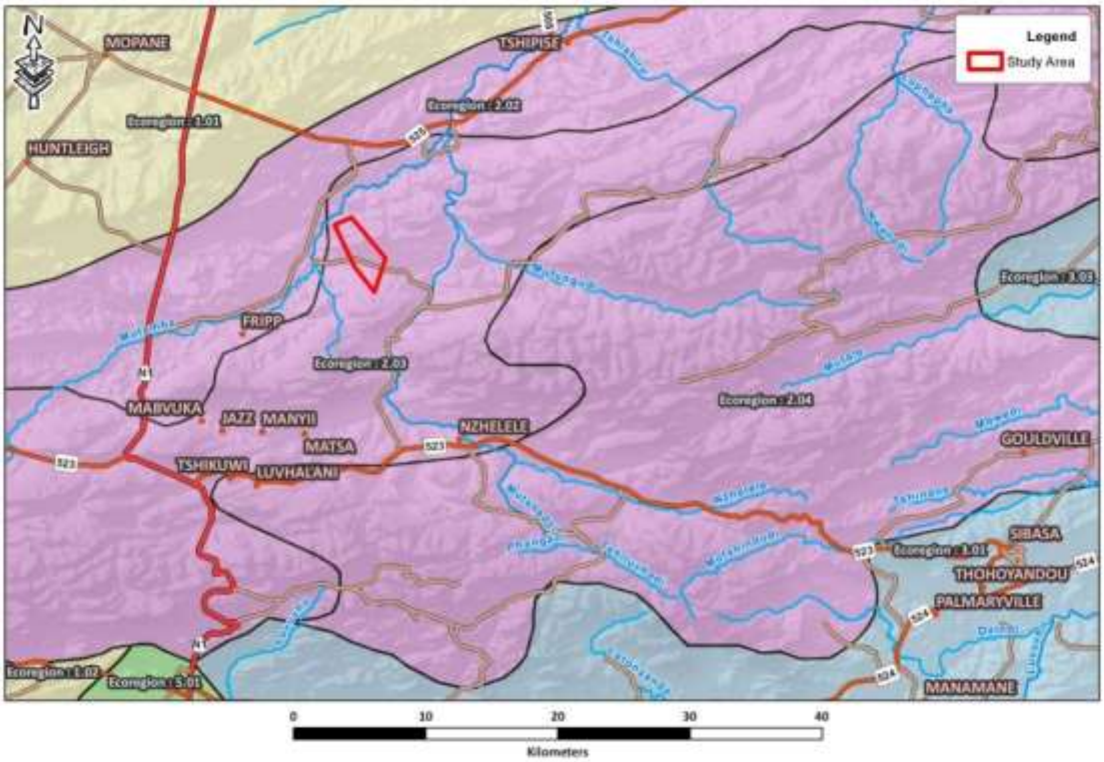


FIGURE 4.1: LOCATION OF THE STUDY AREA IN ECO-REGION

TABLE 10: CHARACTERISTICS OF THE SOUTPANSBERG ECO-REGION

MAIN ATTRIBUTES	**SOUTPANSBERG 2.03** (dominant types in bold)
Terrain Morphology: Broad division	Plains; Low Relief **Closed Hills; Mountains; Moderate and High Relief;;**
Terrain Morphology	Slightly undulating plains **Low Mountains**
Vegetation types (Primary)	Soutpansberg Arid Mountain Bushveld;
Altitude (m a.m.s.l.)	300-1500
MAP (mm)	300 to 700
Coefficient of variation (% of annual precipitation)	20 to 34
Rainfall concentration index	60 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 >19
Mean daily min temp (°C) July	4 to >9
Median annual simulated runoff (mm) for quaternary catchment	5 to 10; 20 to 100; (80 to 100 limited); 150 to 200 (limited)

KLEYNHANS ET AL. 2005

4.2. 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 11** below.

TABLE 11: 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.

This database was searched for the quaternary catchment of concern (A80F) in order to define the EIS, PEMC and DEMC. The findings are based on a study undertaken by Kleynhans (1999) as part of "A procedure for the determination of the ecological reserve for the purpose of the national water balance model for South African rivers". The results of the assessment are summarised in the **Table 12.**

TABLE 12: SUMMARY OF THE ECOLOGICAL STATUS OF QUATERNARY CATCHMENT A80F BASED ON KLEYNHANS (1999)

Catchment	Resource	EIS	PEC	DEMC
A80F	Mutamba River	High	Class D	B: Sensitive system

A80F

According to the ecological importance classification for the quaternary catchment, the system can be classified as a Sensitive system which, in its present state, can be considered a Class D (largely modified) stream.

The points below summarize the impacts on the aquatic resources in the A80F quaternary catchment (*Kleynhans 1999*):

- The aquatic resources within this quaternary catchment have been marginally affected by scouring of the system.
- Flow modification within the catchment is considered very high due to the control of flow by a dam upstream.
- Marginal impacts from inundation of the system occur.
- Riparian zones and stream bank conditions are considered to be moderately impacted by erosion.
- A low impact occurs as a result of the introduction of in-stream biota with special mention of *Azzola sp*. (Water Fern) and *Cyprinus sp.* (Carp).
- Impacts on water quality in the system are considered high as water released by the dam has a modified temperature and quality.

