CHAPTER 2

DETAILED OVERVIEW OF THE OLIFANTS RIVER BASIN

LOCATION OF THE OLIFANTS RIVER

The Olifants River has its origin near the town of Breyten on the Highveld Grasslands of the Mpumalanga province in South Africa (Figure 3). The upper reaches of the river flows through the industrial and mining area near the towns of Witbank and Middelburg in Mpumalanga before it cuts through the mountains to the Loskop Dam. From here, the Olifants River meanders through the Springbok flats; passes the Strydpoort Mountains and carries on through the Drakensberg Mountains to descend over the escarpment. Finally, the Olifants River flows through the Lowveld and the Kruger National Park. Crossing the international border, the river flows into the Massingire Dam in Moçambique and eventually on to the Indian Ocean.

The Olifants River catchment covers approximately 54 570 km^2 and is subdivided in nine secondary catchments (Water Research Commission, 2001). The area covered by the catchment is equal to 4.3% of the total surface area of the whole of South Africa and 18.9% of the former Transvaal province (Kleynhans, 1992). A total run-off of approximately 1 861 million m^3 is recorded annually in the Olifants River catchment (Kleynhans, 1992). This run-off is equal to 4.1% of the annual run-off recorded for the entire South Africa (O'

Keeffe, 1986). According to the Department of Water Affairs and Forestry (2008), the total length of the Olifants River from its origin to the mouth near the town of Xai-Xai on the Indian Ocean coast of Moçambique is approximately 954.9 km.

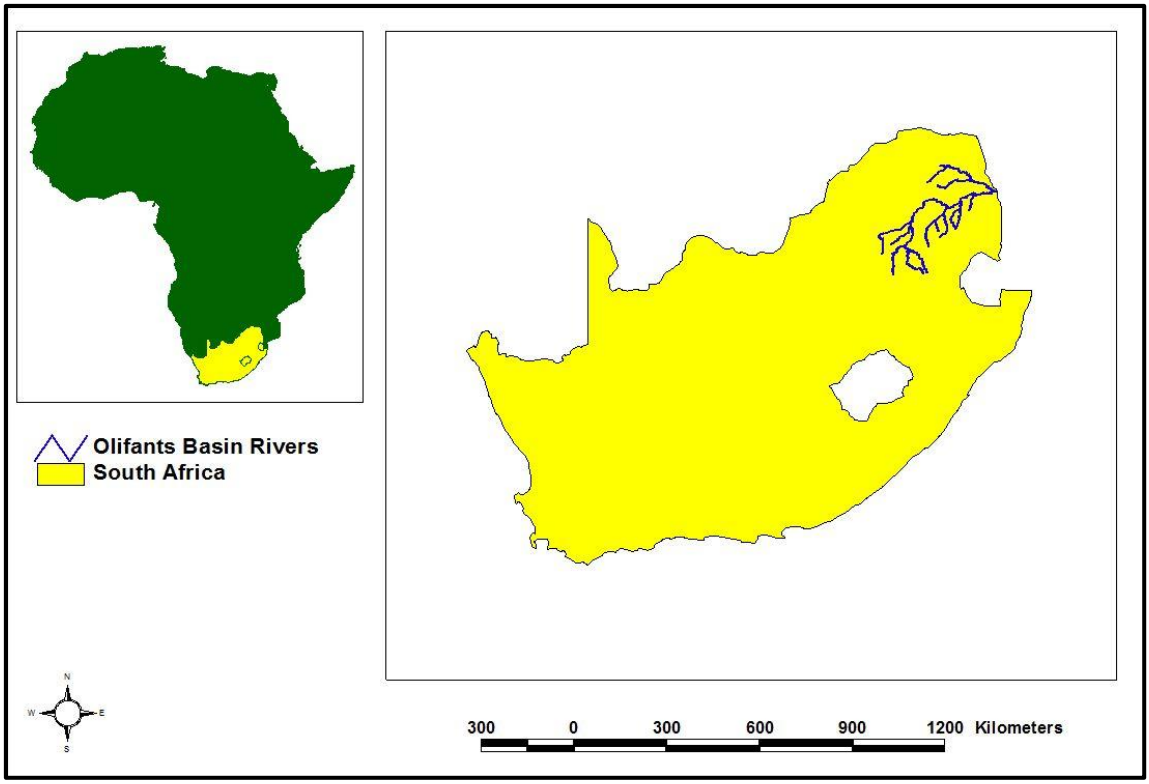

Figure 3: Locality of the Olifants River basin in South Africa.

According to Havenga (2007) of the Department of Water Affairs and Forestry, the Olifants River is currently one of the most stressed catchments in South Africa. It is estimated that the Olifants River cannot supply enough water to meet the current and future water demand from industry, residential developments, agriculture, forestry, mining and the environment. According to Havenga (2007), the river already exhibited a negative water balance in 2004 (i.e. more water was being abstracted from the river than was available) and that this

negative water balance is estimated to be a staggering -242 million m^3/a in the year 2025 (Table 1).

Table 1: The calculated water balance of the Olifants River for 2004 and the projected water balance of the Olifants River for 2025 (Basson and Rossouw, 2003).

Water demand	Year 2004	Year 2025
Water available in the river	609 million m^3 L/a	630 million m^3 L/a
Water required by users	965 million m^3 L/a	1074 million m^3 L/a
Balance before water transfers	**-356 million m^3 L/a**	**-444 million m^3 L/a**
Water transferred in	172 million m^3 L/a	210 million m^3 L/a
Water transferred out	8 million m^3 L/a	7 million m^3 L/a
Balance remaining	**-192 million m^3 L/a**	**-241 million m^3 L/a**

There are more than 2500 dams in the Olifants River catchment, of which more than 90% have a volume of less than 20 000 m^3 and 30 major dams with capacities of more than 2 000 000 m^3 (Swanepoel, 1999). The Department of Water Affairs and Forestry (Basson and Rossouw, 2003) have determined that irrigation (agriculture) alone uses 58% of the available water in the Olifants River. Table 2 shows the extent and requirements of current and projected water use in the Olifants River catchment area although the figure of 3 million m^3/a in 2004 given for the forestry industry seem very low when compared to 1987 and the expected 2010 need. This could be a calculation mistake by the original author.

Table 2: Major water users in the Olifants River and projected needs for 2010 (Theron *et al.*, 1991; Basson and Rossouw, 2003).

Water users	Percentage use 2004	1987 (million m^3 L/a)	2000 (million m^3 L/a)	2010 (million m^3 L/a)
Power generation	18.76	208	181	208
Irrigation	57.72	538	557	640
Forestry	0.31	56	3	63
Domestic & Industrial	13.58	90	131	180
Mining	9.64	80	93	100
Total	**100**	**972**	**965**	**1191**

According to the Water Research Commission (2001), the Olifants River experiences extreme demand for natural resources, with associated land modification and pollution. Thus, the river ecosystems of the Olifants River are currently classified as moderately to largely modified. In the upper parts of the catchment, mining related disturbances are the main causes of impairment of river health (Water Research Commission, 2001). There is also extensive invasion by alien vegetation and alien fauna. Ecologically insensitive releases of water and sediment from storage dams are another major cause of environmental degradation downstream (Water Research Commission, 2001). This is particularly relevant in the middle and lower parts of the catchment. The Olifants River was historically a

perennial river but is currently so over utilised that large parts of the river north of the Flag Boshielo Dam is currently characterised by large pools connected by narrow flows during the dry season.

The study area is defined as the Olifants River from the confluence of the Wilge River above the Loskop Dam downstream past the town of Groblersdal, on to the Flag Boshielo Dam, then past Penge and Burgersfort, onward past the confluence of the Blyde River into the Kruger National Park ending at the RSA/Moçambique international border (Figure 4).