In terms of ecological functions, importance and sensitivity, the following points summarise the conditions in this catchment:

- The riverine systems in this catchment have a high diversity of habitat types.
- The site has a moderate importance in terms of conservation with special mention of a gorge in the system.
- The riverine resources in this system have a moderate intolerance to flow and flow related water quality changes.
- The aquatic resources in the area have a high importance in terms of migration of species and form a transition zone between mountain and lowveld. Special mention is made of the migration of eels, fish and birds.
- The system is considered to be of high importance in terms of rare and endemic species conservation. Some species may occur upstream of Nzhelele Dam.
- The aquatic resources in this catchment are moderately important in terms of the provision of refuge areas.
- The riverine resources in this system have a moderate sensitivity to changes in water quality and flow. The gorge area is particularly sensitive to changes in flow.
- The aquatic resources in this area are of high importance in terms of Species/Taxon richness with up to 16 different species present.
- The system is of high importance with regards to unique or endemic species with special mention of *Barbuseutenea* (Orangefin Barb), *Barbuslineamaculatus* (Line-spotted Barb) and *Barbusmaculatus*.

5. FLOOD PEAK CALCULATIONS

As seen in **Figure 5.1** surface water flows occur in a network of defined flow paths within the Study Area. Flows upstream from the pit, dumps and plant area will have to be deviated to maintain clean water surface flow. The extent of the flood zones (i.e. flood lines) are required to identify impacted areas and the flood peaks are required to size the infrastructure required to control the flow

The flood peak assessment of the site streams has been done, as described below:

A number of methods can be used to determine flood peaks, as described in the SANRAL Drainage Manual (*Kruger, 2006*). These are generally categorized 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 Kovacs.

Rational Method with alternative (Alexander) method of calculating rainfall intensity

This version of the Rational Method as described in the SANRAL Drainage Manual (2006) was used to determine the flood peaks for the site streams. The software 'Utility Programs for Drainage' which has been developed by Sinotech, using the methods in the Manual, was used in this study.

The parameters for the calculations are as follows:

- rainfall intensity is derived from the modified Hershfield equation for low time of concentrations and from interpolated values up to the 24-hour rainfall event
- time of concentration is calculated for stream and overland flow as applicable
- the runoff factor is calculated for each area respectively as it may differ, for instance in the slope, vegetation cover and land use

- the percentage reduction factor for estimating the average precipitation over the catchments is applied

Rainfall data used in the assessment

For the purpose of the analyses, data from one rainfall gauging station closest to the site, given in Adamson's study, was used to obtain representative site specific rainfall information for the Study Area as shown in **Table 13**. Note that the 24-hour rainfall with a recurrence interval of 1:2 years ("M2") of 46 mm is used in the Alternative Rational Method.

TABLE 13: RAINFALL INTENSITY DATA

Station Number	Description	MAP (mm)	24-Hour Rainfall (mm)					
			1:2	1:5	1:10	1:20	1:50	1:100
765707	Mutamba Ranch	304	46	66	81	98	122	143

5.1. FLOOD ESTIMATES OF SITE STREAMS

In terms of Regulation 4 of Government Notice GN704 as described in **Section 2** any mining activity within the 1:100-year floodline of a river or stream or within a horizontal distance of 100 meters from its banks, will trigger the need for the authorization of a water license as well as a basic assessment or full environmental impact assessment.

Figure 5.1 below shows the 100 m buffer zone as per GN704. It is evident that the location of mining activities is impeding this zone and therefore it will be required to construct diversion infrastructure along with mitigation measures to maintain a natural conveyance of stream flow in the drainage system as far as possible.

5.2. HYDRAULIC ASSESSMENT

As no surface elevation data was available during the investigation, no floodlines could be determined.

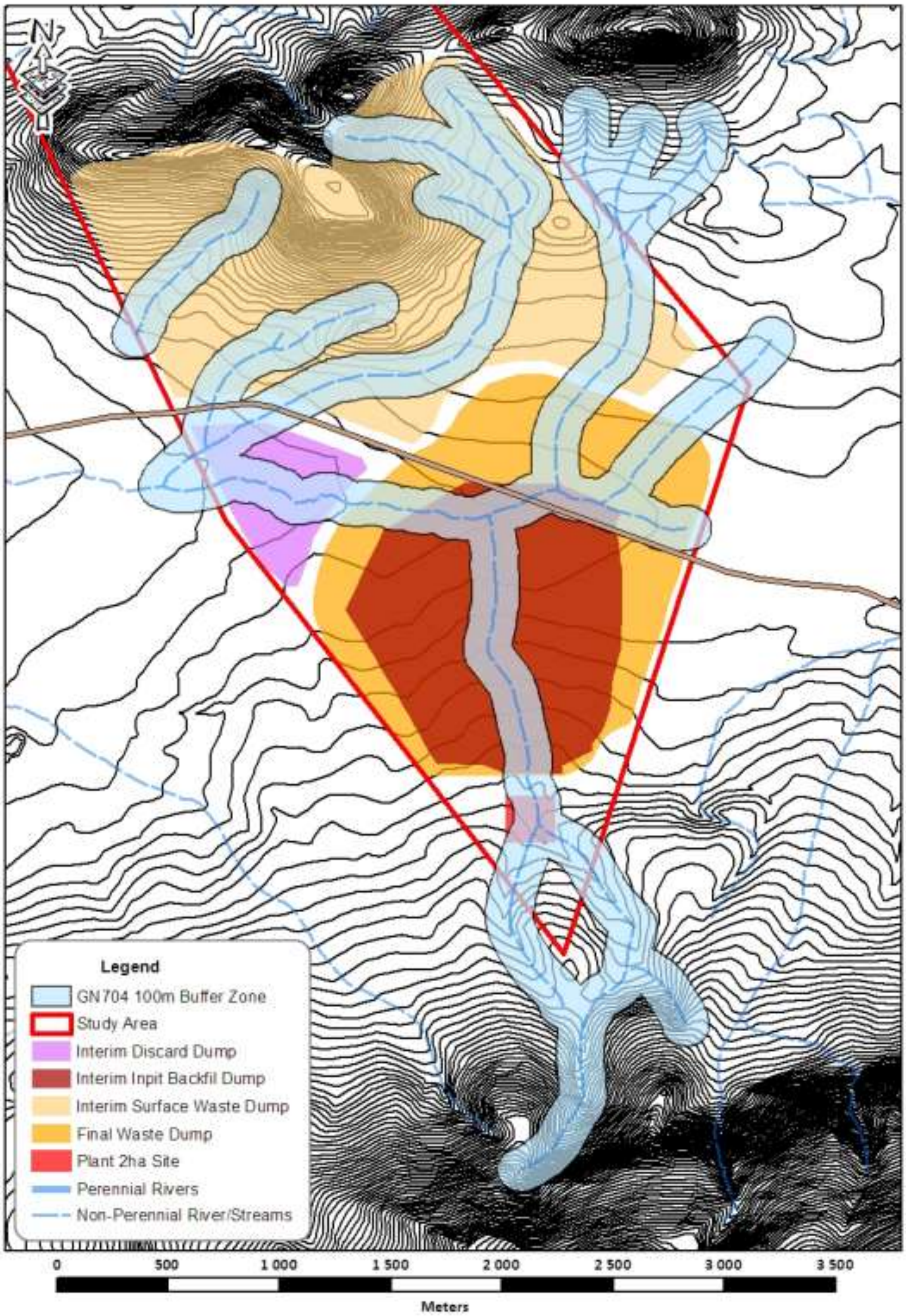


FIGURE 5.1: 100 m GN704 BUFFER ZONE

6. EXPECTED IMPACTS OF MINING DEVELOPMENT ON SURFACE WATER WITH NO MITIGATION MEASURES

The impacts on surface water manifest as changes in the **quantity** and/or **quality** of water in streams.

Table 14 below lists the impact number related to the specific project component and the locality is shown in **Figure 6.1**.

TABLE 14: IMPACT NUMBER OF PROPOSED COMPONENTS

IMPACT NUMBER	PROJECT COMPONENT
PR01	Plant 2h Site
PR02	Interim Inpit Backfill Dump
PR03	Final Waste Dump
PR04	Interim Discard Dump
PR05	Interim Surface Waste Dump

The various expected impacts on surface water resulting from the Study Area's mining activities are described in this section of the report. Residual impacts on the surface water system is identified and quantified where applicable.