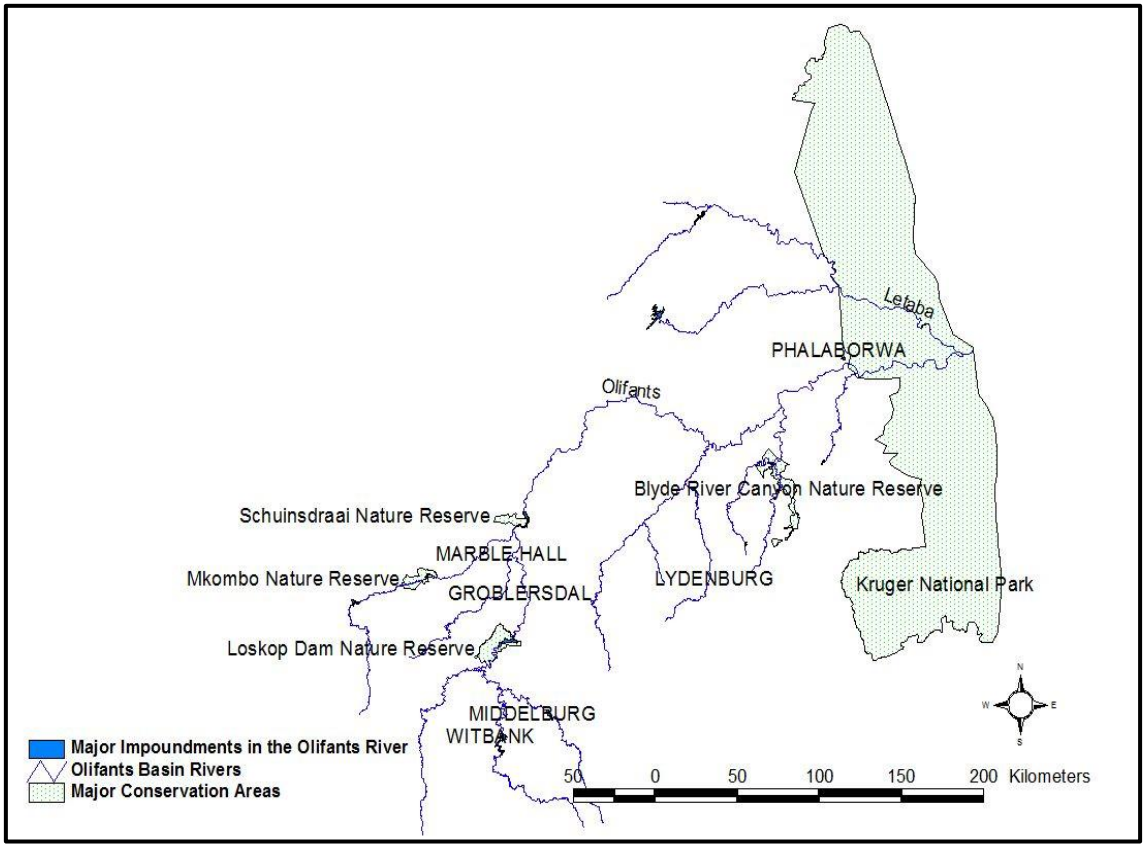

Figure 4: The Olifants River and its major tributaries in relation to major towns and conservation areas in the region.

In terms of the aerial survey, the following tributaries were included in the study area: the Steelpoort River from its confluence with the Olifants to the general area near Roossenekal, the Ohrigstad River from the town to its confluence with the Blyde River and the Blyde River from the Blyderivierspoort Dam (Swadini) to its confluence with the Olifants River. Also surveyed was the Elands River from the Flag Boshielo Dam to the Rust der Winter Dam and short distance of the Wilge River from its confluence with the Olifants River (just before the Loskop Dam). The Loskop Dam, Flag Boshielo Dam, Blyderivierspoort Dam, Rhenosterkop Dam, Rust der Winter Dam were surveyed as part of the aerial survey. It is important to note that the entire length of some of the rivers (e.g. Wilge River) was not surveyed due to the habitat clearly being unsuitable for Nile crocodiles.

Blood and urine samples of selected Nile crocodiles inhabiting the Loskop Dam, Flag Boshielo Dam and the Blyderivierspoort Dam were also collected. These three populations have been chosen as research sites because they represent populations in the upper, middle and lower Olifants River.

In 1992, Kleynhans wrote: *"There was a river ... The Olifants River. This name recalls a vision of untouched Africa with large herds of game on vast plains drinking from a huge river. Unfortunately, this idyllic vision has become only a vague dream to be replaced by a nightmarish reality."*

TOPOGRAPHY OF THE OLIFANTS RIVER BASIN

Myburgh (1999) describes the topography of the catchment as varying from approximately 2300 metres above mean sea level in the Drakensberg, to less than 300 metres above sea level in the Lowveld of the Kruger National Park. However, in their detailed description the Water Research Commission (2001) divided the Olifants River Catchment into five ecoregions namely: Highveld, Central Highlands, Bushveld Basin, Great Escarp Mountains and Lowveld. Ecoregions will be used as the unit for comparison when discussing topography, geology, present ecological state and land-use. Biomes, bioregions and vegetation are discussed in terms of broad vegetation types.

Highveld Ecoregion:

The Olifants River originates on the Highveld Grasslands which is characterised by flat grasslands and rolling rocky zones on top of the escarpment (1500 to 1750 m above mean sea level). In this region, the river structure varies from a narrow channel with no definite riparian zone to a 20-30 m wide channel with well developed riparian habitat.

Central Highlands:

From the confluence of the Olifants and Klein-Olifants Rivers the river decreases in altitude from 1500 to 1000 m above mean sea level while it flows in a north-westerly direction until the Wilge River joins up with it upstream of the Loskop Dam. Here the river varies from a

single channel to multiple channels with afforested islands and steep river banks with narrow floodplains in some areas. Rapids and pools are common as are boulders and large rocks in the riverbed. The central highlands ecoregion is also present where the Olifants River passes south of the Strydpoort Mountains foothills.

Bushveld Basin:

From the Loskop Dam the Olifants River flows through relatively flat landscape of the Bushveld Basin Ecoregion past the towns of Groblersdal and Marble Hall to the Flag Boshielo Dam (1500 to 800 m above mean sea level). The river is steep with many riffles in this ecoregion, becoming gentler with a sandy bed due to alluvial deposits.

Great Escarpment Mountains:

In this area, the Olifants River passes through the upper slopes of the Drakensberg Mountains where it meanders through the landscape at an altitude of 1000 to 2000 m above mean sea level. The riverbed is stony and between 50 and 80 m wide with deep alluvial sand and silt deposits. In some areas the river forms secondary channels, floodplains and woody islands.

Lowveld:

The Olifants and the Blyde River meanders through the Drakensberg and enters the Lowveld just before the confluence of the two rivers. This region is characterised as a lowland area

with rolling plains and has a mean altitude of 200 - 600 m above mean sea level where the river flows eastward through the Kruger National Park. In the Lowveld Ecoregion, the river is a broad sandy channel changing to several channels with permanent reed-grown islands, sand banks and floodplains. Floodplains are usually elevated in relation to the riverbed.

Lebombo Uplands:

The Letaba River joins the Olifants River west of the Olifants Rest Camp in the Kruger National Park. Here a narrow gorge with towering stone walls form where the Olifants River flows through the Lebombo Mountains before it crosses the international border with Moçambique. The river is characterised in this area by an abundance of big rocks, stones and pebbles while the riparian zone alternates between narrow zones close to the stream to broader zones with sand banks.

GEOLOGY OF THE OLIFANTS RIVER BASIN (FIGURE 5)

Various authors (Louw, 1951; Kruger, 1971; van Wyk, 1983) have shown that geology has an important influence in the determination of plant communities. Although geology does play an important role in the distribution of riverine vegetation, there are several other factors that have a direct influence on the occurrence and distribution of plant species in the riparian habitat (Myburgh, 1999). Geomorphology with its associated hydrological processes such as floods, siltation, erosion, groundwater movement, fluctuations of the water

table all play a critical role in the occurrence and distribution of plant species associated with the riparian zones of rivers (Myburgh, 1999).

Bedrock plays a very important role in controlling water transmission and storage in the catchment of river systems. The extent of this role of the bedrock is determined by the hydraulic conductivity and porosity of the rock matrix and by structural features such as fissures, cracks and joints (Bosch *et al.*, 1986). Variations in these properties will influence seasonal flow patterns of rivers, stormflow characteristics, subsurface flow patterns, water quality, erosion and sedimentation (Bosch *et al.*, 1986).

In general terms, the geological foundation of the Olifants River as it occurs in each ecoregion can be summarised as follows:

Highveld Ecoregion:

This region covers the area of approximately 142km in length from the source of the Olifants River near Breyten to just downstream of the Witbank Dam and is characterised by geology of the Madzaringwe Formation (Karoo Supergroup), the Loskop Formation (Transvaal Supergroup), and the Dwyka Group (Karoo Supergroup). Rock formations of this area consist of mudstone, shale and siltstone at the base overlain by coarse to fine sandstone and coal seams (Water Research Commission, 2001; Johnson *et al.*, 2006).