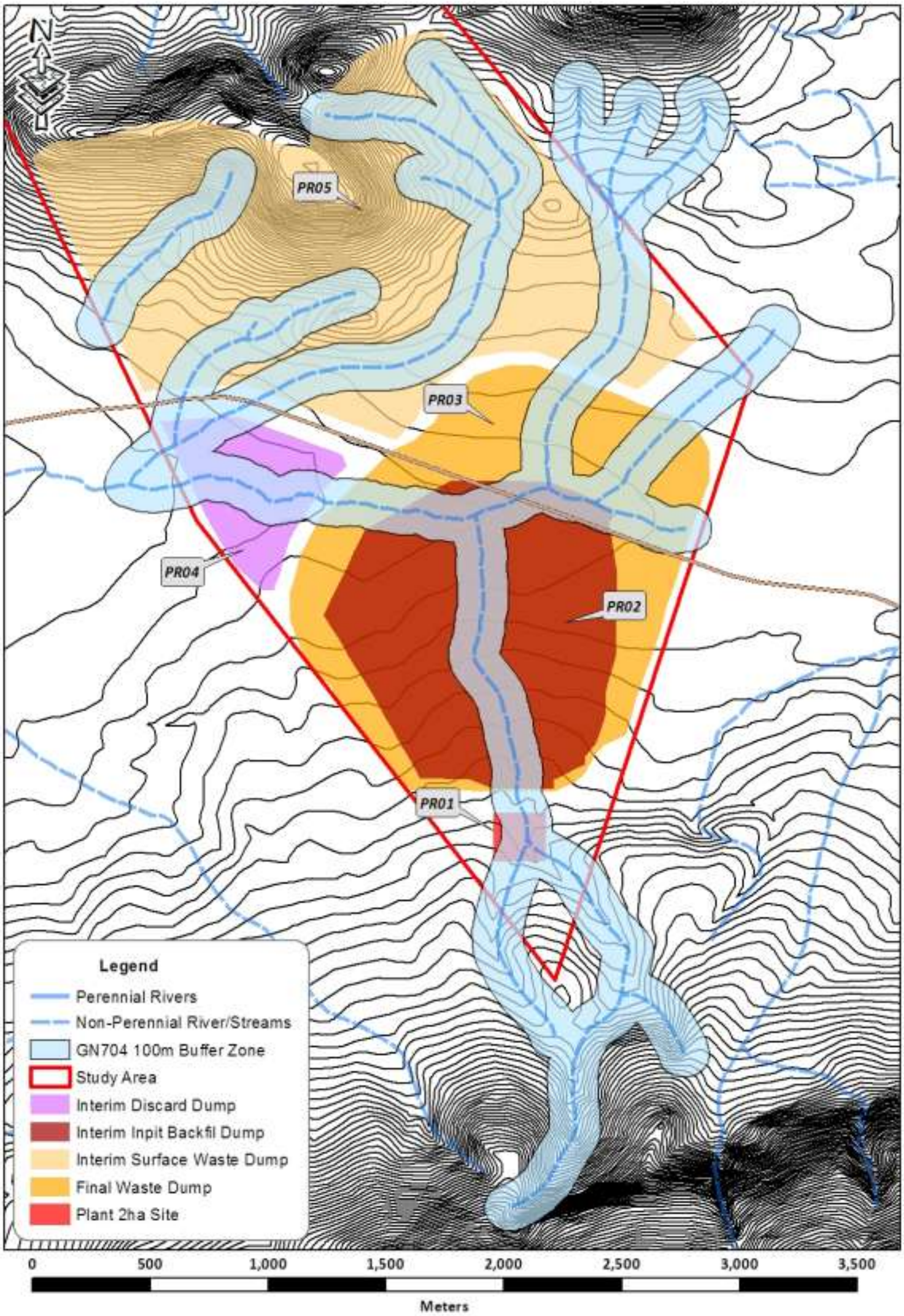


FIGURE 6.1: IDENTIFIED IMPACTS

6.1. IMPACT ON MEAN ANNUAL RUNOFF (MAR) TO THE MAIN STREAM

Mean annual runoff (MAR) from the Study Area into the main stream via its affected tributaries is anticipated to be primarily affected by the following:

- ***Direct rainfall in the opencast pits***. Rain falling directly into the pits will collect in a sump at the bottom of the pit/s and thus be polluted. This water may be recycled for use, or be evaporated in dirty water dams, thereby ***decreasing*** **the MAR of the stream**.
- ***Concentration of flow when runoff is intercepted by canals***. The use of a canal system will intercept run-off that would otherwise have flowed naturally over the ground surface until reaching a defined watercourse. Vegetation and surface topography, particularly in flatter areas, would in the natural state have encouraged interception and infiltration. Once water has been intercepted by a canal however, no further interception or infiltration is likely until the canal discharges the flow into a watercourse. There is thus likely to be a **marginal *increase* in MAR** resulting from the construction of a canal system.

6.2. CHANGE TO PEAK FLOW RATES IN THE MAIN STREAM AND ITS AFFECTED TRIBUTARIES DURING FLOOD CONDITIONS

A substantial increase to the peak flow of flood events in the main stream and its tributaries could cause erosion and change in channel character and dimensions, destroy riverine vegetation, alter bed roughness and cause eroded sediment to be deposited downstream.

However, it is expected that the Study Area's activities will cause only a slight change to peak flows in the main stream and its affected tributaries downstream of the study area, due to the following factors:

- ***Change in surface coverage***. Development of the Study Area area will change the surface coverage in some areas from vegetated soil to buildings, hardened gravel roads, paved areas (parking), and compacted earth. These new surface types will allow considerably less infiltration into the ground (typically 0-20%) than the natural surface (typically 60-70%), resulting in more surface runoff following storms and consequently ***higher*** peak flow rates.
- ***Capture of Run-off***. Capture of runoff in the form of an impoundment or in the pits would ***lower*** peak flow rates.
- ***Canalisation of runoff***. Intercepting runoff from the hill-slopes above the opencast pits and canalising the flow could reduce the time that water would take to reach the main stream. This is due to the decreased friction on the water associated with concentrated flow in a concrete-lined canal as opposed to sheet flow on the hill slopes, and consequently the peak flow rates would increase. Transition structures are required where the flow is discharged into natural streams to lower the flow velocities and thus prevent erosion. Furthermore, increasing the length of flow paths and implementing other detention measures, would assist in minimizing the negative impact.

6.3. DRYING UP OF TRIBUTARIES AND ESTABLISHMENT OF NEW WATERCOURSE DUE TO CANALIZATION

A cut-off canal system is required to separate unpolluted ('clean') and polluted ('dirty') water, which is a positive intervention.

6.4. INCREASED SEDIMENT LOAD IN THE MAIN STREAM AND ITS AFFECTED TRIBUTARIES

In the natural state of the Study Area, vegetation cover reduces flow velocities and concomitant erosion – a stable state has normally been reached. If for any reason flow velocities in the clean water system are increased, there is potential for increased erosion to occur. Increased erosion means that the runoff contains a higher silt or sediment load, which is discharged to the main stream. A component of this sediment load is particles fine enough to remain in suspension, 'clouding' or 'muddying' the water.

The extent of this effect can be quantified by measuring the suspended solids in the water – high concentrations can negatively affect biological life.

In addition, a changed sediment load could have similar morphological effects to the river as changing peak flow rates, such as changes in channel character or dimensions and changes to bed roughness. All of these changes could potentially affect biological life.

The following activities are likely to cause an increase in flow velocities, or directly increase erosion:

- Stripping (vegetation clearance) of mining areas prior to excavation of pits;
- Construction of hard-standing areas that increase runoff volumes, including roads, buildings and paved areas;
- Canalization of run-off, particularly if canals do not discharge directly into the main stream; and
- Construction activities that loosen the ground surface.

Furthermore, if runoff from the stockpiles is uncontrolled, such runoff would likely contain a high sediment load due to the fine particles in the waste product resulting from the ore crushing process.

It can thus be stated that without any mitigation measures, the sediment load in the main stream and its affected tributaries will increase as a result of mining activities associated with this Study Area.

6.5. IMPAIRED WATER QUALITY DUE TO POLLUTANTS IN RUNOFF

The water chemistry modifications due to the coal mining activities generally follow three common trends; downstream water becomes more saline, the pH of the water becomes more acidic and the water also develops a strongly modified ionic composition.

Wastewater from the coal ore beneficiation process would contain pollutants in excess of the target water quality ranges for the water uses of the receiving water body and discharge of this would impact negatively on the surface water quality. A further consideration is the runoff of pollutants from the process plant area following rainfall, due to the activities within that area.

Overflow of dirty water systems, whether into surface or groundwater, could release pollutants to the surface water environment.

6.6. IMPAIRED WATER QUALITY DUE TO HYDROCARBON PRODUCT SPILLS

Leakages, spills (petrol, diesel, oils/lubricants) or runoff from vehicle wash bays, workshop facilities, fuel depots or storage facilities of potentially polluting substances has the potential to contaminate surface water resources.

6.7. QUANTATIVE IMPACT OF THE PROPOSED MINING DEVELOPMENT ON SURFACE WATER RUNOFF

6.7.1. TOTAL REDUCTION IN RUNOFF

The total reduction in runoff shown in **Table 15** are based on 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 overburden dumps and plant areas retain polluted runoff. **Figure 6.2** below shows the extent of the affected catchments.

The footprints of the discards, plant and pit were used in the calculations in **Table 15** below.

TABLE 15: ESTIMATED IMPACT ON SURFACE WATER RUNOFF

PROJECT FOOTPRINT (ha)	STREAM CATCHMENT AREA (ha)	QUATERNARY CATCHMENT A80F AREA (ha)	MUTAMBA CATCHMENT AREA (ha)	% OF STREAM CATCHMENT AREA	% OF QUATERNARY CATCHMENT A80F	% OF MUTAMBA CATCHMENT AREA
554.8	1 685	**35 662**	**72 563**	32.9%	1.6%	0.8%

(BASED ON WORST CASE SCENARIO WITH NO REHABILITATION IN PLACE)