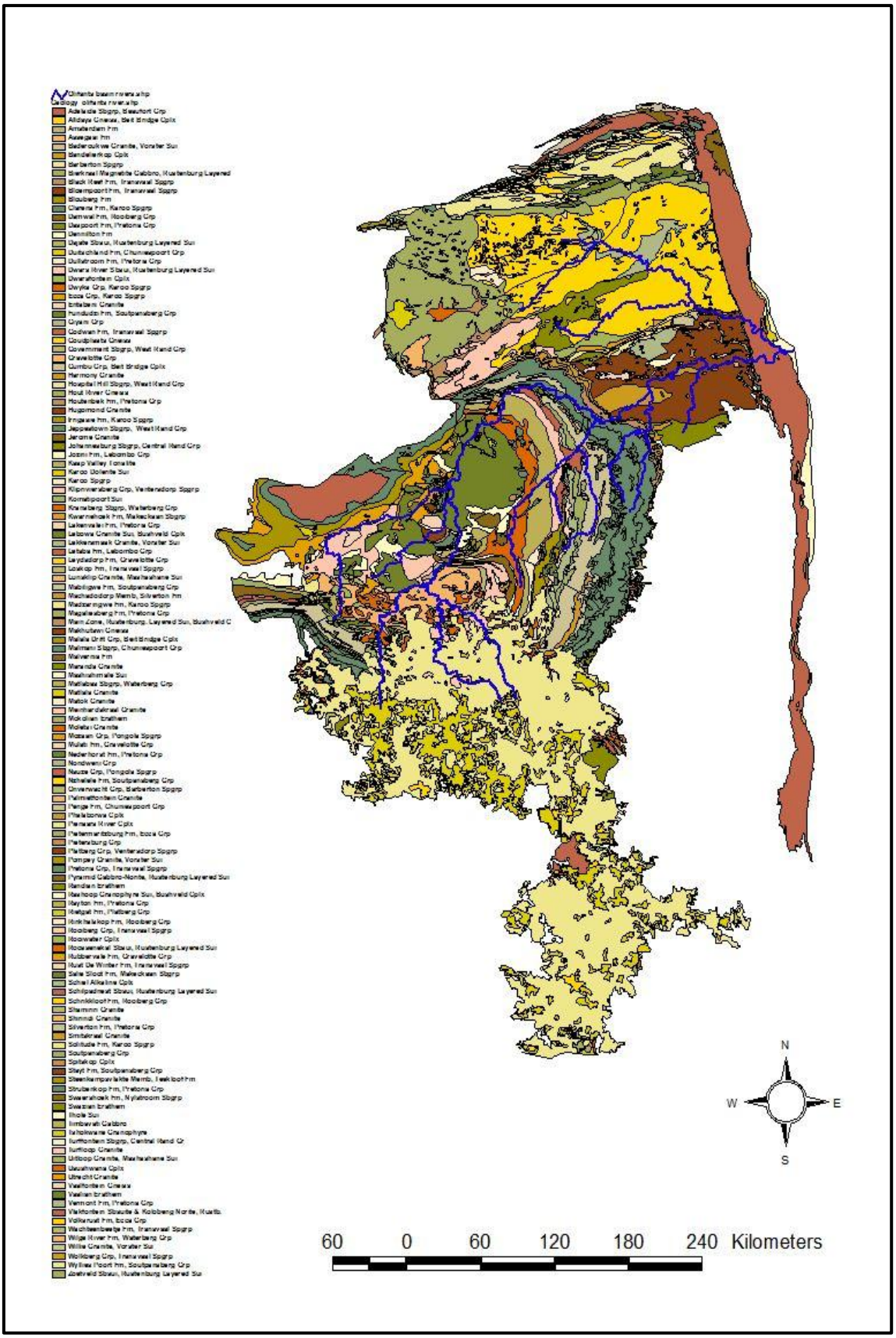

Figure 5: Broad geology of the study area showing the Olifants River superimposed in blue over the figure.

The coal seams are considered economically important and originated as peat swamps, which developed on broad alluvial plains and backswamps (Johnson *et al.,* 2006).

Central Highlands:

This region is situated in an area that can loosely be described as stretching approximately 148km in length from downstream of the Witbank Dam to just downstream of the Loskop Dam. It is characterised by geology of the Wilge River Formation (Waterberg Group) while some elements of the Pretoria Group (Lakenvalei Formation, Magaliesberg Formation, and Silverton Formation) is also present. Therefore, coarse-grained, red-bed sandstones, mudrock and conglomerates dominate the rock formations of the area (Water Research Commission, 2001). Quartzite, feldspar and conglomerates of the Rooiberg Group, Rustenburg Layered Suite (Dsjate Subsuite) and the Rashoop Granophyre Suite also occur (van der Neut *et al.,* 1991).

A further extension of the Central Highlands ecoregion is found wedged between the Bushveld Basin and the Great Escarpment Mountains ecoregions for a distance of approximately 85km of the river. This small area consists of geology of the Rustenburg Layered Suite and the Pretoria Group and Chuniespoort Group of the Transvaal Supergroup (Cawthorn *et al.,* 2006; Eriksson *et al.,* 2006). Rock types of this area are characterised by quartzitic sandstone, sandstone, quartzite, mudstone, ironstone, dolomites and asbestos deposits.

Bushveld Basin:

This region represents an area approximately 152km in length roughly from downstream of Loskop Dam to the Tuduma River downstream of the Flag Boshielo Dam. It is dominated overwhelmingly by the Rashoop Granophyre Suite and Lebowa Granite Suite subdivisions of the Bushveld Complex (Cawthorn *et al.,* 2006) with elements of the Pretoria Group also occurring in this region (Martini *et al.,* 2001). The most prominent rock types occurring in the region are: mudrock, quarzitic sandstone, ironstone, quartzite and feldspar. The Bushveld Complex is very important economically. According to Cawthorn *et al.* (2006) the Bushveld Complex contains some of the largest deposits of major mineral deposits namely the platinum group elements, chromium, vanadium, fluorite andelusite with base and precious metals including tin, copper, silver and gold as well as dimension stone (gabbro, norite and granite) (Cawthorn *et al.*, 2006).

Great Escarpment Mountains:

The Great Escarpment Mountains ecoregion is situated in an area of approximately 68km in length between the Motse River near the town of Penge to area roughly halfway between the Steelpoort and Blyde Rivers. The geology of this region consists of Black Reef Formation (Transvaal Supergroup), the Wolkberg Group, Makhutswi Gneiss and Harmony Granite (Martini *et al.*, 2001). The most prominent rock types of characterising this ecoregion are: quartzite, basalt, sandstone, mudrock quartzitic sandstone and light-grey gneiss (Eriksson *et al.*, 2006; Robb *et al.*, 2006).

Lowveld:

This area of the river stretches for a distance of approximately 186km from roughly halfway between the Steelpoort and Blyde Rivers to the Letaba River in the Kruger National Park. According to Martini *et al.* (2001), the dominant geological formations of this area are Makhutwsi Gneiss, Mulati Formation (Gravelotte Group), Harmony Granite, Clarens Formation (Karoo Supergroup) and the Letaba Formation (Lebombo Group). Rock types typically encountered in this ecoregion includes: granitic gneisses with infolded greenstone belts or greenstone belt remnants, massive quartzitic sandstones, granites and olivine rich basalts (Robb *et al.*, 2006; Johnson *et al.*, 2006, Duncan and Marsh, 2006; Brandl *et al.*, 2006).

The greenstone belts are described as early Archaean rocks and constitute the oldest preserved material on the earth's surface. These rocks are vital in deciphering the evolutionary history of the earth's crust. Although not uncommon in many parts of the world there are only two cratons known (Pilbara in Western Australia and the Kaapvaal Craton in South Africa) which have retained large tracts of relatively pristine rocks. South Africa's Kaapvaal Craton is particularly well endowed with large areas of granitoid gneisses containing a number of infolded greenstone belts or their remnants.

Lebombo Uplands:

The final 8km of the Olifants River before it crosses the international border with Moçambique is situated in the Lebombo Uplands ecoregion. This region is characterised by the Jozini Formation of the Lebombo Group (Martini *et al.*, 2001). The dominant rock type found in this region is rhyolites (Duncan and Marsh, 2006).

LANDFORMS OF THE OLIFANTS RIVER BASIN

Landforms are a map unit denoting land that can be mapped at the 1:250 000 scale over which there is a marked uniformity of climate, terrain form and soil pattern (Soil Science Society of South Africa, 2006). According to the Soil Science Society of South Africa (2006), there are five terrain morphological units or land forms commonly identified. These are: crest, scarp, midslope, footslope and valley bottom. According to this classification, the riverbanks and river system of the Olifants River is situated in the footslope and valley bottom terrain morphological units.

BIOMES AND BIOREGIONS OF THE OLIFANTS RIVER BASIN

The concept of biomes has broad-scale applicability to those who develop conservation and management strategies over large areas. A biome can be viewed as a high-level hierarchical (therefore, simplified) unit having a similar vegetation structure exposed to similar

macroclimatic patterns, often linked to characteristic levels of disturbance such as grazing and fire (Mucina and Rutherford, 2006). Biomes are described by Cox and Moore (2000) as a "large-scale ecosystem". Strictly speaking the term biome includes both plant and animal communities but because of the dominant nature of vegetation cover in all terrestrial ecosystems, biomes have been based on vegetation characteristics only (Mucina and Rutherford, 2006).

A bioregion is a composite spatial terrestrial unit defined on the basis of similar biotic and physical features and processes at the regional scale (Mucina and Rutherford, 2006). Bioregions occupy the intermediate level between that of vegetation type and biome (Mucina and Rutherford, 2006).

The Olifants River catchment flows through only two biomes namely the Grassland Biome and the Savanna Biome which includes four bioregions (i.e. Mesic Highveld Grassland Bioregion, Central Bushveld Bioregion, Lowveld Bioregion and the Mopane Bioregion) and fifteen vegetation types (see table 3).

Table 3: Biomes, Bioregions and Vegetation Types of the Olifants River (after Mucina and Rutherford, 2006) in relation to ecoregions and conservation status.