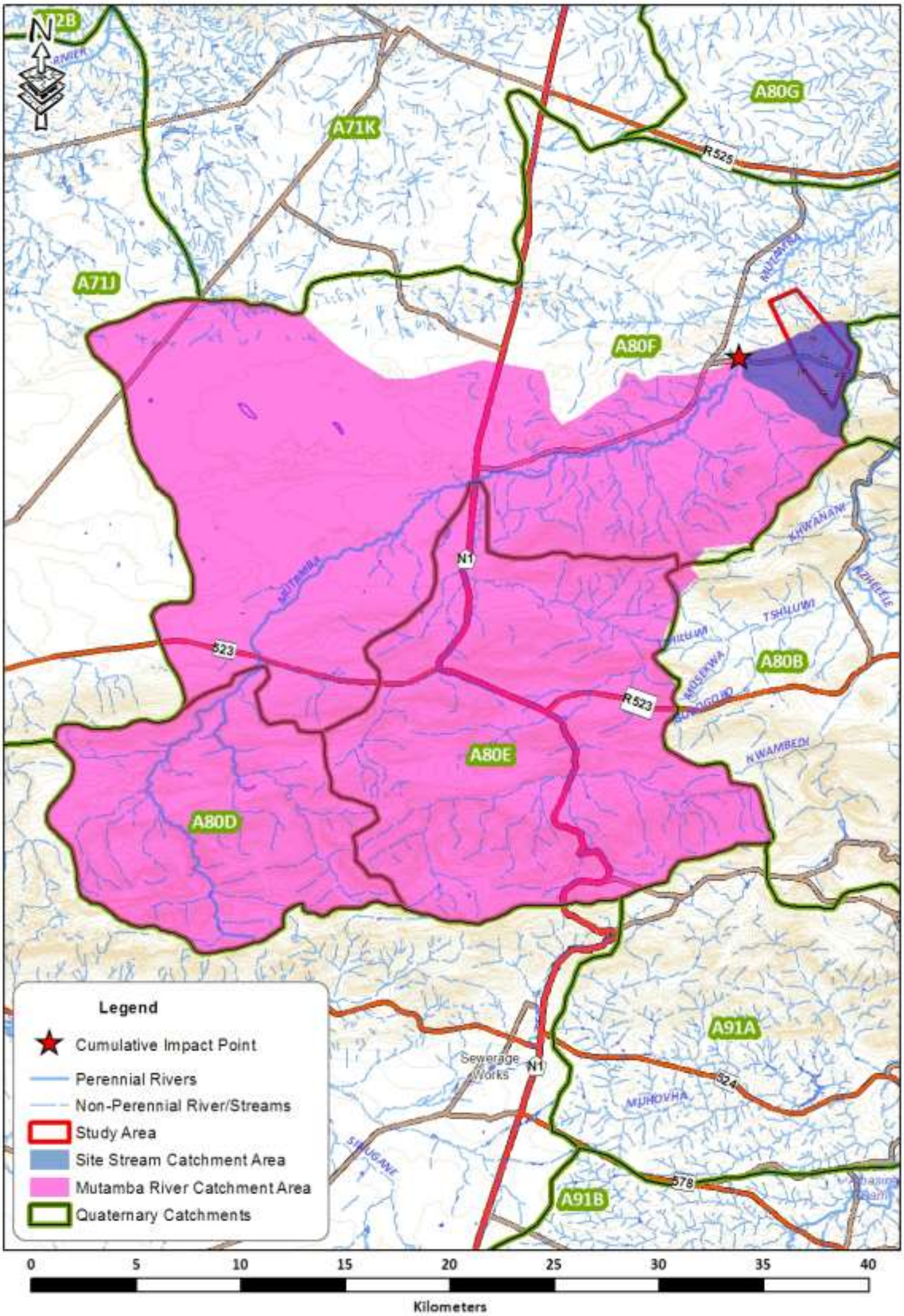


FIGURE 6.2: CATCHMENT AREAS OF SURFACE WATER RUNOFF IMPACTS

7. MITIGATION MEASURES: IMPLEMENTATION OF A STORMWATER MANAGEMENT PLAN (SWMP)

The mitigation measures include the implementation of a Stormwater Management Plan (SWMP) as prescribed in GN704 and DWS's Best Practice Guidelines, discussed in **Section 2.1** and **Section 2.3**. The guiding principle is the separation of clean and dirty storm water runoff, where the unaffected flow is routed to the receiving water body while the contaminated flows are contained for re-use and/or evaporation. If the contaminated flow volumes exceed the capacity that can be re-cycled or evaporated, treatment of the surplus outflow is required. Secondary effects are the impact caused by the SWMP, mainly by reducing (however slightly) runoff in the drainage system; the unavoidable disruption of natural drainage paths; and concentrating flows in some streams, leading to morphological changes accompanied by increased sediment loads (until a new equilibrium state is reached).

This section describes the various mitigation measures that were proposed to be incorporated to comply with the implementation of the Government Notice 704 requirements in relation to the National Water Act with the following in place:

- Residue deposits including slurry ponds or discards located 100m from watercourse
- Construction and maintenance of clean water systems with the aim to prevent water pollution and "keep clean water clean"
- Construction and maintenance of dirty water systems with the aim to prevent water pollution, and the capacity thereof "collect and contain dirty water"

Due to the unavailability of survey data, only a conceptual layout or master plan of the required stormwater system has been done, based on the requirements in the Best Practice Guideline G1: Stormwater Management, DWA, August 2006, using the available mining footprints as at January 2015.

Note that the conceptual layouts do not take the timeline into account. 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 long diversion structures around the continuous pits are required. Furthermore, we have indicated 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.

As a general mitigation measure, it is proposed that all access and haul roads be constructed so as to also act as diversion berms and incorporates canals, where required.

It is also proposed that runoff at all dirty areas be contained by dirty water berms and excess water be drained by canals (if no access road or haul road can fulfil this function) to discharge dirty stormwater to the proposed dirty water ponds.

Table 16 lists the various types of SWMP mitigation measures that are proposed and **Table 17** shows the details of the mitigations.

TABLE 16: SWMP MITIGATION MEASURE TYPES

MITIGATION MEASURES	
I	Construct **dirty water** collection berms downslope of all "dirty areas", i.e. areas where pollution of a water resource is likely to occur.
II	Construct **clean water** cut-off canals upslope of dirty areas to convey unpolluted water to its nearest outfall.
III	Construct a **pollution control dam** for the retention of water containing waste ("dirty" water).
IV	Construct **bridges, culverts or low-water crossings** over drainage lines to minimise disturbance of streams.

Figure 7.1 shows the localities of the mitigation measures that are proposed for the various sections respectively and should be read in conjunction with **Table 17.**

TABLE 17: MITIGATION MEASURE

ITEM NUMBER	PROJECT COMPONENT	DESCRIPTION OF IMPACT	MITIGATION TYPE
PR01	Plant 2h Site	It is proposed to construct dirty water berms around the **Plant 2ha Site** to retain any pollutant surface water runoff.	I
		A clean water cut-off canal is proposed to convey unpolluted water from just upstream of the **Plant 2ha Site** around the **Interim Inpit Backfill Dump, Final Waste Dump** and **Interim Discard Dump** and discharge into the nearest downstream release point.	II
		Dirty water runoff retained in the **Plant 2ha Site** should drain to a properly designed and constructed pollution control dam.	III
PR02	Interim Inpit Backfill Dump	Appropriate infrastructure addressed in PR01 and PR05	II
PR03	Final Waste Dump	Appropriate infrastructure addressed in PR01 and PR05	II
PR04	Interim Discard Dump	It is proposed to construct dirty water berms around the **Interim Discard Dump** to retain any polluted surface water runoff.	I
		Dirty water runoff retained in the **Interim Discard Dump** should drain to a properly designed and constructed pollution control dam.	III
PR05	Interim Surface Waste Dump	A clean water cut-off canal is proposed just north of the **Final Waste Dump** footprint to convey unpolluted water from the **Surface Waste Dump** away from the **Interim Inpit Backfill Dump**, **Final Waste Dump** and **Interim Discard Dump** to the nearest downstream release point.	II

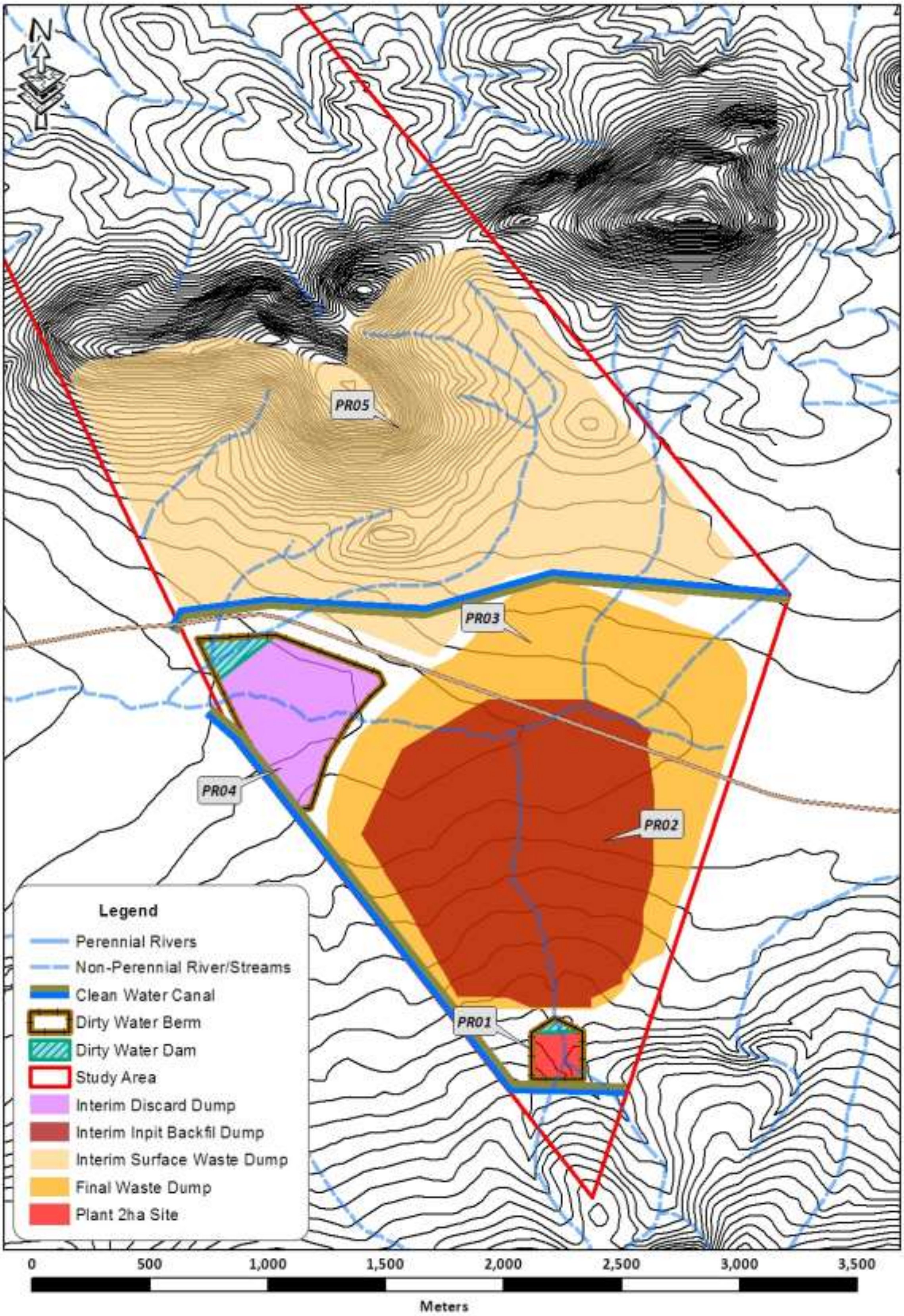


FIGURE 7.1: PROPOSED MITIGATION MEASURES

8. RISK ASSESSMENT

This risk assessment was done as a desktop study and should be viewed as a guideline for the Study Area. For a more accurate assessment, it is essential that this assessment be conducted by biologists familiar with the particular area in question, or of comparable areas.