Ecoregion (WRC, 2001)	Biome	Bioregion	Vegetation Type	Percentage Protected	Percentage Remaining	Conservation Status	Protected Status
Highveld	Grassland	Mesic Highveld Grassland	Soweto Highveld Grassland	0.2	52.7	Endangered	Hardly Protected
Highveld	Grassland	Mesic Highveld Grassland	Eastern Highveld Grassland	0.3	56.0	Endangered	Hardly Protected
Highveld/Central Highlands	Grassland	Mesic Highveld Grassland	Rand Highveld Grassland	0.9	58.5	Endangered	Hardly Protected
Central Highlands	Savanna	Central Bushveld	Loskop Mountain Bushveld	14.5	97.6	Least Threatened	Moderately Protected
Central Highland	Savanna	Central Bushveld	Loskop Thornveld	11.3	75.8	Vulnerable	Poorly Protected
Bushveld Basin	Savanna	Central Bushveld	Central Sandy Bushveld	2.4	75.9	Vulnerable	Poorly Protected
Bushveld Basin/Central Highlands	Savanna	Central Bushveld	Sekhukhune Plains Bushveld	0.8	74.5	Vulnerable	Hardly Protected
Great Escarpment Mountains	Savanna	Central Bushveld	Ohrigstad Mountain Bushveld	7.6	90.7	Least Threatened	Poorly Protected
Great Escarpment Mountains	Savanna	Central Bushveld	Poung Dolomite Mountain Bushveld	9.9	94.1	Least Threatened	Poorly Protected
Lowveld	Savanna	Lowveld	Granite Lowveld	17.5	79.2	Vulnerable	Moderately Protected
Lowveld	Savanna	Mopane	Lowveld Rugged Mopaneveld	34.4	80.2	Least Threatened	Well Protected
Lowveld	Savanna	Lowveld	Makuleke Sandy Bushveld	31.5	7303	Vulnerable	Well Protected
Lowveld	Savanna	Mopane	Mopane Basalt Shrubland	100.0	99.6	Least Threatened	Well Protected
Lowveld	Savanna	Lowveld	Tshokwane-Hlane Basalt Lowveld	64.4	83.5	Least Threatened	Well Protected
Lebombo Uplands	Savanna	Lowveld	Northern Lebombo Bushveld	98.8	99.8	Least Threatened	Well Protected

Grassland Biome (Figure 6):

The Grassland Biome is characterised by grasslands which are structurally simple and strongly dominated by grasses (Poaceae). The canopy cover is moisture-dependant and decreases with lower mean annual rainfall but is influenced by the amount and type of grazing and by the presence of fire (Mucina and Rutherford, 2006). Minimum temperature plays an important role in structurally distinguishing temperate grasslands from those where frost is rare (Walker, 1993). Woody species are limited to specialised niches/habitats in the Grassland Biome while forbs are also considered by Mucina and Rutherford (2006) to contribute heavily to the species richness of grasslands.

Savanna Biome (Figure 6):

Savanna usually has an herbaceous layer dominated by grass with a discontinuous or open tree layer. According to Mucina and Rutherford (2006) the term "bushveld" used in southern-Africa, seems appropriate because the woody component of savanna areas often does not form a distinct layer as in miombo vegetation to the north. The vegetation exhibits an irregular series of interlocking, low canopies with openings and little distinction between tall shrubs and small trees. Savanna is influenced by rainfall in terms of leaf retention into winter, soil moisture through the concentrated application of water to the soil by stemflow, absence of rainfall during drought when smaller trees show marked mortality and to some extent frost (Mucina and Rutherford, 2006). The strong seasonality of rainfall in the southern African savanna allow for plant material produced in the wet season to dry and

burn during the dry season. Fire has long been regarded as a tool for directly influencing the woody components of savanna to control bush encroachment and to maintain trees and shrubs at an available height and acceptable state for browsing animals (Trollope, 1980).

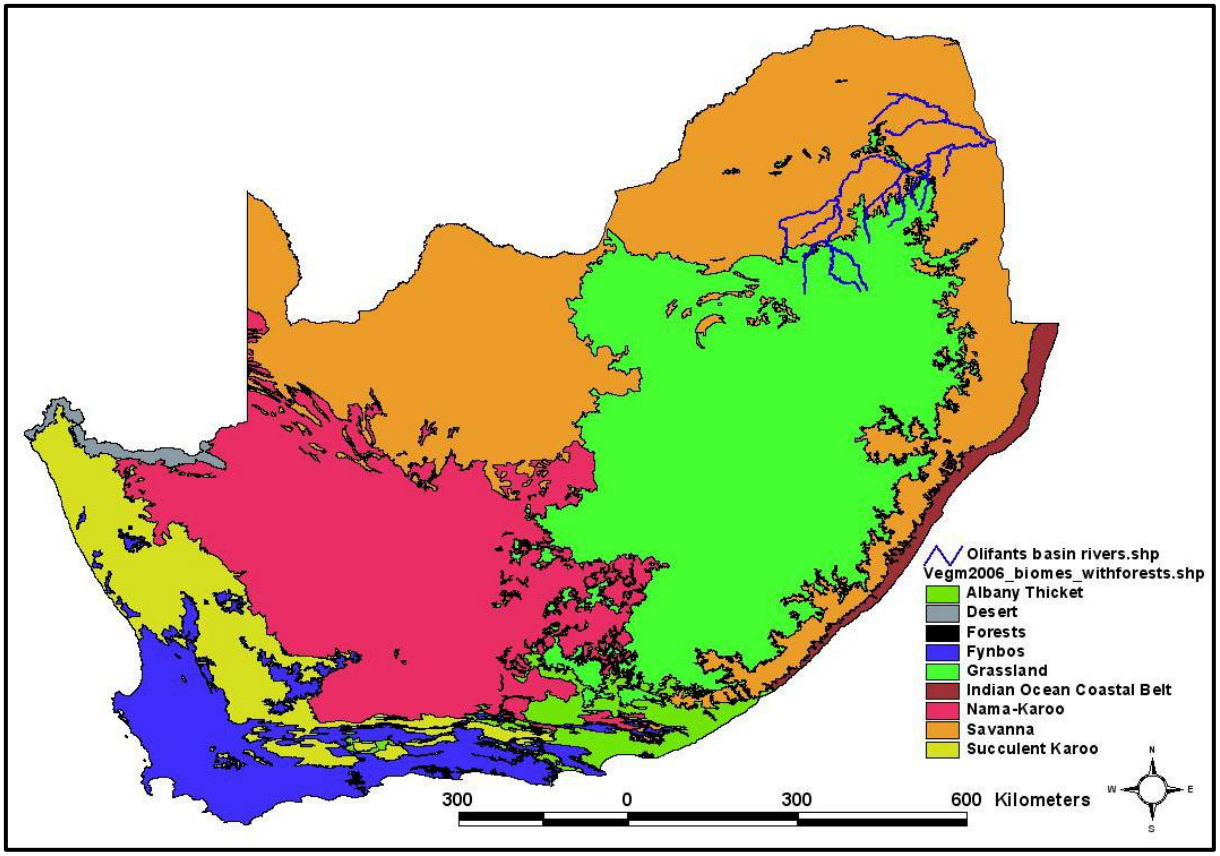

Figure 6: Biomes of South Africa showing the Olifants River superimposed in blue over the north-east of the country.

Mesic Highveld Grassland Bioregion:

There are four bioregions in the Grassland biome and the Mesic Highveld Grassland Bioregion is the largest and has the highest number of vegetation types. It is found mainly in the high precipitation parts of the Highveld and extends northwards along the eastern escarpment and includes bushveld summit grasslands (Mucina and Rutherford, 2006). The

Olifants River flows through three vegetation types of this bioregion namely; Soweto Highveld Grassland, Eastern Highveld Grassland and Rand Highveld Grassland (Table 3; Figure 7).

Central Bushveld Bioregion:

The Savanna Biome contains six bioregions of which three is crossed by the Olifants River. The Central Bushveld Bioregion has the highest number of vegetation types and covers most of the high-lying plateau west of the main escarpment from the Magaliesberg in the south to the Soutpansberg in the north (Mucina and Rutherford, 2006). In this bioregion, the Olifants River flows through six vegetation types namely; Loskop Mountain Bushveld, Loskop Thornveld, Central Sandy Bushveld, Ohrigstad Mountain Bushveld and the Poung Dolomite Mountain Bushveld (Table 3; Figure 7).

Lowveld Bioregion:

The Lowveld Bioregion extends from the eastern foot of the Soutpansberg southwards along the base and lower slopes of the escarpment through the lower parts of Swaziland to the low-lying areas of Zululand in KwaZulu-Natal (Mucina and Rutherford, 2006). In this bioregion, the Olifants River flows through four vegetation types namely; Granite Lowveld, Makuleke Sandy Bushveld, Tshokwane-Hlane Basalt Lowveld and Northern Lebombo Bushveld (Table 3; Figure 7).

Mopane Bioregion:

The Mopane bioregion has the smallest area of the bioregions in the Savanna Biome and lies at a relatively low altitude north of the Soutpansberg and north-eastern flats of the Limpopo province (Mucina and Rutherford, 2006). The Olifants River flows through two vegetation types of the Mopane Bioregion, namely the Lowveld Rugged Mopaneveld and the Mopane Basalt Shrubland (Table 3; Figure 7).

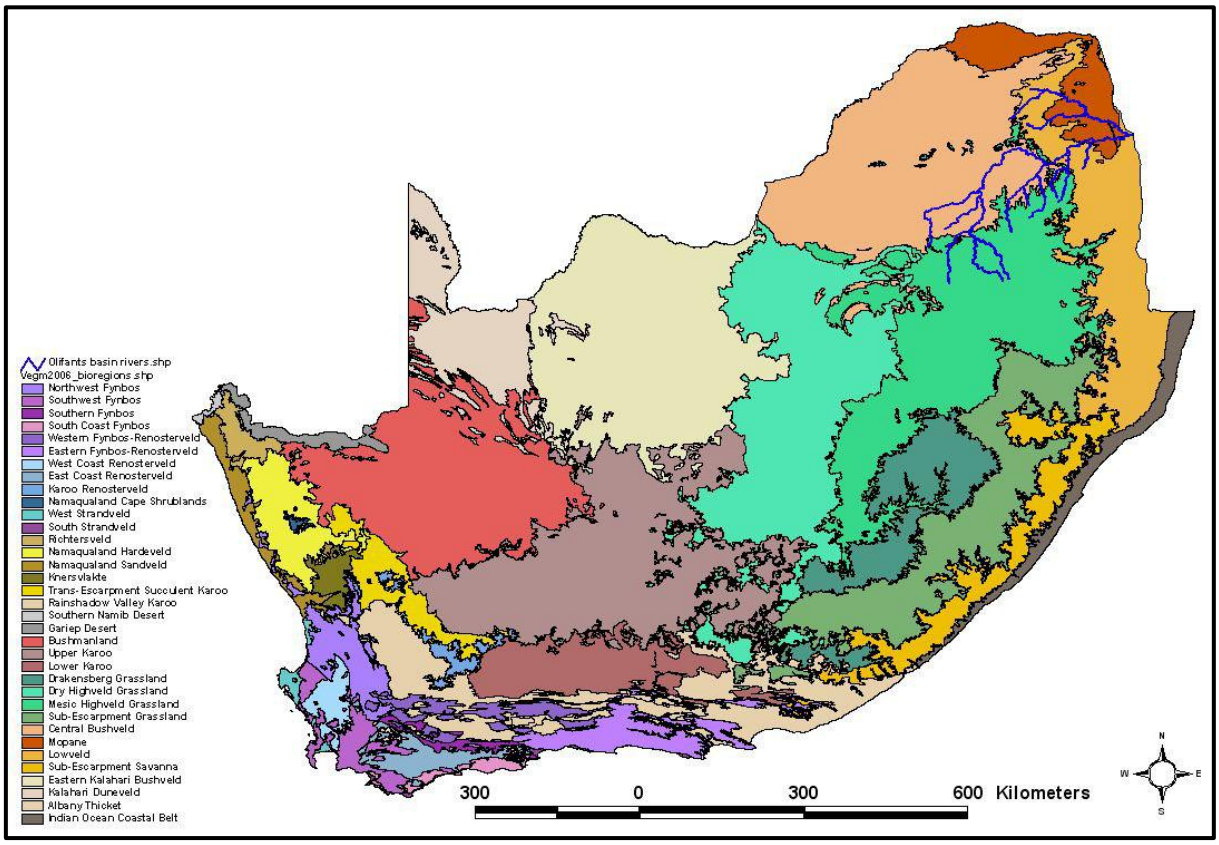

Figure 7: Bioregions of South Africa showing the Olifants River superimposed in blue over the north-east of the country.

VEGETATION TYPES OF THE OLIFANTS RIVER BASIN (FIGURE 8)

The concept of veld types was defined by Acocks in 1953 when he wrote a veld type could be defined as a unit of vegetation whose range of variation is small enough to permit the whole of it to have the same agricultural potentialities. However, Mucina and Rutherford (2006) defined the basic map unit, referred to as vegetation units, used for mapping the vegetation of South Africa, Lesotho and Swaziland as *"a complex of plant communities ecologically and historically (both in spatial and temporal terms) occupying habitat complexes at the landscape scale".*

The Olifants River flows through fifteen vegetation types as described by Mucina and Rutherford (2006). These are discussed below in order of occurrence from the river's origin to where it crosses the international border with Moçambique.

Soweto Highveld Grassland:

This vegetation type occurs at altitudes of 1420 - 1760 m above mean sea level on the gently to moderately undulating landscape of the Highveld plateau which characterised by short to medium-high tufted grassland (Mucina and Rutherford, 2006). This vegetation type is dominated almost entirely by *Andropogon appendiculatus, Brachiaria serrata, Cymbopogon pospischilii, Cynodon dactylon, Elionurus muticus, Eragrostis capensis, E. chloromelas, E. curvula, E. plana, E. planiculmis, E. racemosa, Heteropogon contortus,*

Hyparrhenia hirta, Setaria nigrirostris, S. sphacelata, Themeda triandra, Tristachya leucothrix and *Hermania depressa* (Mucina and Rutherford, 2006). The continuous grassland cover is only interrupted by small scattered wetlands, narrow alluvial streams, pans and occasional ridges or rocky outcrops.

Mucina and Rutherford (2006) describe this vegetation type as endangered and hardly protected in South Africa. They estimate that only 52.7% of the vegetation type remains intact with only 0.2% being protected in provincial nature reserves and private conservation areas. Soweto Highveld Grassland is threatened by cultivation, urban sprawl, mining, road building and flooding by dams (Mucina and Rutherford, 2006).

Eastern Highveld Grassland:

This vegetation type occurs at altitudes of 1520 - 1780 m above mean sea level but also as low as 1300 above mean sea level on slightly to moderately undulating plains including low hills and pan depressions (Mucina and Rutherford, 2006). The vegetation is characterised by short dense grassland dominated by *Aristida aeguiglumis, A. congesta, A. junciformis subsp. galpinii, Brachiaria serrata, Cynodon dactylon, Digitaria monodactyla, D. tricholaenoides, Elionurus muticus, Eragrostis chloromelas, E. curvula, E. plana, E. racemosa, E. sclerantha, Heteropogon contortus, Loudetia simplex, Microchloa caffra, Monocymbium ceresiiforme, Setaria sphacelata, Sporobolus africanus, S. pectinatus, Themeda triandra,*

Trachypogon spicatus, Tristachya leucothrix, T. rehmannii, Berkheya setifera, Haplocarpha scaposa, Justicia anagalloides and *Pelargonium luridum* (Mucina and Rutherford, 2006).

Mucina and Rutherford (2006) describe this vegetation type as endangered and hardly protected in South Africa. They estimate that only 56.0% of the vegetation type remains intact with only 0.3% being protected in provincial nature reserves and private conservation areas. Eastern Highveld Grassland is threatened by cultivation, plantations, urbanisation and flooding by dams to the extent that roughly 44% of the vegetation type is already transformed (Mucina and Rutherford, 2006).

Rand Highveld Grassland:

This vegetation type occurs at altitudes of 1300 - 1635 m above mean sea level but reaches 1760 above mean sea level in places where this vegetation type is situated in a highly variable landscape with extensive sloping plains and a series of low ridges (Mucina and Rutherford, 2006). The vegetation is described as wiry sour grassland alternating with low sour shrub land on rocky outcrops and steeper slopes and the dominant grasses, herbs and shrubs on the plains are *Ctenium concinnum, Cynodon dactylon, Digitaria monodactyla, Diheteropogon amplectens, Eragrostis chloromelas, Heteropogon contortus, Loudetia simplex, Monocymbium ceresiiforme, Panicum natalense, Schizachyrium sanguineum, Setaria sphacelata, Themeda triandra, Trachypogon spicatus, Tristachya biseriata, T. rehmannii, Acanthospermum australe, Justicia anagalloides, Pollichia campestris* and *Lopholaena*

corrifolia (Mucina and Rutherford, 2006). The following species are considered to be endemic to this vegetation type: *Melanospermum rudolfii, Polygala spicata, Anacampseros subnuda* subsp. *lubbersii, Frithia humilis, Crassula arborescens* subsp. *undulatifolia, Delosperma purpureum, Encephalartos lanatus* and *E. middelburgensis* (Mucina and Rutherford, 2006).

This vegetation type is described by Mucina and Rutherford (2006) as endangered and hardly protected in South Africa. They estimate that only 58.5% of Rand Highveld Grassland remains intact with only 0.9% being protected in provincial nature reserves and private conservation areas and list cultivation, plantations, urbanisation and flooding by dams as the major threats to this vegetation types.

Loskop Mountain Bushveld:

This vegetation type occurs at altitudes of 1050 - 1500 m above mean sea level along low mountains and ridges with open tree savanna (Mucina and Rutherford, 2006).. Dominant species in this vegetation type are: *Acacia burkei, A. caffra, Burkea africana, Combretum apiculatum, C. zeyheri, Croton gratissimus, Faurea saligna, Heteropyxis natalensis, Ochna pulchra, Protea caffra, Pseudolachnostylis maprouneifolia, Terminalia sericea, Diplorhynchus condylocarpon, Elephantorrhiza burkei, Rhus zeyheri, Aristida transvaalensis, Loudetia simplex,* and *Trachypogon spicatus* (Mucina and Rutherford, 2006). The following species

are considered to be endemic to this vegetation type: *Gladiolus pole-evansii* and *Haworthia koelmaniorum* (Mucina and Rutherford, 2006).