8.1. ASSESSMENT

The likelihood of the river system to change (or risk) within the particular Study Area was assessed in terms of the anticipated magnitude of changes in the quantity as well as the changes in quality of surface water before any mitigation measures are put in place and also after the mitigation measures are introduced.

The levels of significance used in the assessment ranges from 1 to 9, with Level 1 meaning that the likelihood of a significant change in surface water runoff quantity or quality is unlikely to happen and the magnitude may be small if any. A Level 9 score means that a significant change is very likely to happen to a large degree. **Table 18** depicts each level of sensitivity.

TABLE 18: LEVELS OF SIGNIFICANCE

		Magnitude of Change		
		SMALL	MODERATE	LARGE
Likelihood	UNLIKELY	1	2	3
	LIKELY	2	4	6
	VERY LIKELY	3	6	9

Table 19 and **Table 20** below scores the impacts of each project component in terms of the level of significance as per **Table 18** above, with no mitigation measures in place and with mitigation measures in place respectively.

TABLE 19: IMPACTS WITH NO MITIGATION

Impacts with no mitigation measures in place.					
Impact on **Quantity** of runoff reaching the main stream		Score	Impact on **Quality** of runoff reaching the main stream		Score
Plant 2h Site	A change in the volume of runoff will be **LIKELY**, however a **MODERATE** change is anticipated.	4	**Plant 2h Site**	A reduction in the water quality of runoff will be **LIKELY**, however a **MODERATE** change is anticipated.	4
Interim Inpit Backfill Dump	A change in the volume of runoff will be **VERY LIKELY** and a **LARGE** decrease in volume is anticipated.	9	**Interim Inpit Backfill Dump**	A reduction in the water quality of runoff will be **VERY LIKELY**, with **LARGE** changes in quality.	9
Final Waste Dump	A change in the volume of runoff will be **VERY LIKELY** and a **LARGE** decrease in volume is anticipated.	9	**Final Waste Dump**	A reduction in the water quality of runoff will be **VERY LIKELY**, with **LARGE** changes in quality.	9
Interim Discard Dump	A change in the volume of runoff will be **VERY LIKELY** and a **LARGE** decrease in volume is anticipated.	9	**Interim Discard Dump**	A reduction in the water quality of runoff will be **VERY LIKELY**, with **LARGE** changes in quality.	9
Interim Surface Waste Dump	A change in the volume of runoff will be **LIKELY**, however a **MODERATE** change is anticipated.	4	**Interim Surface Waste Dump**	A reduction in the water quality of runoff will be **LIKELY**, however a **MODERATE** change is anticipated.	4
PROPERTY EXIT	A change in the volume of runoff will be **VERY LIKELY** and a **LARGE** decrease in volume is anticipated.	9	**PROPERTY EXIT**	A reduction in the water quality of runoff will be **VERY LIKELY**, with **LARGE** changes in quality.	9

TABLE 20: IMPACTS WITH MITIGATION IN PLACE

Impacts with mitigation measures in place.					
Impact on **Quantity** of runoff reaching the main stream		Score	Impact on **Quality** of runoff reaching the main stream		Score
Plant 2h Site	A clean water diversion canal will **LIKELY** alter the volume of runoff, however a **SMALL** change is still anticipated.	2	**Plant 2h Site**	It is **LIKELY** that a clean water canal will retain most of the water quality with a **SMALL** change anticipated.	2
Interim Inpit Backfill Dump	It is **VERY LIKELY** that no clean surface water runoff will reach the downstream river reach. Therefore a **LARGE** change in volume is anticipated.	9	**Interim Inpit Backfill Dump**	It is **VERY LIKELY** that **LARGE** changes in surface water quality will still occur.	9
Final Waste Dump	It is **VERY LIKELY** that no clean surface water runoff will reach the downstream river reach. Therefore a **LARGE** change in volume is anticipated.	9	**Final Waste Dump**	It is **VERY LIKELY** that **LARGE** changes in surface water quality will still occur.	9
Interim Discard Dump	It is **VERY LIKELY** that no clean surface water runoff will reach the downstream river reach. Therefore a **LARGE** change in volume is anticipated.	9	**Interim Discard Dump**	It is **VERY LIKELY** that **LARGE** changes in surface water quality will still occur.	9
Interim Surface Waste Dump	A clean water diversion canal will **LIKELY** alter the volume of runoff, however a **SMALL** change is anticipated.	2	**Interim Surface Waste Dump**	A reduction in the water quality of runoff will be **LIKELY**, however a **SMALL** change is anticipated.	2
PROPERTY EXIT	A change in the volume of runoff will **LIKELY occur** and a **MODERATE** decrease in volume is anticipated.	4	**PROPERTY EXIT**	A reduction in the water quality of runoff will be **LIKELY**, with **MODERATE** changes in quality.	4

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