Mucina and Rutherford (2006) describe this vegetation type as least threatened but moderately protected probably because about 15% is protected in provincial nature reserves. They estimate that 97.6% of Loskop Mountain Bushveld remains intact with less than 3% of the vegetation type being transformed by cultivation and urbanisation (Mucina and Rutherford, 2006).

Loskop Thornveld:

This vegetation type occurs at altitudes of 950 - 1300 m above mean sea level in the valleys and plains of the upper Olifants River catchment and is described by Mucina and Rutherford (2006) as open, deciduous to semi deciduous, tall thorny woodland usually dominated by *Acacia* species. Dominant vegetation in these areas are *Acacia burkei, Sclerocarya birrea subsp. caffra, Acacia gerrardii, A. sieberiana var. woodii, Euclea crispa subsp. crispa, Rhus pyroides var. pyroides, Clematis brachiata, Rhynchosia minima, Bothriochloa insculpta, Digitaria argyrograpta* and *Themeda triandra* (Mucina and Rutherford, 2006)

Mucina and Rutherford (2006) describe this vegetation type as vulnerable and poorly protected in South Africa. They estimate that roughly 75.8% of the vegetation type remains intact with 11.3% being protected in provincial nature reserves and private conservation

areas. Loskop Thornveld is mainly threatened by the cultivation of agricultural crops requiring irrigation. Crops planted in this vegetation type include maize, cotton, citrus, grapes and wheat with a dramatic increase in the establishment of vineyards (Mucina and Rutherford, 2006). Old lands are often invaded by *Acacia tortilis, Hyparrhenia hirta, Cereus jamacaru, Opuntia ficus-indica, Melia azedarach, Lantana camara* and *Solanum seaforthianum*.

Central Sandy Bushveld:

This vegetation type occurs at altitudes of 850 - 1450 m above mean sea level in low undulating areas, between mountains on sandy plains and catenas where the vegetation is dominated by T*erminalia sericea* and *Burkea africana* woodland on deep sandy soils, and low broadleaved *Combretum* woodland on shallow rocky or gravely soils (Mucina and Rutherford, 2006). Dominant species in this vegetation type are: *Acacia burkei, Burkea africana, Combretum apiculatum, C. zeyheri, Terminalia sericea, Agathisanthemum bojeri, Indigofera filipes, Dichapetalum cymosum, Brachiaria nigropedata, Eragrostis pallens, E. rigidior, Hyerthelia dissolute, Panicum maximum, Perotis patens* and *Dicerocaryum senecioides* (Mucina and Rutherford, 2006).

This vegetation type is vulnerable and poorly protected in South Africa (Mucina and Rutherford, 2006). It is estimated that roughly 75.9% of this vegetation type remains intact with only 2.4% protected in provincial nature reserves and private conservation areas.

Approximately 24% of Central Sandy Bushveld is transformed. Much of this vegetation type in the broad arc south of the Springbok flats is heavily populated by rural communities. Several alien plant species have invaded the area. Among these are: *Cereus jamacaru*, *Eucalyptus sp.*, *Lantana camara*, *Melia azedarach*, *Opuntia ficus-indica*, and *Sesbania punicea*.

Sekhukhune Plains Bushveld:

This vegetation type occurs at altitudes of 700 - 1100 m above mean sea level on semi-arid plains and is characterised by open valleys between chains of hills and small mountains running parallel to the escarpment with predominantly short open to closed thornveld vegetation, with an abundance of *Aloe* spp. (Mucina and Rutherford, 2006). Dominant species in this vegetation type are: *Acacia erioloba*, *Philenoptera violacea*, *Acacia mellifera subsp. detinens*, *A. nilotica*, *A. tortilis* subsp. *heteracantha*, *Boscia foetida* subsp. *rehmanniana*, *Euphorbia tirucalli*, *Rhus engleri*, *Felicia clavipilosa* subsp. *transvaalensis*, *Seddera suffruticosa*, *Aloe cryptopoda*, *Euphorbia enormis*, *Kleinia longiflora*, *Cenchrus ciliaris*, *Enneapogon cenchroides*, *Panicum maximum*, *Urochloa mosambicensis*, *Becium filamentosum* and *Phyllanthus maderaspatensis* (Mucina and Rutherford, 2006).

Mucina and Rutherford (2006) describe this vegetation type as vulnerable and hardly protected in South Africa. It is estimated that 74.5% of this vegetation type remains intact with only 0.8% protected in provincial nature reserves and private conservation areas.

According to Mucina and Rutherford (2006), 25% of Sekhukhune Plains Bushveld is transformed and is mainly threatened by dry-land subsistence cultivation and chrome and platinum mining with its associated urbanisation. Much of the remaining vegetation is threatened by unsustainable harvesting and utilisation resulting in widespread high levels of erosion and donga formation. Several alien plant species have invaded the area. Among these are: *Caesalpinia decapetala, Lantana camara, Melia azedarach, Nicotiana glauca, Opuntia* sp., *Verbesina encelioides* and *Xanthium strumarium*.

Ohrigstad Mountain Bushveld:

This vegetation type occurs at altitudes of 500 - 1400 m above mean sea level and is characterised by open to dense woody layer with herbaceous shrubs and open grass layer on moderate to steep slopes of mountainsides and deeply incised valleys (Mucina and Rutherford, 2006). Dominant vegetation includes: *Sclerocarya birrea* subsp. *caffra, Acacia exuvialis, A. karroo, A. tortilis* subsp. *heteracantha, Combretum apiculatum, C. molle, Kirkia wilmsii, Euphorbia tirucalli, Dichrostachys cinerea, Grewia vernicosa, Psiadia punctulata, Aloe castanea, A. fosteri, Pterolobium stellatum,* and *Loudetia simplex* (Mucina and Rutherford, 2006). The following species are considered to be endemic to this vegetation type: *Encephalartos cupidus, Asparagus lynnetteae, Rhoicissus laetans* and *Ceropegia distincta* subsp. *verruculosa* (Mucina and Rutherford, 2006).

According to Mucina and Rutherford (2006) this vegetation type is regarded as least threatened but poorly protected in South Africa. They estimate that roughly 90.7% of the vegetation type remains intact while only 7.6% is being protected in provincial nature reserves and private conservation areas. According to Mucina and Rutherford (2006), Ohrigstad Mountain Bushveld is probably about 9% transformed and is mainly threatened by cultivation. Several alien plant species have invaded these areas with the most common being *Melia azedarach, Caesalpinia decapetala* and *Nicotiana glauca.*

Poung Dolomite Mountain Bushveld:

This vegetation type occurs at altitudes of 600 - 1500 m above mean sea level extending to about 1600 above mean sea level and is characterised by open to closed woodland with well developed shrub layers occurring on low to high mountain slopes (Mucina and Rutherford, 2006). Dominant vegetation includes *Hippobromus paucifloris, Kirkia wilmsii, Seemannaralia gerrardii, Asparagus intricatus, Plectranthus xerophilus, Brewsia biflora, Brachiaria serrata, Eragrostis lehmanniana, Loudetia simplex, Melinis repens, Panicum maximum, Themeda triandra* and *Cheilanthes dolomitica* (Mucina and Rutherford, 2006). The following species are considered to be endemic to this vegetation type: *Encephalartos dolomiticus, E. inopinus, Melhania integra, Delosperma vandermerwei, Euphorbia grandialata, Barleria dolomiticola, Lotononis pariflora, Brachystelma minor, B. parvulum, Gladiolus dolomiticus, G. pavonia, Ledebouria dolomiticola, Aloe branddraaiensis, A.*

monotropa, *Gasteria batesiana* var. *dolomitica*, *Huernia blyderiverensis* and *Plectranthus dolomiticus* (Mucina and Rutherford, 2006).

Mucina and Rutherford (2006) describe this vegetation type as least threatened but poorly protected in South Africa. They estimate that roughly 94.1% of the vegetation type remains intact while 9.9% is being protected in provincial nature reserves and private conservation areas. According to Mucina and Rutherford (2006), Poung Dolomite Mountain Bushveld is probably about 6% transformed and is mainly threatened by cultivation.

Granite Lowveld:

This vegetation type occurs at altitudes of 250 - 700 m above mean sea level and is characterised by tall shrubland with few trees to moderately dense low woodland on deep sandy uplands (Mucina and Rutherford, 2006). Dominant species in this vegetation type are: *Acacia nigrescens*, *Sclerocarya birrea subsp. caffra*, *Acacia nilotica*, *Albizia harveyi*, *Combretum apiculatum*, *C. imberbe*, *C. zeyheri*, *Ficus stuhlmannii*, *Peltophorum africanum*, *Pterocarpus rotundifolius*, *Terminalia sericea*, *Combretum hereroense*, *Dichrostachys cinerea*, *Euclea divinorum*, *Strychnos madagascariensis*, *Brachiaria nigropedata*, *Digitaria eriantha* subsp. *eriantha*, *Eragrostis rigidior*, *Melinis repens*, *Panicum maximum* and *Pogonarthria squarrosa* (Mucina and Rutherford, 2006).

Mucina and Rutherford (2006) describe this vegetation type as vulnerable but moderately protected in South Africa. They estimate that roughly 79.2% of the vegetation type remains intact with about 17.5% being protected in provincial nature reserves and private conservation areas. According to Mucina and Rutherford (2006), Granite Lowveld is probably more than 20% transformed and is mainly threatened by cultivation and settlement development.

Lowveld Rugged Mopaneveld:

This vegetation type occurs at altitudes of 250 - 550 m above mean sea level and is characterised by irregular plains with sometimes steep slopes and a number of prominent hills (Mucina and Rutherford, 2006). Dominant species in this vegetation type are: *Acacia nigrescens, Sclerocarya birrea subsp. caffra, Colophospermum mopane, Combretum apiculatum, Terminalia prunioides, Aristida congesta, Enneapogon cenchroides, Melinis repens* and *Sporobolus panicoides* (Mucina and Rutherford 2006).

According to Mucina and Rutherford (2006) this vegetation type is regarded as least threatened but well protected in South. They estimate that roughly 80.2% of the vegetation type remains intact while 34.4% is being protected mostly in the Kruger National Park but also in some provincial nature reserves and private conservation areas. Lowveld Rugged Mopaneveld is probably about 20% transformed mainly through high

density rural settlements and the associated urban sprawl and agricultural activities (Mucina and Rutherford, 2006).

Makuleke Sandy Bushveld:

This vegetation type occurs at altitudes of 300 - 700 m above mean sea level and is characterised by variable landscapes from low mountains to extremely irregular plains to hills while tree savanna occurs on the deep sands and stony soils (Mucina and Rutherford, 2006).

Dominant species in this vegetation type are: *Burkea africana, Kirkia acuminata, Pseudolachnostylis maprouneifolia, Terminalia sericea, Pteleopsis myrtifolia, Andropogon gayanus, Digitaria eriantha* subsp. *pentzii* and *Panicum maximum* (Mucina and Rutherford, 2006). The following species are considered to be endemic to this vegetation type: *Euphorbia rowlandii* and *Ceratotheca saxicola* (Mucina and Rutherford, 2006).

This vegetation type is described as vulnerable but well protected in South Africa with roughly 73.3% of the vegetation type remaining intact and 31.5% protected mostly in the Kruger National Park but also in some provincial nature reserves and private conservation areas (Mucina and Rutherford, 2006). It is estimated that 27% of Makuleke Sandy Bushveld is transformed mainly through cultivation.

Mopane Basalt Shrubland:

This vegetation type occurs at altitudes of 200 - 450 m above mean sea level and is characterised by plains and slightly undulating plains with medium to low shrubs dominated overwhelmingly by multi-stemmed *Colophospermum mopane* (Mucina and Rutherford, 2006). Dominant species in this vegetation type are: *Acacia nigrescens, Philenoptera violacea, Sclerocarya birrea* subsp. *caffra* and *Colophospermum mopane* (Mucina and Rutherford, 2006).

Mucina and Rutherford (2006) describe this vegetation type as least threatened and well protected in South Africa. They estimate that roughly 99.6% of Mopane Basalt Shrubland remains intact with probably 100% being protected mostly in the Kruger National Park.

Tshokwane-Hlane Basalt Lowveld:

This vegetation type occurs at altitudes of 180 - 400 m above mean sea level and is characterised by fairly flat plains with open tree savanna often dominated by tall *Sclerocarya birrea* subsp. *caffra* and *Acacia nigrescens* (Mucina and Rutherford, 2006). Dominant species in this vegetation type are: *Acacia nigrescens, Sclerocarya birrea* subsp. *caffra, Bothriochloa radicans, Digitaria eriantha* subsp. *eriantha, Panicum coloratum, P. maximum, Themeda triandra* and *Urochloa mosambicensis* (Mucina and Rutherford, 2006). The following species are considered to be endemic to this vegetation type: *Boscia foetida* subsp. *minima* (Mucina and Rutherford, 2006).

Mucina and Rutherford (2006) rank this vegetation type as least threatened and well protected in South. They estimate that roughly 83.5% of Tshokwane-Hlane Basalt Lowveld remains intact while 64.4% is being protected mostly in the Kruger National Park and Hlane Game Sanctuary in Swaziland and that about 17% of this vegetation type is currently transformed by cultivation practises.

Northern Lebombo Bushveld:

This vegetation type occurs at altitudes of 200 - 450 m above mean sea level and is characterised by open bushveld dominated by Combretaceae on rocky slopes, ridges and hills reaching 100m and higher above the surrounding basalt plains (Mucina and Rutherford, 2006). Dominant species in this vegetation type are: *Sclerocarya birrea subsp. caffra, Combretum apiculatum, Euphorbia confinalis, Dichrostachys cinerea, Aristida congesta, Digitaria eriantha* subsp. *eriantha, Enneapogon cenchroides, Heteropogon contortus* and *Panicum maximum* (Mucina and Rutherford, 2006).

Mucina and Rutherford (2006) describe this vegetation type as least threatened and well protected. They estimate that roughly 99.8% of Northern Lebombo Bushveld remains intact while 98.8% is being protected mostly in the Kruger National Park. Mucina and Rutherford (2006) estimate that this vegetation has seen virtually no transformation.

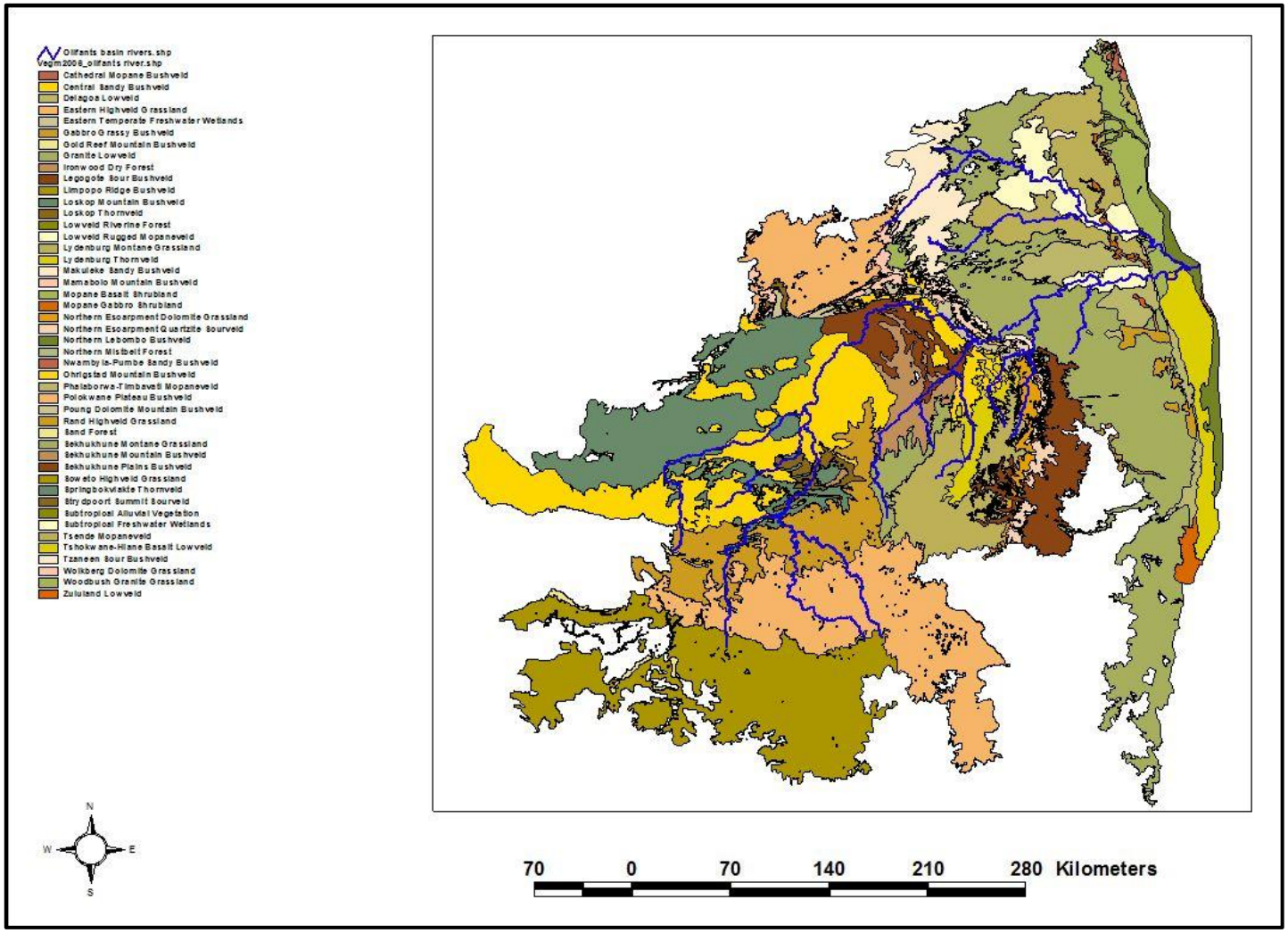

Figure 8: Vegetation types of the study area showing the Olifants River superimposed in blue over the area.

PRESENT ECOLOGICAL STATE OF THE OLIFANTS RIVER

The application of biological and habitat indices during river surveys provide a framework for determining the degree of ecological modification at specific sites in the river. The degree of modification observed in each ecoregion at particular sites was translated into the present ecological state of the catchment. The ecological state of the catchment is classified using the categories shown in table 4 below.

Table 4: Categories used to define the present ecological state of the Olifants River ecosystem (Water Research Commission, 2001).

Ecological state of river	Description
Natural	No measurable modification
Good	Largely unmodified
Fair	Moderately modified
Poor	Largely modified
Unacceptable	Seriously or critically modified

In their State of the Rivers Report, the Water Research Commission (2001) describes the present ecological state of the Olifants River summarised into one overall state as follows:

The **Highveld Ecoregion** show a fair to unacceptable state in terms of in-stream and riparian habitats with general conditions being poor to fair. Biological communities are considered to be in fair to unacceptable health. In the **Central Highlands Ecoregion,** the Olifants River is generally in good health with the in-stream conditions being variable and ranging from good to fair. The present ecological state of the **Bushveld Basin Ecoregion** is described as poor to unacceptable with in-stream biota of the Olifants River being fair to poor and the riparian vegetation being in a poor state. In the second area of the **Central Highlands Ecoregion** situated downstream of the Flag Boshielo Dam between the Tudumo and Motse Rivers, biological indicators reflect a predominantly poor ecological state with river habitats in an unacceptable state. The state of in-stream and riparian habitats in the **Great Escarpment Mountains Ecoregion** vary from unacceptable to fair with fish populations in a poor state. Some of the tributaries in this ecoregion, such as the Blyde River, Treur River and Belvedere Creek, are in a good to natural ecological state whereas the Spekboom River is slightly lower at a good to fair ecological state. The Olifants River in the **Lowveld Ecoregion** is in a fair to poor ecological state in terms of in-stream and riparian habitat while biological indicators in general suggest a fair ecological state. The water quality of the Olifants River in the **Lebombo Uplands Ecoregion** is lower than desirable. According to the Water Research Commission (2001), the reasons for this are:

(i) High concentrations of dissolved salts having accumulated as a result of activities in the upper reaches of the catchment,

(ii) The Massingire Dam across the border in Moçambique causes the river flow to decrease and result in sediment being deposited in the Olifants River Gorge.

In conclusion then, river systems in the Olifants River catchment are generally in fair to poor condition. Exceptions are the Tongwane, Mohlapitse and Blyde Rivers where a natural ecological state prevails (Water Research Commission, 2001) and the lower reaches of the Olifants River which is protected by conservation activities. In the upper parts of the catchment, mining related disturbances are the main causes of impairment of river health (Water Research Commission, 2001) and there are also extensive invasions by alien vegetation and to a lesser extent alien fauna. The Water Research Commission (2001) states that ecologically insensitive water releases and sediment from storage dams are major causes of environmental degradation downstream in the Olifants River and particularly so in the middle and lower parts of the catchment in the Olifants River Catchment.

LAND-USE IN THE OLIFANTS RIVER BASIN

Land-use activities contribute greatly to the ecological state of the Olifants River and are accepted as drivers of ecological change in the ecosystem of the Olifants River Catchment. The State of the Rivers Report (Water Research Commission, 2001) describes the following land-use activities as drivers of ecological change in each ecoregion of the Olifants River Basin:

Highveld Ecoregion:

Coal mining activities (figure 9) and other industries are the major contributors to poor in-stream and riparian habitat conditions in this ecoregion (Water Research Commission, 2001). Non-functioning sewage works in major towns such as Witbank is also considered to have a huge negative influence on water quality, in-stream and riparian habitat conditions. Acid leachate from abandoned mines is a primary contributor to the poor water quality in this ecoregion where low pH and high concentrations of dissolved salts characterise many of the streams (Water Research Commission, 2001). Activities such as access roads and stream diversions may also have a severely disrupting influence on riparian habitats by causing erosion of the riverbed which in some areas have been eroded down to bedrock leaving little suitable habitat for aquatic life.

Figure 9: Aerial view of an opencast coal mine (Kromdraai Coal Mine) situated on the watershed of the Olifants River and Wilge River (Photo: A.C Driecher).

Central Highlands Ecoregion:

Agricultural activities such as grazing but especially intensive irrigation of crop are the main influences on the aquatic habitat in this ecoregion. The heavy abstraction of water for irrigation of crops (including orchards) reduces the available water for downstream ecological functioning (Water Research Commission, 2001). Commercial farming activities reach up to the riverbank and the clearing of ground cover associated with these activities increases the potential for erosion and sedimentation in the river channel. Pump houses, weirs and other water abstraction infrastructure contribute towards changes in the flow regime of the river while unseasonal and ecologically insensitive releases from or retention of water in dams have a definite negative impact on in-stream biological communities and may cause erosion of the riverbed (Bruwer and Ashton, 1989; Water Research Commission, 2001). Alien vegetation is abundant along the river in this ecoregion.

Bushveld Basin Ecoregion:

The riparian vegetation in this ecoregion is overgrazed and over-utilised by small scale subsistence agricultural activities such as grazing by cattle and goats (Water Research Commission, 2001). As a result the riverbank is collapsing in areas due to erosion with resulting sedimentation occurring in the riverbed. Run-off from commercial agricultural activities contains agro-chemicals which may cause eutrophication and contamination of the water (Water Research Commission, 2001). Alien vegetation (including *Melia azedarach*) is abundant in this ecoregion.

Central Highlands Ecoregion:

In the second, small area characterised as part of the Central Highlands Ecoregion, land and vegetation are generally highly degraded due to bad land management practises and over utilisation (Water Research Commission, 2001). Activities in this area are mainly small-scale subsistence crop cultivation and commercial banana plantations. Sections of the riverbanks are seriously degraded due to clearing for crops and collection of fire wood (Water Research Commission, 2001). Donga erosion is common in the riparian zone.

Great Escarpment Mountains Ecoregion:

Intensive cultivation and grazing in this ecoregion have caused general degradation of land cover (Water Research Commission, 2001). Serious erosion occurs due to the highly erodible soils occurring in this ecoregion while sediment originating in the Sekhukuneland area settles here in the river resulting in siltation and loss of habitat (Water Research Commission, 2001).

Lowveld Ecoregion:

Sediment from upstream activities (including overgrazing, mining and industries) accumulates in the Phalaborwa Barrage to be released in large quantities when the barrage is flushed from time to time (Water Research Commission, 2001). This may cause severe damage to in-stream habitats and biota downstream in the Olifants River with fish dying from oxygen depletion and smothering from silt clogging their gills. Heavy metals and

chlorides may reach unacceptable levels during low flow periods and abstraction of water often cause flow in the Olifants River to cease altogether (See Figure 10).

Lebombo Uplands Ecoregion:

The water quality of the Olifants River is this ecoregion is lower than desirable considering that this area is situated inside the Kruger National Park. The river is characterised by high concentrations of dissolved salts which accumulate due to activities in the upper reaches of the catchment (Water Research Commission, 2001). The Massingire Dam across the international border in Moçambique causes the flow to decrease and allow sediments to deposit in the Olifants River Gorge - once prime habitat for Nile crocodiles in the Kruger National Park (Water Research Commission, 2001).

Figure 10: Olifants River Gorge during a period of no-flow in October 2005 (Photo: Dr F. Venter).

CLIMATE OF THE OLIFANTS RIVER BASIN

The climate of the Olifants River catchment is semi-arid and is largely controlled by movement of air-masses associated with the Inter-Tropical Convergence Zone (McCartney and Arranz, 2007). During summer, high land temperatures produce low pressures and moisture is brought to the catchment through inflow of maritime air masses from the Indian Ocean. During winter, the sun moves north and the land cools, causing the development of a continental high pressure system. The regional dry season is produced by descending, out flowing air. Therefore, rainfall in the Olifants River catchment is seasonal and largely occurs during the summer months, October to April (McCartney, 2003). Mean annual precipitation for the whole catchment is 630 mm but the rainfall pattern is irregular with coefficients of variation greater than 0.25 across the catchment (McCartney and Arranz, 2007). The catchment is divided into two distinct areas by an escarpment orientated roughly north-south with the highest rainfall in the area of the escarpment. Orographic rainfall in the vicinity of the escarpment results in mean annual precipitation that exceeds 1000 mm in places (McCartney, 2003).

The mean annual potential evapotranspiration for the catchment is 1450 mm (McCartney and Arranz, 2007). Runoff from the catchment reflects the temporal and spatial distribution of rainfall with the highest volumes along the escarpment. The average annual runoff from the catchment is 37.5 mm (McCartney and Arranz, 2007).

The temperature range over the catchment shows a wide annual variation from about -4°C in winter to approximately 45°C in summer (de Lange *et al.*, 2005). This wide variation is due to the Olifants River basin being situated only 24° South of the equator but with much of the basin located at relatively high elevations above sea level (de Lange *et al.*, 2005).

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